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A TEXT-BOOK
OF
PATHOLOGICAL ANATOMY
AND
PATHOGENESIS

BY

ERNST ZIEGLER

PROFESSOR OF PATHOLOGICAL ANATOMY IN THE
UNIVERSITY OF TÜBINGEN

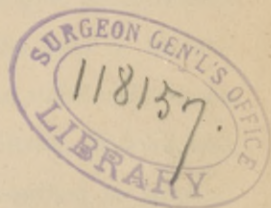
TRANSLATED AND EDITED FOR ENGLISH STUDENTS

BY

DONALD MAC ALISTER M.A. M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS; FELLOW AND MEDICAL
LECTURER OF ST. JOHN'S COLLEGE, UNIVERSITY LECTURER IN
MEDICINE, AND PHYSICIAN TO ADDENBROOKE'S
HOSPITAL, CAMBRIDGE.

PART II—SPECIAL PATHOLOGICAL ANATOMY
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PREFACE.

WHEN the second volume of this work appeared in 1884 I expressed the hope that the third and concluding volume would be ready in the following year. Owing in part to my increased academical duties, and in part to the unexpected demand for new editions of the volumes already published, I have been unable until now to find time for the fulfilment of my task. To the many readers in all parts of the world who have sent me friendly enquiries on the subject, I must here express my regret at the unforeseen delay. In some respects at least the work has not suffered thereby, for I have been enabled to profit in some measure by the valuable improvements which Professor Ziegler has made in the fourth German edition, and to bring up to date the references to some of the rapidly advancing parts of the subject. The indexes of authors and of subjects appended to the volume have been made with much care, and refer to the entire work.

It should be stated that the author, in order to give completeness to the text-book for German students, has with the help of his colleagues Dr. Haab and Dr. Wagenhäuser prepared an additional volume on the pathological anatomy of the Eye, Ear, Bones, Muscles, and Genital Organs—on what in fact is generally described as surgical pathology. After consultation with several teachers of experience I have decided to adhere to the plan indicated in the second volume, and

to leave these additional sections alone, at least for the present. They are not wholly Professor Ziegler's, and their subject-matter is perhaps more likely to be studied profitably in special text-books.

To the acknowledgments already made I have to add my sincere thanks to Dr. James Ross, who has read for me the pages on the Nervous System. His general approval of them gives me reason to hope that in this difficult part of the work I have not fallen into any serious error.

DONALD MAC ALISTER.

ST. JOHN'S COLLEGE, CAMBRIDGE,

October 1886.

CONTENTS.

SECTION IX.

THE URINARY ORGANS.

	PAGE
CHAP. LXIV. MALFORMATIONS OF THE URINARY ORGANS (Arts. 516-519)	3
LXV. CLASSIFICATION OF RENAL DISORDERS (Arts. 520-521)	9
LXVI. DISORDERS OF THE RENAL CIRCULATION (Arts. 522-528)	13
LXVII. RENAL DEPOSITS DERIVED FROM THE BLOOD (Arts. 529-533)	26
LXVIII. RENAL DEGENERATION AND NECROSIS (Arts. 534-537)	33
LXIX. HÆMATOGENOUS NEPHRITIS (Arts. 538-550)	42
<i>Acute Nephritis</i> (Arts. 540-543)	47
<i>Chronic Parenchymatous Nephritis</i> (Arts. 544-546)	55
<i>Chronic Indurative Nephritis</i> (Arts. 547-548)	60
<i>Tuberculous and Syphilitic Nephritis</i> (Arts. 549-550)	65
LXX. RENAL CYSTS AND HYDRONEPHROSIS (Arts. 551-552)	68
LXXI. PYELITIS AND PYELONEPHRITIS (Arts. 553-555)	71
LXXII. RENAL TUMORS AND PARASITES (Arts. 556-557)	74
LXXIII. DISORDERS OF THE BLADDER (Arts. 558-563)	76
LXXIV. MORBID CHANGES IN THE URETHRA (Art. 564)	82
LXXV. MORBID CHANGES IN THE SUPRARENALS (Art. 565)	84

SECTION X.

THE RESPIRATORY ORGANS.

LXXVI. INTRODUCTORY (Art. 566)	89
LXXVII. THE NASAL CAVITIES (Arts. 567, 568)	90
LXXVIII. THE LARYNX (Arts. 569-576)	93
LXXIX. THE TRACHEA (Arts. 577, 578)	103
LXXX. THE BRONCHI (Arts. 579-583)	106
LXXXI. STRUCTURE AND FUNCTION OF THE LUNGS (Arts. 584, 585)	116
LXXXII. DISORDERS OF CIRCULATION IN THE LUNG (Arts. 586-590)	120

	PAGE
LXXXIII. ATELECTASIS, COLLAPSE, AND EMPHYSEMA OF THE LUNG (Arts. 591-594)	126
LXXXIV. DEGENERATIONS OF THE LUNG (Art. 595)	133
LXXXV. PULMONARY INFLAMMATIONS IN GENERAL (Arts. 596-601)	134
LXXXVI. FORMS OF PNEUMONIA (Arts. 602-609)	146
LXXXVII. FORMS OF BRONCHOPNEUMONIA (Arts. 610-618)	159
LXXXVIII. TUMORS AND PARASITES OF THE LUNGS (Arts. 619-620)	181
LXXXIX. THE THYROID GLAND (Arts. 621-623 a)	184
XC. THE THYMUS GLAND (Art. 623 b)	195

SECTION XI.

THE CENTRAL NERVOUS SYSTEM.

XCI. STRUCTURE AND FUNCTIONS (Arts. 624-629)	199
XCII. MALFORMATIONS OF THE BRAIN AND SPINAL CORD (Arts. 630-634)	219
XCIII. DISORDERS OF CIRCULATION (Arts. 635-637)	233
XCIV. SIMPLE AND DEGENERATIVE ATROPHY (Arts. 638-651)	242
XC.V. INFLAMMATORY DISORDERS.	
<i>Serous inflammations</i> (Art. 652)	288
<i>Purulent inflammations</i> (Arts. 653, 654)	284
<i>Chronic Meningitis</i> (Arts. 655-657)	289
<i>Cicatrization and Sclerosis</i> (Arts. 658, 659)	296
XCVI. TUBERCULOSIS AND SYPHILIS (Arts. 660, 661)	305
XCVII. TUMORS AND PARASITES (Arts. 662, 663)	312
XCVIII. THE DURA MATER, PINEAL BODY AND PITUITARY BODY (Arts. 664, 665)	321

SECTION XII.

PERIPHERAL NERVOUS SYSTEM.

XCIX. STRUCTURE OF PERIPHERAL NERVES (Art. 666)	329
C. ATROPHY AND DEGENERATION (Art. 667)	331
CI. REGENERATION OF NERVES (Art. 668)	336
CII. INFLAMMATION OF PERIPHERAL NERVES AND GANGLIA (Art. 669)	340
CIII. TUMORS (Art. 670)	344
INDEX OF AUTHORS CITED	347
INDEX OF SUBJECTS	361

INDEX OF FIGURES.

FIG	PAGE
201. Cortex of a kidney with recent interstitial nephritis,	10
202. Senile atrophy of the kidney,	16
203. Contracted kidney with arterial sclerosis,	17
204. Cortex of an arteriosclerotic contracted kidney,	19
205. Cloudy swelling of the renal epithelium,	33
206. Necrosis of the tubular epithelium in <i>icterus gravis</i> ,	35
207. Necrosis of the glomerular epithelium in <i>icterus gravis</i> ,	36
208. Amyloid kidney with fatty degeneration,	40
209. Glomerular capillaries in acute nephritis following diphtheria,	47
210. Diffuse nephritis with sero-fibrinous exudation,	49
211. Cortex of a kidney in recent acute disseminated (interstitial) nephritis,	51
212. Disseminated suppurative nephritis,	54
213. Chronic hæmorrhagic (parenchymatous) nephritis,	56
214. Inflammatory induration and atrophy of the renal tissue,	62
215. Cirrhotic contracted (or 'granular') kidney,	64
216. Tuberculosis of the bronchial mucous membrane,	107
217. Two occluded bronchioles from a tuberculous lung,	109
218. Indurative peribronchitis,	111
219. Termination of a bronchiole and of a pulmonary arteriole,	116
220. Section of an injected healthy lung,	117
221. Cirrhosis from collapse of the pulmonary tissue,	127
222. Chronic vesicular emphysema,	130
223. Rarefied pulmonary tissue in emphysema,	131
224. Recent bronchopneumonia,	134
225. Catarrhal bronchopneumonia,	136
226. Croupous pneumonia (red hepatization),	136
227. Caseating lobular bronchopneumonia,	137
228. Growth of fibrous tissue in the walls and in the contents of an alveolus,	140
229. Croupous hepatization of the lung,	146
230. Simple cirrhosis of the lung,	150
231. Miliary tuberculosis of the lung,	153
232. Chronic pleurogenous interlobular pneumonia,	157
233. Miliary bronchopneumonia,	159
234. Miliary bronchopneumonia,	159
235. Mason's lung with bronchopneumonic fibrous nodules,	161
236. Primary tuberculous bronchopneumonia with commencing tuberculous lymphangitis,	164
237. Miliary tuberculous bronchopneumonia,	168
238. Chronic nodular tuberculous bronchopneumonia,	171
239. Nodular tuberculous bronchopneumonia,	174
240. Chronic nodose tuberculous cirrhosis,	176

FIG.	PAGE
241. Lobular caseous tuberculous bronchopneumonia,	178
242. Goitre partly hypertrophic and partly colloid,	185
243. Outer surface of the left cerebral hemisphere,	200
244. Median surface of the left cerebral hemisphere,	201
245. Diagrammatic transverse vertical section of the cerebrum,	203
246. Diagrammatic section of the spinal cord,	206
247. Basal aspect of the cerebral axis,	208
248. Diagram of the nuclei of the cranial nerves,	209
249. Section of the medulla through the middle of the olivary body,	211
250. Degeneration of cells and fibres from the cerebral cortex,	242
251. Calcified ganglion-cells and fibres,	243
252. Degeneration of the cord from pressure,	243
253. Degenerating patch from a case of multiple sclerosis of the brain,	244
254. Section through the margin of a patch of softening of the brain,	247
255. Ascending degeneration of the cord (recent),	248
256. Ascending degeneration of the cord (advanced),	248
257. Left anterior horn (normal) at the level of the fourth cervical nerve,	251
258. Left anterior horn (atrophied) at the level of the fourth cervical nerve,	251
259. Atrophy of the cortex of the cerebellum,	252
260. Ischæmic softening of the cortex of the brain,	258
261. Sclerosis of the posterior white columns of the cord,	267
262. Complete sclerosis of posterior columns and atrophy of posterior roots,	268
263. Sclerosis of posterior and lateral columns,	268
264. Sclerosis of posterior columns and of marginal region,	268
265. Amyotrophic lateral sclerosis,	270
266. Commencing sclerosis of the posterior columns,	273
267. Sclerotic patch in the white matter of the cord,	276
268. do. do. cervical region,	277
269. do. do. dorsal region,	277
270. do. do. lumbar region,	277
271. Gray gelatinous degeneration of the anterior horn,	278
272. Marginal sclerosis of the cervical cord,	281
273. Chronic meningoencephalitis with atrophy of the cortex,	292
274. Encephalitis experimentally produced by a puncture,	297
275. Sclerosis and shrinking of the left anterior horn,	300
276. Gelatinous degeneration of both anterior horns,	300
277. Sclerosis and shrinking of the entire gray matter,	301
278. Sclerosis after acute transverse myelitis,	302
279. Chronic disseminated tuberculous meningoencephalitis,	306
280. Gummatous syphilitic meningoencephalitis,	309
281. Angiomatous glioma,	318
282. Papillomatous carcinoma of the choroid plexus,	317
283. Papillomatous carcinoma with gelatinous degeneration of the stroma from the third ventricle,	318
284. Endothelioma of the dura mater,	323
285. Atrophy of motor nerves in anterior poliomyelitis,	323
286. Central end of a nerve-bundle in process of regeneration,	327
287. Chronic neuritis,	340
288. Multiple fibroma of a nerve of the sciatic plexus,	344
289. Plexiform neurofibroma of the sacrum,	346

SECTION IX.

THE URINARY ORGANS.

CHAPTER LXIV.

MALFORMATIONS OF THE URINARY ORGANS.

516. **The urinary organs** include the kidneys, the ureters, the bladder, and the urethra. The kidney is the secreting organ, by which water and a number of other substances are separated from the blood. The other organs named serve merely to convey the urinary secretion out of the body.

The development of the urinary organs is subject to certain abnormalities, but they are seldom such as to imperil life by preventing or seriously hindering the secretion and removal of the urine. The consequent malformations consist chiefly of deviations from the normal form, position, or number of particular parts: anomalies in the minute structure of the kidney are much more rare. Such anomalies, however, are of great importance, inasmuch as they may prove the starting-point for tumors of great size.

The post-embryonic disorders of the urinary apparatus affect either the kidney or some part of the urinary tract. Many of them continue to affect the part only in which they arise, while others extend by continuity to contiguous parts of the tract and in some cases ultimately affect the whole apparatus.

Most urinary disorders are hæmatogenous, *i. e.*, traceable to some disorder of the blood; and of all the urinary organs the kidney is most liable to be affected. Disease of the kidney or of the internal parts of the urinary channels is much less frequently the result of injurious agencies reaching them from the urethra. A third and not unimportant group of affections arise from the extension to the urinary organs of morbid processes affecting adjacent parts.

Development of the urinary organs. In man the urinary organs are derived from two distinct groups of structures which may be described respectively as embryonic and permanent (KÖLLIKER), or primary and secondary. The primary structures are the primordial kidneys or wolffian bodies, and the wolffian ducts.

The **wolffian duct** on each side arises from a columnar mass of cells (the intermediate cell-mass) lying between the lateral mass of the mesoblast and the anterior part of the protovertebral column. This mass presently becomes hollowed out into a duct opening posteriorly into that part (urogenital cloaca) of the

stalk of the allantois which lies within the body of the embryo, and which ultimately becomes the urinary bladder and the urachus.

The **wolffian body** arises independently of the wolffian duct from another part of the intermediate cell-mass. The mass breaks up into a number of transverse cords of cells appearing at first to be connected with the peritoneal epithelium. These cords speedily become excavated into cæcal tubules (wolffian tubes), which are more or less convoluted and ultimately open into the wolffian duct. The organ thus developed is not unlike the permanent kidney.

The secondary or **permanent kidney** and the ureter are later developments. The ureter arises as a dorsal diverticulum from the hind-end of the wolffian duct near its opening, the diverticulum growing forwards on the dorsal side of the wolffian body. The kidney is developed from the hindmost part of the intermediate cell-mass, the part namely that did not break up into wolffian tubes. The cells of the mass apply themselves to the growing ureter, and become excavated into tubules; collecting tubes spring simultaneously from the ureter, and becoming continuous with the former give rise to typical renal tubules. The **ureter** does not long remain attached to the wolffian duct, its opening being gradually carried back until it enters the cloaca independently. The renal tubules in the cell-mass become convoluted and round their cæcal ends appear small aggregations of cells, in which blood-vessels develop forming the vascular **glomeruli**. These glomeruli then push in or invaginate the renal tubules, and presently a series of spherical structures is produced, each consisting of a coil of convoluted blood-vessels almost entirely surrounded by a double envelope continuous with the wall of a renal tubule. The stalk or pedicle of the glomerulus passes out at the point where the original invagination took place, which is usually opposite to the starting-point of the tubule. This spherical structure so formed is the **malpighian body**, the spherical envelope being the **capsule** of Bowman. Meanwhile the tubules become elongated and convoluted, and are soon differentiated into the various segments recognized in the adult kidney.

In the human foetus of eight weeks the kidney is already a lobulated organ with a number of completely-formed malpighian bodies. The papillæ (Art. 520) are apparent at the end of the third month, and some of the tubules have attained their permanent form by the fourth month. Glomeruli continue to be formed throughout the whole time of foetal life and for some time after birth. The lobulated external form usually disappears during the first year of infancy.

The **bladder** is derived from the primitive urachus or stalk of the allantois, which arises in the first month from the hind-gut as a cæcal diverticulum lined with hypoblast. The urachus thus opens primarily into the terminal portion of the gut and afterwards becomes separable into two segments, the posterior forming the urogenital sinus or cloaca, the anterior being dilated into the bladder and receiving the ureters. In the second month the bladder appears as a spindle-shaped cavity communicating below with the anal portion of the gut and above through the still patent urachus with the umbilical cord. At a later stage the urachus contracts and ultimately closes into a solid cord—the median ligament of the bladder. The closure is not in all cases complete (LUSCHKA, *Virch. Arch.* vol. 23); even in adults it may persist as a fine tube communicating with the bladder and lined with epithelium.

References on the development of the urinary organs:—BALFOUR, *Comp. Embryology* II. ch. 23 London 1881 (with bibliography); KÖLLIKER, *Entwicklungsgeschichte* Leipzig 1879; FÜRBRINGER, *Morphol. Jahrbuch* IV. 1878; SEMPER, *Arbeiten a. d. zool. Inst.* II., III. Würzburg 1875-76; SPENGLER, *ibidem* III.; BRAUN, *ibidem* IV.; KUPFFER, *Arch. f. mikr. Anat.* I., II. (1865-66); KOWA-

LEWSKY, *Die Bildung d. Urogenitalanlage b. Hühnchenembryonen* Warsaw 1875; SEDGWICK, *Quart. J. Micro. Sci.* XXI. 1880-81; ALLEN THOMSON, *Quain's Anatomy* II. London 1882 (with full references).

517. Total **absence of the kidneys** occurs only in gravely malformed foetuses, and is of course incompatible with independent life.

Absence of one kidney is rare in foetuses otherwise well-developed. It does not interfere with growth and development, inasmuch as the other kidney becomes hypertrophied and assumes the whole work of excretion. The left kidney is more often wanting than the right. The corresponding suprarenal and ureter are usually absent, though in some instances rudiments of the lower extremity of the ureter have been found.

Congenital atrophy of one kidney is more common than entire absence. In well-marked cases the atrophied kidney appears as a thin plate of fibrous tissue 2-5 cm. in length and 1.5-3 cm. broad, with few or no traces of tubules or glomeruli, and supplied by renal vessels normal in position but abnormally small. Where the atrophy is less marked the remnants of renal tissue are more abundant.

The causes which determine the non-development of one of the kidneys are unknown. We can only say that for some reason the outgrowth from the primitive ureter out of which the kidney is fashioned has been hindered or altogether suppressed. Atrophy of the kidney must often originate in some similar condition of whose precise nature we are equally ignorant. In some cases however traces of inflammation, in the form of cellular infiltration and fibrous hyperplasia, are discoverable in the rudimentary organ. We are thus led to infer that intra-uterine inflammation of the kidney is possible and may lead to arrest of its development.

Among congenital **anomalies of form** the persistence of the foetal lobulations is the most common. The boundaries of the renal segments are usually indicated by shallow furrows; it is very uncommon to find the furrows so deep that the segments are entirely separated into distinct *reniculi*.

Cohesion of the two kidneys most frequently takes the form of the so-called '**horse-shoe kidney**,' in which the organs are found closer to each other than is normal and their lower ends are united by a band either of fibrous tissue or of ordinary renal tissue. Cohesion of the upper or middle parts is very much rarer. When the kidneys coalesce entirely into one there is usually very considerable misplacement of the organ. It is often seated just above the promontory of the sacrum in the form of a thick cake or disc, from the anterior aspect of which arises a single or double pelvis with from one to four short ureters. In a few cases the united kidneys have been found on one or other side of the spinal column.

The renal vessels of the united kidneys are always abnormal in their

origin, and are frequently multiple. Thus when the organ is just above the sacrum the arteries spring from the lower part of the aorta near its bifurcation, or from one of the common iliacs, while the veins enter the corresponding parts of the vena cava or iliac veins.

This abnormal cohesion and the malposition of the kidneys indicate that the primitive ureters or the corresponding cell-masses were checked in their growth forwards and came early into contact.

A normal or malformed single kidney, like the horse-shoe kidney, may be misplaced during development; this condition is referred to as **dystopia**. It occurs most frequently in the case of the left kidney, which approaches the middle line in the neighborhood of the sacrum. The renal vessels are abnormal in their origin and the ureter is shortened, but the corresponding suprarenal usually occupies its normal position in the abdomen.

The kidneys may in like manner be displaced after birth. The right is most often displaced: the cause is to be sought partly in some outward mechanical violence, partly in a loose or extensible condition of the perinephral structures, and especially of the peritoneum. The origin of the renal vessels in such cases is not necessarily abnormal, and the ureter is not abnormally short, though it may be twisted or otherwise disturbed. The kidney is moreover in general readily movable. When the mobility is due to the presence of a mesonephron, or peritoneal fold loosely attaching the kidney to the spine, the case is described as one of **floating kidney**. It is more common in women than in men, and on the right side than on the left. On congenital renal cysts and tumors see Arts. 551 and 556.

References:—**RAYER**, *Maladies d. reins* III. Paris 1839; **HARE**, *Med. Times and Gaz.* 1, 1858 and 1, 1860; **ROLLET**, *Die bewegliche Niere* Erlangen 1866; **KLEBS**, *Handb. d. path. Anat.* I. 1870; **ROSENSTEIN**, *Virch. Arch.* vol. 53; **PERL**, *ibid.* vol. 56 (with references); **GRUBER**, *ibid.* vols. 33, 68; **BEUMER**, *ibid.* vol. 72; **SAWYER**, *Floating kidney*, *Birmingham Med. Rev.* 1872; **WÖLFLE**, *Wien. med. Wochenschrift* 1876; Report, *Trans. Path. Soc.* XXVII. (1876); **EBSTEIN**, *Ziemsens's Cyclopaedia*, xv. (1877); **HERTZ**, *Virch. Arch.* vol. 46; **LANDAU**, *Die Wanderniere d. Frauen* Berlin 1882, trans. by **CHAMPNEYS** (New Syd. Soc.) London 1884; **NEWMAN**, *Glasgow Med. Journal* August 1883 (with full bibliography); **W. ROBERTS**, *Urinary and renal diseases* London 1885.

518. **Malformations of the ureter and pelvis of the kidney** are met with both in normal and in malformed kidneys (Art. 517).

The commonest variety is the duplication on one or both sides of the pelvis and first part of the ureter. It is very rare for the pelvis to be further subdivided into a larger number of tube-like calices.

The duplication seldom extends throughout the whole length of the ureter so that the tubes open separately into the bladder. They usually run side by side, though cases are on record in which they appeared to cross each other.

Partial duplication of the ureter implies an early subdivision of the primitive diverticulum (Art. 516); complete duplication must be due to the simultaneous development of two diverticula from the wolffian duct.

Both normal and abnormal ureters may open in abnormal situations. In the male one ureter may open into the colliculus seminalis or into a seminal vesicle, in the female into the urethra, vagina, or uterus. A secondary coalescence of one ureter with the müllerian duct is sometimes observed.

In rare instances valvular folds of mucous membrane and twists or kinks in the tube may so obstruct the outflow of urine as to give rise to hydronephrosis (Art. 552).

Congenital atresia of a ureter or pelvis, or of a single calix, is rare.

References:—KLEBS, *loc. cit.*; HELLER, *Deut. Arch. f. klin. Med.* v.; WEIGERT, *Virch. Arch.* vol. 70; HOFFMANN, *Arch. d. Heilk.* XIII.; BOSTRÖM, *Beitr. z. path. Anat. d. Niere* Freiburg 1884.

519. Of the **malformations of the bladder** the most serious is extroversion (otherwise *fissura, ectrophia, or inversio vesicæ*).

As was pointed out in Art. 9 this malformation is due to the imperfect closure of the abdominal walls and of the bladder: a defect remains above the symphysis through which the posterior wall of the bladder protrudes. The symphysis in many cases remains likewise unclosed, while the penis is rudimentary and the urethra opens on its upper surface (epispadias).

More rarely the bladder itself is closed and protrudes through the abdominal fissure or through the umbilicus (*ectopia vesicæ*). Sometimes the anterior wall is closed while the posterior remains open, a communication existing between the bladder and the pelvic cavity or the vagina.

Very frequently we find remains of the urachus in the round or median ligament of the bladder. They take the form of a narrow patent channel or of small detached cysts, which may be either closed or open toward the bladder. In the latter case they sometimes become distended with urine when the bladder is overfilled. If any impediment to the normal outflow of urine take place in infancy, the urachus may never close at all; and occasionally it has been known to serve as a means of emptying the bladder.

Division of the bladder into two separate or partly separate portions (*vesica bipartita or bilocularis*) is very rare: the two cavities may lie side by side or one above the other.

Congenital diverticula of the bladder are very rare.

Atresia of the vesical orifice of the urethra or of a ureter is also rare: in the former case, as we have said, the urachus remains patent.

Absence of the bladder unaccompanied by any other grave malformation is seldom observed; but it is more frequently found to be

abnormally small. When the bladder is absent the ureters open into the urethra.

Absence of the urethra occurs in both sexes: in females the bladder may open directly into the vagina.

Atresia of the urethra also occurs in both sexes, and is due either to defect of some part of the canal or to obliteration of its orifice.

The canal may be abnormally narrow either throughout or at some particular part (congenital stricture). The contraction is in some cases due to hypertrophy of the colliculus seminalis.

When the urethra opens on the upper aspect of the penis the condition is called **epispadias**, when it opens on the under aspect **hypospadias**. The latter is the more common: the orifice may be either in the penile portion, or in the anterior and even in the posterior attachment of the scrotum (*hypospadias perineoscrotalis*). The penis is usually small and stunted.

Occasionally we meet with cases in which the urethra has more than one external orifice: and in males the glans penis is sometimes pierced with what appears to be a second meatus, but is in reality a short passage ending cæcally.

CHAPTER LXV.

CLASSIFICATION OF RENAL DISORDERS.

520. **Structure of the kidney.** The kidney is a compound tubular gland by which water, certain salts, and nitrogenous waste-products are separated from the blood and excreted. Abnormal substances which have gained access to the blood are likewise in great measure removed from the body by this channel. The peculiar structure of the kidney corresponds with its function of separating these substances from the blood which circulates through it.

On section the kidney is seen to consist of two well-marked zones, the cortex without, the medulla within. The **cortex** forms a stratum from 8 to 10 mm. in thickness, enclosing the **medulla** which has the form of a number of rounded cones projecting inwardly, the free apices being known as **papillæ**.

These medullary cones or malpighian pyramids are made up chiefly of tubules and blood-vessels, whose general course is from the base to the apex. The number of tubules increases as we approach the base of a pyramid, partly because they subdivide, partly from the presence of tubules passing for a short distance into the pyramid from the cortex and then doubling back towards the cortex again. The latter tubules are slender and narrow, especially in the recurrent part; they are described as **Henle's loops**. The branching tubules are considerably wider and are known as the **collecting tubes**. The blood-vessels and the tubules are bound together by a small quantity of connective tissue containing lymphatic vessels.

The cortex is in the main made up of two distinct structural elements. The simpler structures are the so-called **medullary rays**. These are slightly conical portions passing up from the medulla and ceasing to be distinguishable only at the outer border of the cortex (Fig. 201 *B*): they are simply prolongations of the medullary substance and consist of like bundles of straight tubules (*k*). The vessels (*e*) of these rays are arranged in much the same manner as those of the medulla.

The fissure lying between the medullary rays is the true cortical substance or **labyrinth** (*A*), and consists essentially of a mass of tubules (*i*) of various sizes, together with blood-vessels whose peculiar course and configuration (*a b c d e f g h*) give the kidney its characteristic micro-

scopic appearance. The tubules and vessels are bound together by a scanty connective tissue.

The blood which reaches the kidney enters it by the branches of the renal artery at the boundary zone between the cortex and the medulla. The greater part of it passes thence through the interlobular arteries (*a*) which run in a zigzag course through the labyrinth towards the outer



FIG. 201. SECTION THROUGH THE OUTER HALF OF THE CORTEX OF A KIDNEY AFFECTED BY RECENT INTERSTITIAL NEPHRITIS.

(Arteries injected with gelatine and Prussian blue; section stained with alum-carmin and mounted in Canada balsam; $\times 32$)

A, labyrinth

B, medullary ray

C, capsule

a, interlobular artery

b, vas afferens

c, glomerulus

d, vas efferens

e, capillaries of the medullary ray

f, capillaries of the labyrinth

g, stellate veins

h, interlobular vein

i, convoluted tubules

k, straight tubules with Henle's loops and collecting tubes.

l, degenerated convoluted tubules

m, cellular infiltration round the interlobular veins

surface of the organ, and then by the vasa afferentia (*b*) to the glomeruli (*c*). Only a small part of the blood passes at once into the medullary

substance, and even this usually traverses a glomerulus. There are, however, certain very minute arterial twigs which pass directly into the medulla.

Within the **glomerulus** (*c*) the **vas afferens** breaks up into a multitude of anastomosing capillary loops, which presently reunite into a single vessel (*d*), the **vas efferens**. This leaves the glomerulus side by side with the afferent vessel, passes into the medullary ray, and there once more breaks up into a system of capillaries (*e*). This system (sometimes called the 'portal' system of the kidney) is continuous with the capillary system of the labyrinth (*f*), and this again delivers its blood into venules, which beginning beneath the capsule as **stellate veins** (*g*) pass through the labyrinth as **interlobular veins** (*h*) to the inner border of the cortex.

The course of a urinary tubule commences at the hollow sphere or **capsule** of Bowman which surrounds the glomerulus. At the pole opposite that through which the vessels enter, the cavity of the capsule opens by a somewhat narrow orifice into the lumen of the urinary tubule, which passes through the labyrinth as a comparatively wide **convoluted tubule** lined with a thick epithelial layer. The tubule then passes into the nearest medullary ray and descends with it in a straight course for a certain distance, then bending suddenly it turns back towards the cortex again. The descending limb of the **Henle's loop** thus formed is very slender and narrow, but the ascending limb widens out again, and at length enters a second wide convoluted tube (the **intercalary tube**) which lies in the cortical layer. The intercalary tube passes into a short and narrow **junctional tube**, and this uniting with others gives rise to the **collecting tubes**. These again unite together into the wider **excretory tubes**, which passing down through the medulla open at the papillæ into the **pelvis** or infundibulum of the kidney.

The glomeruli furnish chiefly the water of the urine. The convoluted tubules of the cortex secrete the solid constituents, namely the inorganic salts, urea, uric acid, hippuric acid, kreatinine, xanthine, sarkine, ammonia, coloring-matters, indican, oxalic acid, etc. Some of these substances (such as urea) are contained in the blood, others are elaborated in the kidney. It would appear that the epithelium of the tubules separates these substances from the blood and in an altered or unaltered form gives them up to the water flowing through the tubules from the glomeruli. A certain amount of osmotic diffusion also takes place between the secreted urine and the blood. Noxious substances in the blood, whether generated within the body or derived from without, are in great measure eliminated by the kidneys. In this way the kidneys act as purifying organs.

If a solution containing about 0.4 per cent of sodium sulphindigotate is injected into the external jugular vein of a dog, and the animal is killed a few minutes after, it is found that the coloring-matter is already in process of excre-

tion from the kidneys. According to HEIDENHAIN (*Pflüger's Arch.* vol. 9) and PAUTYNSKI (*Virch. Arch.* vol. 79) the excretion first begins in the convoluted tubules, the intercalary tubes, and the ascending limb of Henle's loops. The blue pigment appears in the form of granules in the striated epithelial cells, and stains both the free border and the nucleus. When excretion is in full activity small crystals appear in the cells. When the injection is made some time before death, and is followed by a second large injection of indigo-carmin, the vascular loops and epithelial cells of some of the glomeruli become stained. It thus appears that indigo-carmin may be excreted by the glomeruli.

When a solution of egg-albumen is injected (RUNEBERG, RIBBERT, and others), this substance is excreted by the glomeruli, and the same is true of hæmoglobin and sugar. These examples show that matters may pass into the urine both from the glomerular loops and from the intertubular capillaries, traversing in the process the epithelial lining of the glomeruli or of the urinary tubules (compare ADAMI, *Journ. of Physiol.* VI. 1885).

521. Classification according to causation. The morbid changes affecting the kidney may be appropriately grouped in five classes, according to their mode of origin.

First, we have those affections which are attributable simply to disturbances of the circulation.

Secondly, a group of changes produced by the deposit in the kidney of solid substances, brought to it as such by the blood or precipitated from their solutions.

A third group includes those degenerations and inflammations of the kidney which are due to impurities or disorders of the blood. As the kidney is one of the chief organs by which abnormal substances are eliminated from the blood, it is much exposed to disturbance of its own functions and even to lesions of its structure from this cause: and as a fact a very large number of renal disorders are thus produced.

A fourth group of disorders are traceable to injurious influences affecting the parenchyma of the kidney through the infundibulum. Thus mere obstruction of the outflow of the urine from the bladder may give rise to grave disorder of the kidney. The danger is of course greater when matters that are actively noxious reach the kidney by this route.

The fifth group comprises the tumors or new growths of the kidney.

COHNHEIM and ROY (*Virch. Arch.* vol. 92, *Proc. Camb. Phil. Soc.* IV. 1881) have investigated the mechanism of the renal circulation. They find that when a sensory or a splanchnic nerve is stimulated, in asphyxia, and in strychnine-poisoning, the volume of the kidney rapidly diminishes. When the renal artery on one side is tied, no effect is produced on the circulation of the other. When therefore in cases of loss of one kidney the other takes on the work of both, it is not due to a reflex action but to the effect produced on the circulation of the working kidney by the presence of urinary substances in the blood.

According to the experiments of RIBBERT (*Virch. Arch.* vol. 93) the quantity of urine excreted by a rabbit increases after the removal of the medullary cones. The view that water is re-absorbed from the urine as it passes through the medulla thus receives experimental corroboration.

CHAPTER LXVI.

DISORDERS OF THE RENAL CIRCULATION.

522. **Active hyperæmia** or congestion of the kidneys is due either to increased pressure within the aorta, or to dilatation of the renal arteries.

As the secretion of urine is in the main determined by the pressure and velocity of the blood flowing through the glomeruli, congestion of the kidneys is accompanied by an increase of secretion.

When one kidney is removed or rendered inactive by disease, the other carries on the urinary function unaided. This is of course possible only so long as its blood-supply is permanently increased. A kidney the demands on which are thus permanently increased presently becomes hypertrophied.

This **compensatory hypertrophy** is usually most extreme in cases where the other kidney has failed in early youth; in such cases the normal bulk may be increased as much as twofold. The increase is due chiefly to an increase in the length and calibre of the tubules and to enlargement of the glomeruli, in part also to a multiplication of both these elements. It is said however that multiplication is observed only in cases where one kidney has been lost before birth or in infancy.

Partial atrophy or destruction of a kidney may be followed by hyperæmia and consequent hypertrophy of the sound portion remaining.

The epithelial cells of the dilated and elongated tubules are larger and more numerous than is normal.

References on compensatory hypertrophy of the kidneys:—LEICHTENSTERN, *Berl. klin. Woch.* 24, 1881; GUDDEN, *Virch. Arch.* vol. 66; BEUMER, *ibid.* vol. 72; PERLS, *ibid.* vol. 56; RIBBERT, *ibid.* vol. 88; GRAWITZ and ISRAEL, *ibid.* vol. 77; EPPINGER, *Prag. med. Woch.* 36, 1879; BOSTRÖM, *Beiträge z. path. Anat. d. Niere* Freiburg 1884.

According to LEICHTENSTERN the diameter of a normal glomerulus measures 135-225 micromm., that of a convoluted tube 49-79 micromm., and that of a straight tubule 26-49 micromm. In hypertrophied kidneys the first measurement rises to 188-402, the second to 49-141, the third to 49-89 micromm.

The weight of the two kidneys (THOMA, *Untersuch. über die Bestandtheile des Körpers* Leipzig 1882) is in new-born infants about 23 grammes, at six months 44 gm., at twelve months 62 gm., at twenty years 285 gm., at twenty-five 304 gm. In the case of a healthy adult the two kidneys may differ in weight by as much as 30 to 40 gm.

523. **Passive hyperæmia** or engorgement of the kidney is usually the result of some general disturbance of the circulation; it is much less often due to local causes. Affections of the heart and lungs give rise to the former, compression and thrombosis of the vena cava or of the renal veins to the latter. Renal thrombosis most frequently occurs in infants of a few weeks old who die of general marasmus. Compression may be due to the gravid uterus or to an abdominal tumor.

If the outflow of blood from the kidneys is suddenly stopped, they become engorged and greatly swollen, assuming a dark brown or purple hue. Very soon hæmorrhages make their appearance, not only in the cortex and beneath the capsule but also in the medulla, Bowman's capsules and the urinary tubules becoming distended with blood.

If the obstruction of the renal veins is gradual, the blood in part finds its way into certain small vessels which pass from the kidney into the capsule and empty themselves into vessels communicating with the phrenic, lumbar, and suprarenal veins. In this way there may be little or no hæmorrhage within the kidney but only œdema, very few red blood-cells escaping from the vessels.

If however the obstruction is great and persistent the renal tissues become fatty and necrotic, and presently disintegrate entirely.

When the engorgement is less extreme, as in cases of uncompensated cardiac lesion, the swelling of the kidney is but slight, but its color becomes dark purple or cyanotic. If this condition persists for any length of time the kidney becomes remarkably dense and firm; at the same time the cortex becomes pale or grayish-red with darker streaks corresponding to the course of the veins. This change is referred to as **cyanotic induration**.

When the engorgement is still recent the vessels are uniformly distended with blood, the veins and capillaries being often greatly dilated. Within the capsule of many of the malpighian bodies and in the lumen of the urinary tubules appears a quantity of liquid, which on boiling yields a granular precipitate of albumen and often contains a few red blood-cells. In some of the tubes lie colorless transparent casts of the lumina, the so-called **hyaline tube-casts** or cylinders. These are simply masses of albumen which have escaped in liquid form with the watery transudation from the glomeruli, and have become solid within the tubules. Some of the epithelial cells, chiefly those of Henle's loops, contain brown and yellow and occasionally crystalline pigment-granules, derived from the coloring-matter of the blood-cells which have escaped into the tubules and there become dissolved. If the escape of red blood-cells from the glomerular vessels has been recent and unusually abundant the capsules of the malpighian bodies and the tubules connected with them may appear crammed with such pigmentary products of disintegration.

In cases of long-standing engorgement where the kidney is indurated,

the intertubular connective tissue is increased in amount, the blood-vessels are wide and flaccid, and the walls of the capillaries and the adventitia of the veins are thickened.

Many of the epithelial cells of the tubules are fatty and contain oil-globules of various sizes. The cells of the straight tubules of the medulla are especially liable to fatty change. The glomeruli appear for the most part unaltered; though here and there a malpighian body is seen whose contents have become homogeneous and shrunken, while the corresponding tubule is narrow, collapsed, or altogether atrophied (see Art. 525).

In engorgement of the kidney the urine is diminished in quantity. The albumen and red blood-cells it contains are derived, according to COHNHEIM and SENATOR, from the capillaries which surround the tubules, the exudation being simply the lymph of engorgement (Art. 24). At a later stage the glomeruli yield a similar albuminous exudation. COHNHEIM regards this as due in some measure to the altered relations of pressure, but in a greater degree to morbid changes in the excretory membrane, namely in the glomerular epithelium. RONEBERG on the other hand refers the albuminuria of engorgement to a diminished difference of pressure between the contents of the glomerular vessels and those of the capsule of Bowman. This explanation is quite untenable in view of the experiments of BAMBERGER, NEWMAN and others.

References:—ROBINSON, *Med. chir. Trans.* xxv. (1843); JOHNSON, *Diseases of the kidney* London 1852; LITTEN and BUCHWALD, *Virch. Arch.* vol. 66; COHNHEIM, *Allg. Pathologie* II.; PERLS, *Arch. f. exp. Path.* VI.; HORTOLÈS, *Étude du processus histologique des néphrites* Paris 1881; LITTEN, *Untersuch. über d. hæmorrh. Infarct* Berlin 1877; TRAUBE, *Ges. Abhand.* I., II. (1871) and III. (1878); WEISSGERBER and PERLS, *Arch. f. exp. Path.* VI.; SENATOR, *Die Albuminurie* Berlin 1822, trans. by SMITH (New Syd. Soc.) London 1884; POSNER, *Virch. Arch.* vol. 79; HEIDENHAIN, *Hermann's Handb. d. Physiologie* v.; GERMONT, *Thèse de Paris* 1883; RONEBERG, *Deutsch. Arch. f. klin. Med.* XXIII.; BAMBERGER, *Wien. med. Woch.* 1881; NEWMAN, *Journ. of Anat.* XII.; CORNIL and BRAULT, *Path. du rein* Paris 1884; ROBERTS, *Urinary and renal diseases* London 1885; VON NOORDEN, *D. Arch. f. klin. Med.* XXXVIII. (1886).

524. In general **anæmia**, and in contraction of the renal arteries by thickening or spasm of their walls, the blood-supply of the kidney is diminished, and it becomes anæmic. When the anæmia is considerable the organ becomes pale or grayish, and to some extent translucent. When the blood which reaches it is for any reason irregularly distributed the pale tint may appear mottled with redder patches.

The first result of renal anæmia is diminution of the urine; when the supply of arterial blood becomes very greatly diminished albuminuria appears. This occurs whether the anæmia be due to general causes (as in cholera), or to local arterial spasm (as in epilepsy, tetanus, asphyxia, pyrexia, or lead-poisoning). COHNHEIM regards it as due to ischæmic degeneration of the glomerular epithelium.

Transient anæmia gives rise to no demonstrable change in the renal structures, but in more chronic conditions degeneration and atrophy of

the tubules and glomeruli make their appearance. The deficient supply of blood and consequently of oxygen also leads to fatty change in the renal epithelium, which if it is at all extensive gives the section of the kidney a spotty or mottled appearance. If the blood-supply is entirely cut off general necrosis of the tissues ensues (Art. 527).

Slight but long-enduring interference with the blood-supply causes the essential elements of the kidney to dwindle and shrink, so that the bulk of the organ as a whole is gradually diminished.

525. Renal anæmia, in addition to the epithelial changes it induces, is very often accompanied by **atrophy** and **obliteration** of certain parts of the vascular system of the organ. These are most marked when they affect the glomerular capillaries.

A normal glomerulus (Fig. 202 *b*) appears as a tuft of capillary ves-



FIG. 202. SENILE ATROPHY OF THE KIDNEY.

(Section hardened in alcohol, stained with alum-carmin, and mounted in Canada balsam: $\times 200$.)

- a*, normal tubule
b, normal glomerulus
c, vascular stroma

- d*, atrophied and functionless glomerulus
e, arteriole with somewhat thickened intima
f, atrophied and collapsed tubules

sels each covered with an investment of nucleated cells; those of an atrophied or functionless glomerulus on the other hand form a compact more or less homogeneous spherule with few nuclei or none (Fig. 202 *d*, Fig. 203 *b*). This spherule may show traces of lobulation, but the several capillary loops are no longer distinguishable. So far as we know, the steps of the change are collapse, thrombosis, and hyaline thickening of the capillary-walls; these latter then become fused into a homogeneous mass, the glomerular epithelium meanwhile disappearing. The capsular epithelium persists somewhat longer, but ultimately perishes in like manner, and the collapsed or shrunken capsule comes thus to

surround directly the altered glomerulus, without any intervening layer of epithelium (Fig. 203 *b*). The capsule itself is not usually altered: sometimes however a slight thickening takes place, and the wall then looks homogeneous or occasionally fibrillar in structure.

A glomerulus thus reduced to a homogeneous spherule is of course no longer permeable, and the vas afferens is either obliterated or delivers its blood directly to the vas efferens. The corresponding urinary tubule is also rendered functionless, and quickly becomes atrophied. The epithelial cells dwindle, lose their characteristic shape and striation, and are transformed into small cubical cells. They may remain as a regular lining or lie without order in the collapsed lumen of the tubule (Fig. 202 *f*, Fig. 203 *d*).

In some of the tubules the cells become entirely disintegrated (Fig. 203 *e*), or while diminished in size they become fatty, and sprinkled with oil-globules.

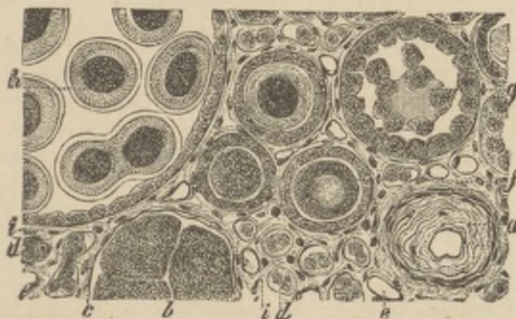


FIG. 203. CONTRACTED KIDNEY WITH ARTERIAL SCLEROSIS.

(Stained with alum-carmine, mounted in Canada balsam: $\times 150$.)

- | | |
|---|--|
| a, artery with thickened and fibrous intima | f, tubules with stratified and unstratified colloid casts and spherules |
| b, obliterated glomerulus denuded of epithelium | g, dilated tubule containing a homogeneous mass beset with shed epithelium |
| c, capsule collapsed but not thickened | h, cyst containing stratified colloid spherules |
| d, tubule collapsed and filled with small cells | i, stroma of cells and delicate fibres |
| e, tubule empty and collapsed | |

In atrophic conditions the altered epithelial cells usually stain very deeply with the ordinary nucleus-staining reagents.

In the lumina of the functionless tubules, straight and convoluted, we frequently find homogeneous **colloid cylinders** and spherules (Fig. 203 *f h*). Some of these are stratified, others unstratified, and they may be so numerous as to distend the tubule into a small cyst (*h*). So far as can be made out with the microscope these homogeneous masses are a colloid product of the renal epithelium, which is produced either in the form of droplets that afterwards unite, or by a transformation of the entire cell when loosened from its place and carried to another part of the tubule (*g*). The dissolved albumen which flows through the

tubule as the degeneration of the glomerulus sets in may have something to do with its formation. When the lumen of a tubule becomes distended with these colloid masses the epithelium becomes flattened and compressed.

Larger colloid masses or agglomerations are visible to the naked eye as translucent yellowish or brownish jelly-like granules, from the size of a pin's head to that of a pea. In rare cases like masses are formed within the Bowman's capsule of the malpighian bodies.

The fibrous tissue of the atrophied region is not increased, but not infrequently there appears to be an accumulation of lymphoid cells in its meshes. It is questionable whether this is an inflammatory process; the impression conveyed is rather that the spaces left free by the collapse of the secreting structures have been partially filled up by indifferent cells.

COHNHEIM and MENDELSON (*Amer. Journ. med. sciences* Oct. 1883) have shown that in pyrexia the kidney becomes markedly anæmic from contraction of the renal vessels.

OVERBECK (*Wiener Sitzungsber.* XLVII.) and HERMANN (*ibid.* XXXVI., XLV.) have demonstrated that albuminuria results either from a short interruption or a considerable diminution of the circulation through the kidney. The albuminuria persists for some time after the circulation again becomes normal, and COHNHEIM thence argues that the cause is to be sought for in an alteration of the glomerular epithelium.

The vascular loops of the glomeruli are covered with a continuous layer of epithelial cells, which must be regarded as glandular in character, and make the glomerulus in effect a secreting gland. The secretion remains normal only so long as these cells are intact.

The great majority of the nuclei seen in the section of a glomerulus belong to these epithelial cells. The actual capillary-walls are either devoid of nuclei or possess very few indeed.

526. The simple atrophy of the glomeruli and tubules described in the last Article is met with in an uncomplicated form as a senile phenomenon: it is seldom absent in the **kidney of old age**. When the atrophied portions lie near the surface of the kidney they appear as small scar-like depressions, the surrounding parts of the parenchyma being somewhat redder than usual.

Simple atrophy of the secreting structures is also extremely common as an accompaniment of the most various renal affections. It occurs for example in embolic occlusion of the renal arteries, in the various forms of nephritis, and in hydronephrosis. We see it however in its purest form and greatest extension in the affection which is best described by the term **arteriosclerotic atrophy**.

The renal arteries and their branches in aged persons are very frequently the seat of sclerotic change (Art. 297), which may simultaneously affect the arteries of other regions also, or be confined to those of the kidney. The intima of the vessels thus becomes notably thickened (Fig.

203 a, Fig. 204 e f) and the lumen narrowed or obliterated: the result is that a certain number of glomeruli become more or less functionless, the number depending on the size of the affected arterial stem. Obstruction of a vas afferens will affect only a single glomerulus; constriction of an interlobular artery may cause the atrophy of an entire series.

The morbid changes appear in patches scattered over the kidney according to the distribution of the affected arteries; but occasionally they are so extensive as to affect almost uniformly the whole of the cortical zone.

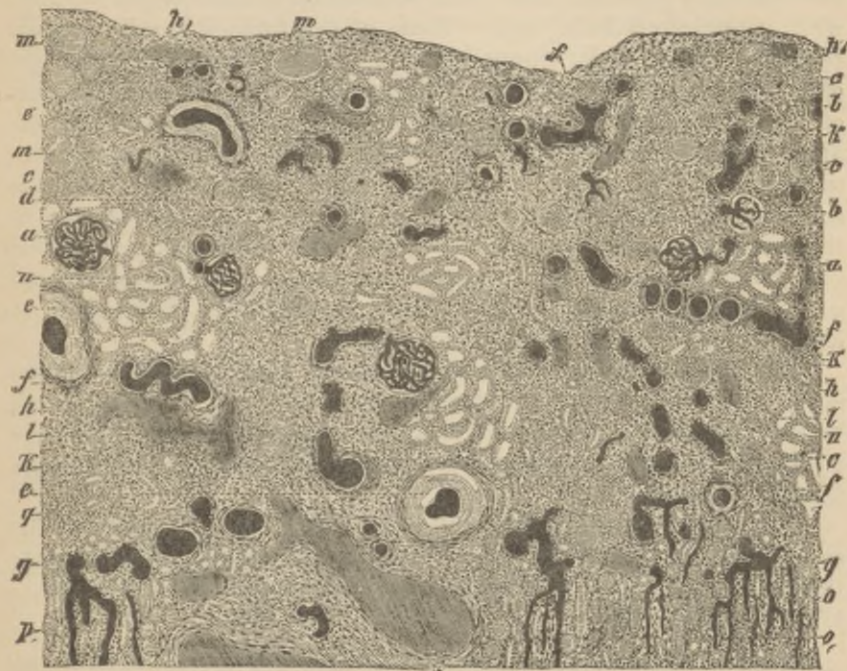


FIG 204. CORTEX OF AN ARTERIOSCLEROTIC CONTRACTED KIDNEY.

(Arteries and glomeruli injected with Prussian blue; the section stained with alum-carmine: $\times 50$)

- | | |
|--|--|
| a, normal glomeruli | h h ₁ , interlobular and subcapsular veins |
| b c, partially and totally atrophied glomeruli without thickening of the capsule | i, large venous trunk |
| d, atrophied glomerulus with thickened capsule | k, atrophied parenchyma with a few shrunken tubules l |
| e, artery with greatly thickened intima | m, cystic dilatation of a tubule with hyaline contents |
| f, interlobular arteries much convoluted and running parallel to the surface of the kidney | n, normal tubules |
| g, dilated arteries passing down to the medullary zone | o, tubules in the medullary ray with hyaline casts |
| | p, patent tubules in the medullary ray |
| | q, cellular infiltration |

In slight cases the section shows only a few scattered cicatricial contractions of various sizes, which are usually somewhat redder than the parts around; these latter are pale grayish-red or reddish-brown in tint.

The greater the number of atrophic patches the more numerous are these cicatricial contractions, so that at length the kidney looks granular and roughened on its surface while its bulk is notably diminished. The condition may then be aptly referred to as **arteriosclerotic contraction**.

This form of contraction sometimes reaches an extreme degree, the whole kidney being remarkably small and shrunken, and the cortex reduced to a thickness of one or two millimetres. In such cases the greater number of the glomeruli are atrophied (Fig. 204 *b c d*), and the corresponding tubules (*l*) are collapsed, shrunken, and empty or filled with atrophied epithelial cells. Some of the tubules usually contain hyaline colloid masses, especially in the loops of Henle (*o*), which are often entirely filled with them. The convoluted tubules of the cortex on the contrary seldom contain casts, though here and there they appear dilated into little cysts (*m*) filled with colloid substance. Cases also occur in which the entire parenchyma is beset with small cysts from the size of a millet-seed to that of a pea. The shrinking and warping of the cortex causes the interlobular arteries (*f*) to be distorted and twisted into irregular spirals, while here and there some of them are so displaced as to run nearly parallel to the surface. Most of them show a more or less marked thickening of the intima (*ef*).

When the vascular system of the cortex is thus damaged or obliterated by the obstruction of the glomerular and interlobular capillaries the vessels running towards the medullary zone (the arteriæ rectæ (*g*)) become widely dilated, and the greater part of the blood-stream passes directly through the medulla.

In the arteriosclerotic kidney there is little or no hyperplasia of the connective tissue, and the capsule of Bowman is seldom perceptibly thickened. Here and there however the connective tissue shows patches of cellular infiltration (*g*).

GULL and SUTTON (*Med. chir. Trans.* LV. 1872) were the first to call special attention to the arterial changes associated with contracted kidney; they described the condition as 'arterio-capillary fibrosis.' Their statements were however somewhat lacking in precision, and they did not sufficiently distinguish between primary arteriosclerosis and the secondary form associated with interstitial nephritis. Dr. GEORGE JOHNSON (*Lectures on Bright's disease* London 1873) drew attention to the hypertrophy of the muscular coats of the arterioles in certain chronic kidney diseases; he interpreted the vascular change as secondary. In Germany THOMA and EWALD (*Virch. Arch.* vol. 71) minutely investigated the vascular changes in contracted kidney, but they too failed to keep distinct the various forms of the affection. ZIEGLER (*Deutsch. Arch. f. klin. Med.* XXV.) first discussed in detail the great importance of primary changes in the vessels in determining the contraction of the kidney, and showed that primary sclerosis gives rise to a special form of contraction, for which he accordingly suggested the term arteriosclerotic atrophy. LEYDEN has recently (*Zeitschr. f. klin. Med.* II., and ROSENSTEIN (*Trans. internat. med. Congress* II. London 1882) examined the subject very fully, and proposes to call the affection renal sclerosis. ZIEGLER ob-

jects to this term on the ground that sclerosis of an organ implies induration, and the absence of induration in the arteriosclerotic kidney is what essentially distinguishes it from the cirrhotic contracted kidney. See also HOLSTI (*D. Arch. f. klin. Med.* XXXVIII. 1885), and GULL (*Amer. Journ. med. sci.* 1886).

The vascular change as we have seen begins usually in the arterioles. There is however evidence that the glomeruli may be the seat of primary sclerosis, the capillaries becoming obstructed by a hyaline thickening of their walls. It is worthy of note that arteriosclerotic contraction is very common among workers in lead, especially in the young; the sclerotic change is most marked in the smallest vessels and in the glomeruli. It would thus appear that lead has a selective degenerative action on these parts of the vascular system. The affection is usually accompanied by symptoms of gout. See OLLIVIER (*Archives générales de méd.* 1863), DANJOY (*ibid.* 1864), TRAUBE (*Allg. med. Centralzeitung* 1861), DICKINSON (*Diseases of the kidney* II. London 1877), HOFFA (*Ueb. Nephritis saturnina* Freiburg 1883), CHARCOT and GOMBAULT (*Arch. de Physiologie* 1881), WAGNER (*Ziemssen's Handb. d. spec. Path.* 3d edition IX.), GARROD (*Gout and Rheumatic gout* 3d edition London 1876).

Arteriosclerotic contraction is very gradual in its progress. Albuminuria is slight or absent altogether. Cardiac hypertrophy may ensue as in other atrophic affections of the kidney. For cases see LEMCKE (*Deut. Arch. f. klin. Med.* XXXV. with references), SCHUCHARDT (*Berl. klin. Woch.* 41, 1882).

527. The renal vessels having no arterial anastomoses, when a renal arteriole is blocked by an embolus **embolic infarction** ensues. Immediately after the stoppage of the circulation through the region supplied by the embolised vessel there is no apparent change in the renal tissue. In a few hours however the starved tissue dies, and gradually assumes a turbid grayish or yellowish tint. Presently there is more or less extensive hyperæmia and hæmorrhage and the pallor of the dead tissue disappears at least in part. LITTEN'S investigations show that the hæmorrhage takes place chiefly from the capillaries, and is in fact an extravasation from engorgement (Art. 30). The blood in the capillaries of the embolised region being derived solely from the neighboring capillaries the pressure is insufficient to drive it through them into the larger veins; stasis ensues, and soon the capillaries and venules are distended with blood, which at length escapes into the surrounding tissue. The extravasation takes place mainly from the intertubular capillaries, but blood-cells and plasma may escape from the glomeruli likewise and accumulate within the capsules and tubules. COHNHEIM and GULLEBEAU have sought to make out that a certain amount of reflux takes place from the veins of the embolised region.

The hæmorrhage may be slight and limited to the marginal zone of the region, or it may be great and extend over the whole of it. In the latter case the entire patch becomes uniformly dark-red or mottled with red and gray. Very soon however this appearance changes, the centre of the patch becoming rapidly pale again by the diffusion and absorption of the coloring-matter of the blood. The infarct then closely resembles a simply anæmic patch.

In a few days after the embolism the infarct appears as a more or less regularly-shaped wedge or cone of a dull yellowish or grayish tint, surrounded by a zone of hæmorrhagic infiltration. Sometimes a narrow white zone intervenes between the latter and the pale centre. This white zone contains vessels filled with plasma and a great multitude of white blood-cells. The base of the cone is always directed outwards, and its apex is rounded off.

The size of the infarct depends on the size of the obstructed artery. The smallest may be no larger than a millet-seed; more commonly they are larger, measuring from 4 to 10 mm. at the base, and extending to the middle of the cortex or even to the boundary zone; now and then they are so large as to include a third or more of the whole kidney.

The renal epithelium perishes some two hours after the circulation ceases (LITTEN); it becomes homogeneous, or turbid and granular, and ceases to take up staining-reagents. The nuclei become pale and indistinct, and ultimately dissolve or break up into fragments. At first the dead cells retain their normal place and arrangement, but presently some of them break away from their attachment to the membrana propria of the tubule and are transformed into structureless flakes and blocks, or they crumble into amorphous granules. Sometimes a part of the necrosed and detached epithelium becomes calcified. Meanwhile the intertubular connective tissue swells, being pervaded with liquid and blood-cells or granular detritus. The former are met with chiefly in the red marginal zone, the latter in the pale centre. The nuclei of the connective tissue are pale and some of them lose their outline, while the membrana propria of the tubules is more or less swollen up.

The glomeruli remain for a considerable time unaltered, but by and by they too lose their nuclei and are transformed into colorless spherules in which the constituent parts are no longer distinguishable. When blood has escaped from the glomerular capillaries into the capsule and its tubule, the blood-cells may disintegrate into granular masses which form brownish casts of the lumen. But these are never numerous, and are often absent.

528. The changes just described take place of course only in the region where the tissue perishes, that is to say in the central parts and in a portion of the marginal zone of the infarct. This region gradually becomes disintegrated and liquefied, its structural elements losing their distinctness more or less completely. Even the fibrous structures and the glomeruli may in extreme cases break down and ultimately dissolve like the rest.

Notwithstanding this a focus of true colliquative softening is seldom produced, inasmuch as the products of disintegration and liquefaction are absorbed as fast as they appear. The epithelial cells are the only elements which disappear entirely over any considerable area, the fibrous tissue and glomeruli in great part remain undissolved, though of course

they are greatly altered. In the smaller infarcts no part of the fibrous structure entirely disappears.

The necrosis and disintegration of part of the tissue is accompanied by degenerative changes, chiefly fatty, of other parts. They are later in appearing, and affect the elements which do not at once undergo necrosis. The renal epithelium, the glomeruli and their capsules, and the fibrous stroma appear beset with oil-globules, though the fatty change never becomes extensive or extreme. Fatty degeneration may affect those glomeruli whose vessels remain intact as well as those where obstruction or obliteration has taken place. Collapsed and functionless tubules occasionally become distended with oil-globules, which may also make their appearance in the lumen of tubules that remain healthy.

Some portions of the embolised region may promptly receive a supply of blood from the neighboring capillaries or from the vessels of the capsule which penetrate the tissue of the organ (LITTEN, PAUTYNSKI). In other parts the interrupted circulation may in a few days be partially restored by the opening up of collateral channels, or of the obstructed vessel itself through shrinking or absorption of the embolus. The restoration of the circulation can hardly ever (at least in the larger infarcts) be sufficient to repair fully the damage done to the renal tissue. Some of the tubules and glomeruli always perish outright, or become so atrophied that they no longer perform their functions.

Complete restoration of an embolised region is in fact possible only when the normal circulation is very speedily re-established. If a glomerulus be permanently obstructed its tubule can no longer be restored to its normal state. If the conditions are so favorable that its epithelium once partially degenerated is reproduced by multiplication of the remaining cells, the new elements remain small and functionless. The same is true of the epithelial elements which do not perish outright, if the circulation through the corresponding glomerulus is permanently interrupted.

The loss of tissue brought about by the embolism results in the formation of a contracted cicatrix, which looks gray or reddish according to the blood it contains, and in later stages may become slaty-gray or brown from pigmentation.

In large infarcts extending through the whole thickness of the cortex the centre of the cicatrix shows no trace of renal structure, but is occupied entirely by fibrous tissue partly representing the original stroma and partly of new formation. Whitish fibrous nodules with few nuclei represent the glomeruli, the capsule of Bowman being no longer recognizable. There are no tubules, the only trace of their existence being clefts or streaks devoid of epithelium scattered through the cicatrix. The larger arterioles are collapsed and impermeable, and ill-defined against the surrounding fibrous tissue.

Surrounding the obliterated region is an irrégular zone within which

the fibrous stroma is increased, the glomeruli reduced to homogeneous denucleated impermeable spherules, and the tubules collapsed.

The altered glomeruli are enclosed in a capsule which is either normal or consists of thickened fibrous tissue disposed in concentric strata: in recent infarcts the glomeruli may show a few scattered oil-globules. The tubules are either empty or contain small epithelial cells, usually lying without regular order in the lumen. Here and there towards the margin of the infarct tubules containing fatty epithelium are seen.

The intertubular fibrous tissue is always increased; in parts it is dense and coarsely fibrous, in others soft and beset with numerous round-cells. The latter are more numerous as the cicatrix is recent or imperfectly developed. Pigment is seldom present, though occasionally it appears in the form of granules and crystals.

The boundary between the cicatrix and the healthy tissue is seldom sharply defined, but the transition from normal to atrophied tissue is sufficiently clear. The neighboring healthy tubules sometimes contain hyaline casts.

The cicatrix is due to the absorption of the dead and degenerate tissue, which is only to a very slight extent regenerated, and to hyperplasia of the fibrous structures.

The number and magnitude of the embolic cicatrices determine the degree of distortion which the kidney as a whole undergoes by their contraction. When they are numerous and large the bulk of the organ may be considerably diminished, and a form of contracted kidney which we may appropriately call the **embolic contracted kidney** is produced. It is always characterized by the irregularity of the contraction.

Emboli containing infective matters give rise to metastatic abscesses (Art. 543).

References:—KIRKES, *Med. chir. Trans.* XXV. (1842); BECKMANN, *Virch. Arch.* vol. 20; CORNIL and RANVIER, *Man. d'hist. path.* Paris 1878; ARGATINZKI, *Beiträge z. norm. u. path. Anat. d. Niere* 1877; UTTHOFF, *Exp. Beiträge z. Nephritis* In. Diss. Berlin 1881; LITTEN, *Zeitschr. f. klin. Med.* I. (1879), *Unters. üb. d. hæm. Infarct* Berlin 1879; COHNHEIM, *Allg. Path.* I. Berlin 1883; WEIGERT, *Virch. Arch.* vols. 72, 79; GUILLEBEAU, *Ueber d. Hist. d. hæm. Infarcte* Berne 1880; GRAWITZ and ISRAEL, *Virch. Arch.* vol. 77; TALMA, *Zeitschr. f. klin. Med.* II. (1880); PAUTYNSKI, *Virch. Arch.* vol. 79; HAMILTON, *Liverpool Med. chir. Journ.* July 1883 (who questions the existence of a hæmorrhagic stage); MÖGLING, *Zur Entstehung d. hæmorrhagischen Infarcts* Jena 1884 (with an admirable summary of the literature).

LITTEN has shown experimentally that the renal epithelium dies if deprived of blood for two hours. If the deprivation is of shorter duration it becomes for a time incapable of performing its functions. When the anæmia is maintained for six to eight hours the connective-tissue elements likewise perish. In rabbits and dogs the epithelium when killed by temporary ligature of the renal artery is in part detached from the tubules and forms epithelial casts which ultimately become calcified.

The urine secreted by a kidney in this state of anæmic degeneration and

necrosis is found to contain albumen. LITTEN holds that the albumen is derived from the degenerate epithelium, inasmuch as the glomeruli are apparently unaltered. This theory cannot be confuted, but it does not seem necessary, seeing that the admitted degeneration of the glomerular epithelium suffices to explain the escape of albuminous liquid from the capillaries. See also VON WERRA, *Virch. Arch.* vol. 88.

CHAPTER LXVII.

RENAL DEPOSITS DERIVED FROM THE BLOOD.

529. Deposits in the renal tissue of **solid or corpuscular matters** coming from the blood are of three kinds.

In the first place they may consist of foreign substances circulating in the blood. Secondly, they may consist of constituents of the blood which have abnormally escaped from the blood-vessels, in consequence of morbid changes in the parenchyma of the kidney. Thirdly, substances normal or morbid, which in health remain dissolved, may under special conditions be precipitated in the solid form within the kidney. In many cases two or all three of these forms of deposits are met with simultaneously.

Substances abnormally escaping from the blood-vessels are deposited in the fibrous stroma or in the tubules, whence they may ultimately reach the collecting tubes and the pelvis of the kidney. From the pelvis they may be at once carried off to the bladder, or they may remain for a considerable time.

Many deposits give rise to an appreciable alteration of the renal structures. Others induce more or less extensive degenerations, or inflammations. In this respect the behavior of bacteria reaching the kidney from the blood is very various. Anthrax-bacilli may crowd the renal vessels without giving rise to degenerative or inflammatory change, while the micrococci of pyæmia at once set up intense inflammation and wide-spread necrosis (Art. 543).

According to LITTEN bacteria may so multiply and accumulate in the Bowman's capsules and in the tubules as to distend them and effectually block them up.

530. **Leukæmic infiltration** of the kidney is one of the results of leukæmia (Art. 260); it is characterized by an accumulation of white blood-cells in the renal tissue. When the infiltration is well marked the kidney becomes pale-gray in color and is somewhat swollen; or grayish nodules appear scattered through it.

See VIRCHOW (*Gesammelte Abhandl.* Frankfort 1856), FRIEDREICH (*Arch. f. path. Anat.* XII.), BÖTTCHER (*ibid.* XIV.), RINDFLEISCH (*Path. Hist.* II. London 1873), GREENFIELD (*Trans. Path. Soc.* XXIX. 1878).

Hæmorrhagic infiltration is usually due to extravasation of blood

from the glomeruli, or more rarely from the intertubular capillaries. As the blood escapes from the capsule of the malpighian body into its tubule (Art. 544, Fig. 213) the infiltration takes the form of reddened streaks and specks of the size of a millet-seed. Such extravasations are due partly to disturbances of the circulation, partly to alterations or degenerations of the glomeruli; but large hæmorrhages from the glomeruli are seldom due to mere disturbances of the circulation, except in the case of embolism. Blood which has escaped from a glomerulus, especially if it is considerable in quantity, usually becomes disintegrated within the tubules, forming granular yellowish or brownish casts of their lumina. After a time yellow or brown pigment granules also appear. As these lie chiefly within the epithelial cells (Art. 544, Fig. 213) we must apparently assume that the pigment is formed in the cells from the diffused coloring-matter of the blood. It is however possible that the cells may take up pigment-granules lying free within the tubules. This secondary condition is referred to as **pigmentary infiltration**.

Blood-cells, whether entire or disintegrated, which reach the pelvis of the kidney through the collecting tubes are in general speedily removed with the urine. It is only when a large intra-renal hæmorrhage has taken place, or when the mucous membrane of the pelvis itself is the source of the bleeding, that fibrinous coagula are produced, and then they take the form of tough dirty-white, yellow, or brown clots.

If as described in Art. 262 a solution of hæmoglobin in the blood-plasma has taken place, the dissolved hæmoglobin and methæmoglobin are excreted through the kidney (hæmoglobinuria). At the same time we find in the tubules deposits of lustrous reddish-yellow or brownish globules of hæmoglobin, yellow and brown pigment-granules, and less frequently red blood-crystals. This form is also described as pigmentary infiltration, but more fitly perhaps as **hæmoglobin infarction**.

The pigment-granules are partly deposited as such from the blood, partly precipitated from the dissolved coloring-matter in the process of excretion. In the deeper parts of the kidney these products of disintegration of the blood become aggregated into brownish granular tube-casts: the globules of hæmoglobin form homogeneous pale-yellow casts.

A third form of pigmentary deposit, **biliary infiltration**, is due to the precipitation of yellow or brown amorphous granules and flakes of bile-pigment. It is a result of icteric contamination of the blood. These granules lie for the most part within the epithelial cells, especially those of the convoluted tubules. Sometimes crystals of bilirubin are formed; this is most frequently observed in cases of *icterus neonatorum*.

These coloring-matters may give the kidney a dark-brown (from methæmoglobin) or a yellow or brownish-yellow tint (from bile-pigment). Deposits of amorphous and crystalline pigment appear to the eye as small reddish-brown to black, yellow, yellowish-brown, or yellowish-red

spots and streaks. In adults these are most numerous about the cortex, in infants chiefly in the medulla about the neighborhood of the papillæ.

A peculiar form of pigmentation, known as **argyrosis** or silver-staining, is due to the deposit of silver-particles in cases where preparations of the metal have been medicinally administered. The particles lie chiefly in the medullary zone, and give it a dark-gray tint.

Small hæmorrhages and pigmentary deposits cause no perceptible injury to the renal tissue. Larger hæmorrhages and extensive deposits of methæmoglobin and pigment may give rise to obstruction of the tubules and degeneration of the epithelium.

References:—PONFICK, *Berl. klin. Woch.* 17, 1876 and 46, 1877, *Virch. Arch.* vols. 62, 88; LESSER, *ibid.* vol. 79; MARCHAND, *ibid.* vol. 77; NEISSER, *Zeitschr. f. klin. Med.* I.; ADAMS, *Hæmoglobinausscheidung in den Nieren* In. Diss. Berlin 1880; BOSTRÖM, *Ueb. d. Intoxication durch d. essbare Morchel* Leipzig 1882, *Deut. Arch. f. klin. Med.* XXXII.; LEBEDEFF, *Virch. Arch.* vol. 91; LUCHSINGER, *Pflüger's Arch.* vol. 11; BÖHM, *Arch. f. exp. Path.* VI.; MASIUS, In. Diss. Breslau 1882; LICHTHEIM, *Sammlung klin. Vorträge* 134; JACOBI, *New York Med. Rec.* 11, 1879; DRESCHFELD, *Trans. internat. med. congress* I. London 1881; AFANASSIEW, and BOAS, *Arch. f. klin. Med.* VI. 1883, *Virch. Arch.* vol. 98.

After transfusion of blood from another animal (PANUM, PONFICK), after severe burns (PONFICK, LESSER, LICHTHEIM), poisoning with the morel mushroom (BOSTRÖM, PONFICK), and subcutaneous injection of glycerine (LUCHSINGER, hæmoglobinuria has been observed; and after poisoning with potassium chlorate methæmoglobinuria (MARCHAND, LEBEDEFF, JACOBI, DRESCHFELD). According to the recent researches of PONFICK (*Congress f. innere Medicin* Wiesbaden 1883) hæmoglobin is excreted not only by the glomeruli but also by the renal epithelium; see also ADAMI (*Journ. of Physiol.* VI. 1885).

The obscure affection known as intermittent or **paroxysmal hæmoglobinuria** appears to be associated with no recognizable anatomical alteration of the kidney other than hæmorrhagic and pigmentary infiltration and congestive hyperæmia. See the references in Art. 262; also MURRI, *Della emoglobinuria da freddo* Bologna 1880; COHNHEIM, *Allg. Path.* II. Berlin 1882; S. MACKENZIE, *Lancet* 1, 1884; DICKINSON, *Renal and urinary affections* III. London 1885; ROBERTS, *Urinary and renal diseases* London 1885.

531. **Uric acid**, whether produced in normal or abnormal quantity (as in gout), may be deposited in the kidney in the solid form or as solid urates when the water excreted is incapable of holding it all in solution. This is especially apt to take place (according to VOIT and HOFFMANN) when the urine becomes acid by fermentation, and acid sodium phosphate being present decomposes the alkaline urates of the urine to form basic phosphate.

The deposit consists partly of uric acid, partly of urates and especially sodium urate: it takes the form of amorphous granular masses or of acicular crystals. These lie in the tubules, chiefly the collecting tubules, and partly in the connective tissue.

The smallest deposits are not visible to the unaided eye. More

abundant precipitation gives rise to the powdery or coarsely granular deposits known as gravel or to renal calculi.

Uratc deposits are most frequently met with in new-born infants, especially such as die two to fourteen days after birth. In the first two days of life and in infants who have not breathed they are rarely found. Apparently the rapid metabolic changes which take place after birth are accompanied by the production of so much uric acid that the urine is incapable of holding it all in solution. These deposits in infants are sometimes described as **uratic infiltration**. They consist of ammonium and sodium urates; they lie in the medullary zone, and appear as pale yellowish-red streaks.

In adults the uratic deposits usually take the form of sand or **gravel**, and lie both in the cortex and the medulla, as well as in the calices and pelvis of the kidney: they vary greatly in amount in different cases. In the calices and pelvis they often become aggregated into concretions from the size of a pea to that of a hazel-nut, and are then known as **renal calculi**. Occasionally these take the form of large branching casts of the infundibulum and its ramifications, and then look something like masses of coral.

Uratc calculi are hard, yellow brown or red in color, and are smooth or slightly nodular on the surface. Small calculi have a crystalline fracture, but the larger ones are amorphous and often wood-like in texture. These deposits whether in the substance of the kidney or in its pelvis may give rise to disorders of secretion or to inflammation (Art. 555).

References on uratic deposits:—GARROD, *On gout and rheumatic gout* London 1876; HELLER, *Die Harnconcretionen* Vienna 1860; NEUBAUER and VOGEL, *Analyse d. Harns* Wiesbaden 1881; SALKOWSKI and LEUBE, *Die Lehre vom Harn* Berlin 1882; CHARCOT, *Leçons sur les maladies du foie et des reins* Paris 1877; COHNHEIM, *Allg. Path.* II. Berlin 1882; SENATOR, *Ziemssen's Cyclop.* XVI.; EBSTEIN, *ibid.* XV., and *Die Natur u. d. Behandlung d. Gicht* Wiesbaden 1882, trans. by SCOTT, London 1885; VIRCHOW, *Berl. klin. Woch.* 1884; DICKINSON, *Renal and urinary diseases* III. London 1885; RALFE, *Diseases of the kidneys* London 1885.

On uratic infiltration in infants:—VIRCHOW, *Gesammelte Abhandlungen* Frankfurt 1856; SCHLOSSBERGER, *Arch. f. physiolog. Heilk.* IX. (1850); B. SCHULTZE, *Deutsche Klinik* 1858; RAPHAEL, *Brit. Med. Journ.* 1, 1870; LIMAN, *Handb. d. gerichtl. Med.* II. (1882).

According to the researches of CARTER (*Urinary calculi* London 1873), ORD (*Influence of colloids* London 1879), EBSTEIN (*Congress f. innere Med.* Wiesbaden 1883) all uratic concretions contain a colloid or albuminoid matrix, in which the various salts are deposited and by which they are cemented together.

532. Concretions of calcium phosphate and carbonate deposited in the kidney constitute what is called **calcareous infiltration**. It occurs chiefly in aged persons, in whom resorption of the bony structures is active; but it may occur without such resorption. The deposits are in the form of white grains, spherules, and nodules, and lie for the most

part in the looped tubules of the medullary zone, though some may be observed in the cortical tubules in the fibrous stroma, and even in the glomeruli.

Calcium phosphate may form gravel and small calculi in the pelvis of the kidney; the calculi are smooth and faceted, and of various degrees of hardness.

Calculi of calcium carbonate are very rare; they are brown or yellow and hard. This salt however not infrequently forms a constituent of other kinds of calculi.

Oxalic acid, whether ingested with the food or formed from the decomposition of uric acid, may be deposited in the kidney or its pelvis as 'dumb-bells' or octahedral crystals of calcium oxalate. This occurs when the amount of acid sodium phosphate in the urine is insufficient to maintain in solution the quantum of oxalic acid present. Within the kidney the oxalate forms white deposits. In the pelvis it forms pale or dark brown warty or spiny calculi. Pure oxalate calculi are very rare. The salt more frequently occurs as a constituent of uratic calculi.

Triple-phosphate of ammonium and magnesium occurs as soft crumbly white concretions, seldom pure, but frequently forming a coating on uratic calculi. The deposit is produced chiefly in ammoniacal decomposition of the urine; ammonium carbonate is first formed, and this precipitates the earthy and ammonium phosphates. The crystals of the triple-phosphate have usually the so-called 'sarcophagus-form,' derived from a rectangular prism by cutting off the angles and edges.

In rare cases renal concretions and calculi are found which consist of **cystine**, an abnormal constituent of the urine containing sulphur and crystallizing in hexagonal plates. They have rounded corners, are soft and wax-colored, and show a radiate crystalline fracture.

Xanthine calculi are extremely rare; they are pale or dark brown, very hard, and not unlike uratic calculi.

In one case (ORD, *Trans. Path. Soc.* XXIX. 1878) a concretion consisting chiefly of **indigo** has been found in the kidney.

All the forms of renal concretion and calculus may give rise to inflammation, and occur on one side or on both. The condition of a kidney containing a calculus in its pelvis is frequently referred to as **nephrolithiasis** (Art. 553).

References:—BENEKE, *Die Oxalurie* Göttingen 1852; NEUBAUER and VOGEL, *loc. cit.*; SALKOWSKI and LEUBE, *loc. cit.*; A. FRÄNKEL, *Zeitschr. f. klin. Med.* II.; LITTEN, *Virch. Arch.* vol. 80; ROBERTS, *loc. cit.*; WAGSTAFFE, *Trans. Path. Soc.* XIX. (1868); BEALE, *Urinary deposits* (plates) London 1883; DICKINSON, *loc. cit.*; ROBERTS, *loc. cit.*

LITTEN asserts that masses of micrococci within the glomeruli and tubules may become calcified. The calcareous deposit in the glomeruli, tubules, and renal epithelium may be so excessive that the function of the kidney is gravely interfered with.

533. When the glomeruli and their epithelium are seriously injured, or the circulation through them greatly disturbed, certain components of the blood may escape from their vessels which normally are held back. In like manner substances may escape from the intertubular capillaries into the tubules. This is most notably the case with regard to the **serum-albumen** of the blood, which in morbid conditions passes in greater or less amount into the urine (**albuminuria**).

This albumen comes from the glomeruli in the soluble form; but within the tubules it may coagulate and thus give rise to granular or homogeneous casts, especially in the region of the loops of Henle, but often in other parts also. These casts are known as **hyaline casts** or cylinders, and there is no doubt that they may consist exclusively of transuded serum-albumen, though they are also formed in other ways.

In many affections of the kidney, especially those of an inflammatory kind, the renal epithelium degenerates or breaks down and desquamates. Moreover we know that from the glomeruli and tubules there escape not only serum-albumen but also white blood-cells. In many morbid affections therefore the tubules contain not only soluble albumen but also albumen derived directly from the protoplasm of cells, and this albumen like the other may take part in the formation of tube-casts. In the first place, the desquamated epithelial cells become agglutinated into casts of the tubules: these have received the name of **epithelial casts**. So also the granular albuminoid and fatty products of their disintegration may in like manner give rise to **fatty casts**. Again the epithelial cells and leucocytes or their albuminous detritus may become transformed and fused into compact hyaline masses, or homogeneous masses may escape from the bodies of the degenerating cells and coalesce into homogeneous cylinders. Finally, both epithelial cells and extravasated leucocytes dissolve in the albuminous urine flowing through the tubules, and in this form play their part in the production of casts. The **granular casts** derived from blood-disintegration have already been spoken of (Art. 530).

Tube-casts may in certain circumstances be washed out of the tubules, and so escape from the kidney. The greater number however remain *in situ*, and are either redissolved or become more firm and dense so as somewhat to resemble wax (**waxy casts**). These occasionally give the reaction of the amyloid substance.

In addition to these casts, formed at least in part from transuded albumen, we may have homogeneous cylinders which are purely epithelial in their origin. These have been described in Art. 525 (Fig. 203) as **colloid casts**.

References on the formation of tube-casts:—BAYER, *Arch. d. Heilk.* 1868; AXEL KEY, *Schmidt's Jahrb.* vol. 114 (1867); BURKHART, *Die Harncylinder* Berlin 1874; AXEL KEY and LANGHANS, *Virch. Arch.* vol. 76; BARTELS, *Ziemssen's Cycl.* xv.; WEISSGERBER and PERLS, *Arch. f. exp. Path.* vi.; FINLAYSON, *Brit. For. Med. Rev.*

Jan. 1876 (on tube-casts without albuminuria); ROVIDA, *Moleschott's Untersuch.* XI.; HUPPERT, *Virch. Arch.* vol. 59; RIBBERT, *Cent. f. med. Wiss.* 1879, *Nephritis u. Albuminurie* Bonn 1881; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* IV.; WEIGERT, *Sammlung klin. Vorträge* 162, 163; POSNER, *Cent. f. med. Wiss.* 1879, *Virch. Arch.* vol. 79; CORNIL, *Journ. de l'anat.* 1879, *Practitioner* XXVIII. (1882); SAUNDBY, *Birmingham Med. Review* Sep. 1883 (with references); KNOLL, *Zeitschr. f. Heilk.* v.

The formation of casts from epithelial cells has been specially investigated by LANGHANS. He showed that the glomerular epithelium may furnish the material. The cells are shed into the lumen of the capsule, reach the tubule, and break up into granular masses: these presently become clear and swell up, and coalesce into homogeneous cylinders.

CHAPTER LXVIII.

RENAL DEGENERATION AND NECROSIS.

534. When poisonous or otherwise noxious matters are excreted by the glomerular and renal epithelium, or when the nutrition of the renal tissue is impaired in consequence of changes in the blood or in the circulation, degenerative changes make their appearance in the glomeruli and tubules, and these changes are generally demonstrable by careful microscopic examination. The most frequent changes are—cloudy swelling, necrosis, and fatty degeneration.

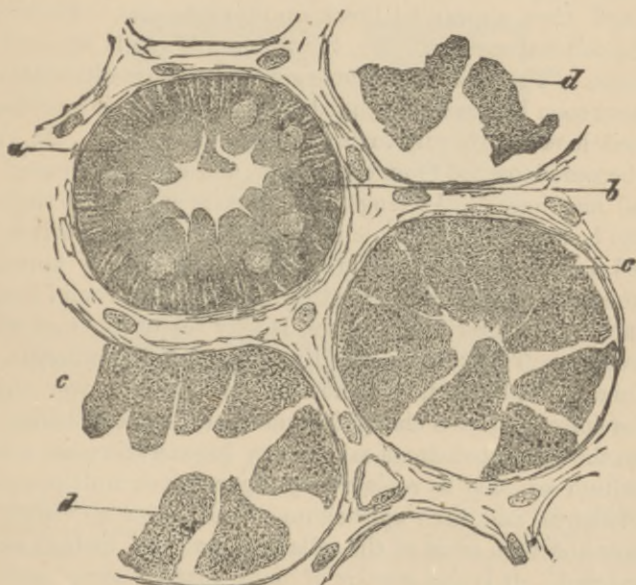


FIG. 205. CLOUDY SWELLING OF THE RENAL EPITHELIUM.

(Preparation treated with chromic acid and ammonia: $\times 800$.)

a, normal epithelium

b, cloudy swelling commencing

c, cells in extreme degeneration

d, loose degenerate epithelium

Cloudy swelling. The epithelial cells (Fig. 205 *a*) of the convoluted tubules are usually wedge-shaped or conical; by broadening of the apex they may become more cylindrical, and by expansion of the base somewhat mushroom-shaped. The outer (parietal) half of each cell is striated with radial rod-shaped markings, due either to differentiation of

the cell-protoplasm into two substances of different refractive power, or to splitting and fibrillation. The inner (apical) half of the cell is homogeneous or finely granular, and in some cases terminates in a process (*a*), which ends in a free point or flattened plate, or joins with other projections, or simply lies over on the apex of the neighboring cell.

In the ascending limb of Henle's loops the cells are similar in form but somewhat shorter; in the descending limb the striated portion of the cell is contracted to a kind of basal plate. The epithelium of the intercalary tubules and collecting tubes is unstriated.

The condition known as cloudy swelling is accompanied by a slight enlargement of the kidney, the cortex assuming a turbid gray or grayish-red tint something like the tint of renal anæmia, but less translucent. If the interlobular veins contain blood the section appears streaked with red, while the medulla is generally livid.

When the affection first sets in the striated cells of the cortex become more markedly granular (*b*). The striations become less fine (NAUWERCK) and then appear to break up into granules. Then the apical part of the cell becomes granular, the whole cell swells up, and loses its normal shape. The processes become swollen, and are ultimately effaced. The nucleus soon becomes distended to a clear vesicle and disappears, and the cell looks uniformly turbid and granular (*c d*). At this stage the cells become loosened from each other, and somewhat raised up from their basal membrane. At length oil-globules may make their appearance in the body of the cell, which then breaks up and dissolves. In the convoluted tubules the first minute oil-globules usually appear at the bases of the cells; in the collecting tubes they appear round the nucleus (NAUWERCK). This series of changes is very frequently met with in infective fevers, such as typhus, small-pox, purulent meningitis, erysipelas, septicæmia, diphtheria, etc., and usually extends over the greater part of the cortex. If the change has not gone far the cells may recover; but where the associated dropsical or fatty degeneration has taken place the epithelium can only be replaced by regenerative multiplication.

The glomeruli and their epithelium usually show no visible change, though now and then some of the cells look swollen, turbid, and granular or powdered. It is also worthy of note that in some cases hemorrhage may occur from the glomeruli, distending their capsules and tubules with blood, and giving rise to red streaks and spots on the section of the cortex. These hemorrhages are due either to obstruction of the capillary circulation in the swollen parenchyma, or to degeneration of the glomeruli themselves. When the cloudy change has advanced to fatty degeneration in the tubular epithelium, that of the glomeruli and their capsules may also become fatty.

In the above account of the degenerative changes affecting the renal epithelium no reference has been made to the statements of other authors on the subject; the account rests solely on the observations made in ZIEGLER'S own labora-

tory in collaboration with NAUWERCK. In many memoirs on the subject no mention is made of the mode of preparation adopted, or hardening-fluids and reagents have been used which greatly alter the renal epithelium. Alcohol especially is entirely inadmissible in such investigations.

References:—KLEBS, *Hanb. d. path. Anat.*; RINDFLEISCH, *Path. Histology* II. (New Syd. Soc.) London 1873; PONFICK, *Berl. klin. Woch.* 1876-77, *Virch. Arch.* vol. 88; BOSTRÖM, *Ueber d. Intox. durch d. essbare Morchel* Leipzig 1882; BARTELS, *Ziemssen's Cyclop.* xv.; WAGNER, *ibid.* (3d German edition) ix.; BRAULT, *Journ. de l'anat.* xvi.; ECKSTEIN, *Deutsche med. Woch.* 1882; GAUCHER, *Lancet* 1, 1881; JACOBI, *Gerhardt's Handb. d. Kinderkrankh.* II.; THOMAS, *ibid.* IV.; WEIGERT, *Sammlung klin. Vorträge* 162, 163; MARCHAND, *Virch. Arch.* vol. 77; LEBEDEFF, *ibid.* vol. 91; P. FÜRBRINGER, *ibid.* vol. 91; LASSAR, *ibid.* vol. 77; NAUWERCK, *Beiträge z. Kenntniss d. Morbus Brightii* Jena 1884.

535. **Dropsical degeneration** of the renal tissue, and especially of the epithelium, plays a great part in the pathology of the kidney. The glomerular epithelium (Fig. 207) and that of the convoluted tubules

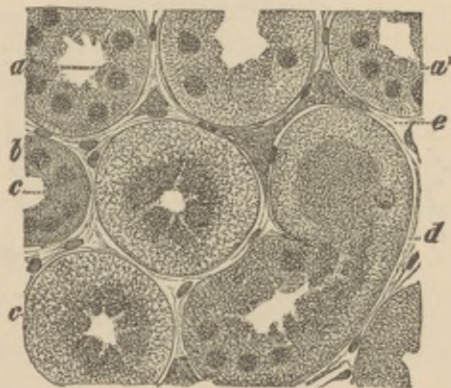


FIG. 206. NECROSIS OF THE TUBULAR EPITHELIUM IN ICTERUS GRAVIS.

(Hardened in Müller's fluid, stained with gentian-violet, and mounted in Canada Balsam:
× 300.)

- | | |
|--|---|
| a, normal convoluted tubule | d, convoluted tubule with epithelium partly
sound, and partly necrosed |
| b, ascending limb of Henle's loop | e, unaltered stroma, with blood-vessels |
| c, convoluted tubules with necrosed epithelium | |

(Fig. 206) is the most frequently affected, less frequently that of the straight tubules and collecting tubes. When the degeneration passes into **necrosis** the tubular epithelial cells become either turbid, or pale and homogeneous. The dropsical cells become greatly swollen, and clear spherules (so-called vacuoles) appear in their protoplasm: these are presently extruded or set free when the cell disintegrates.

Sometimes they coalesce to a frothy-looking mass. The nuclei of the cells sooner or later disappear (Fig. 206 c d), often before the form of the cells themselves is lost. This loss of the nucleus is due either to a process of swelling up and solution, or to disintegration into fragments. The

necrosed cells either break up *in situ*, or are first detached and then dissolve or disintegrate (Art. 533). Sometimes oil-globules may be seen in the necrosed epithelium.

When a portion of the tubular epithelium undergoes necrosis, similar changes are usually to be made out here and there in the glomerular epithelium also. Sometimes the changes are very marked. The cells swell up, are cast off (Fig. 207 e_1, e_2), lose their nuclei (e), and occasionally become vacuolated (e_2). Treatment of the sections with perosmic acid occasionally shows the necrosed epithelium to be studded with minute oil-globules. Ultimately the cells dissolve entirely, or with the exudation from the glomerular vessels form a granular coagulum (g). The denuded capillaries look pale and devoid of nuclei (d); they swell up and appear somewhat thickened. When the necrosis is total all the nuclei disappear.

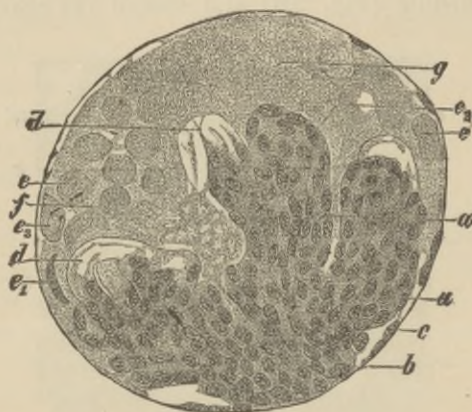


FIG. 207. NECROSIS OF GLOMERULAR EPITHELIUM AND EXUDATION INTO THE CAPSULE OF BOWMAN IN ICTERUS GRAVIS.

(Hardened in Müller's fluid, stained with gentian-violet, and mounted in Canada Balsam: $\times 300$.)

a , normal capillary loop
 b , capsule of Bowman
 c , capsular epithelium
 d , loop denuded of epithelium

e, e_1, e_2, e_3 , shed and degenerate glomerular epithelium
 f , exudation between the epithelial cells
 g , granular exudation and shed cells

The capsular epithelium undergoes necrosis much less frequently than that of the glomerulus, but cases occur in which it entirely perishes.

Necrosis of the renal epithelium appears as a primary affection chiefly in cases where the blood-supply of a region of the kidney is for a time interrupted, and when poisonous matters are excreted through it. Bile, cantharides, chromates, potassium chlorate, have this effect, which is also met with in various infective diseases, such as diphtheria, septicæmia, pyæmia, acute yellow atrophy of the liver, etc. It may be confined

to a few small parts, or be spread over a number of patches of considerable extent.

The cells of the vascular connective tissue are much less often affected by necrosis than the epithelial cells. NAUWERCK makes out that this happens most frequently in the case of the endothelium of the capillaries and venules, the cells of which are shed and transformed into pale homogeneous or finely granular masses, sometimes studded with minute spherules, and rounded, elongated, and sausage-like in shape. This change is not however confined to the kidney, but appears simultaneously in the vessels of other organs. Necrosis of the renal connective tissue is most common after long-persistent anæmia, in septic nephritis, and in cases of uratic deposit. The latter occurs in gout; indeed the formation of homogeneous necrotic patches beset with uratic crystals or granules has been held (EBSTEIN) to be the diagnostic mark of the **gouty kidney**.

Necrosis of the renal structures may also occur idiopathically, as it is called. If the loss of tissue be not great and confined to the epithelium, repair by regeneration is possible. Greater losses, or losses involving the connective tissue, result in permanent atrophy of the parts concerned (Arts. 527, 528). Calcareous salts are occasionally deposited in the necrotic patches, but this is rare.

The presence of necrotic tissue may induce inflammation in the contiguous tissue. In other and not infrequent cases the inflammation accompanies or even precedes the necrosis; the poison or other agent which causes necrosis in one part, acting as an irritant in another. This is exemplified in many bacterial affections of the kidney. Necrosis of the glomerular epithelium is always followed by transudation of albumen (Fig. 207 g), which coagulates when the section is treated with various reagents, and sometimes also during life (Art. 533).

According to FRERICHS diabetes is always associated with a "glycogenous degeneration" of the epithelium of Henle's loops, the cells swelling up and becoming hyaline. When treated with iodine brown-stained spherules and specks become visible in the protoplasm of the cells.

References:—WEIGERT, *Virch. Arch.* vol. 72; LASSAR, *ibid.* vol. 77; MARCHAND, *ibid.*; SCHACHOWA, *Untersuch. üb. d. Nieren* Berne 1876; CORNIL, *Gaz. méd. de Paris* 18, 1879 and *Journ. de l'anat.* 1879; FRÄNKEL, *Zeitschr. f. klin. Med.* II.; LITTEN, *ibid.* IV.; KOHN, *Berl. klin. Woch.* 1882; EBSTEIN, *Die Natur u. Behandlung d. Gicht* Wiesbaden 1882, *Deut. Arch. f. klin. Med.* XXVIII.; WINDLE, *Dublin Journ. med. sci.* 1883; FRERICHS, *Zeitschr. f. klin. Med.* VI. (1883), *Ueber den Diabetes* Berlin 1884; LEBEDEFF, *Virch. Arch.* vol. 91; ELIASCHOFF, *ibid.* vol. 94; AUFRECHT, *Pathol. Mittheil.* II. (1883); NAUWERCK, *Deutsche med. Woch.* 1884; Discussion, *Trans. Path. Soc.* XXXIV. 1883; INGLESSIS, *Le rein dans le diabète* Paris 1886.

536. **Fatty degeneration** of the kidney occurs under various conditions, and affects chiefly the epithelial structures.

In the first place, cloudy swelling (Art. 534) may issue in fatty change; or the latter may be associated with epithelial necrosis (Art. 535). Fatty change however is frequently met with as an independent affection, especially in chronic anæmia or engorgement, in many forms of poisoning (as with phosphorus or arsenic, and in infective diseases such as scarlatina, yellow fever, typhus, small-pox, etc. It may affect not only the tubular but also the glomerular and capsular epithelium, and is characterized by the formation within the cells of droplets of oil of various sizes (Art. 544, Fig. 213). When the degeneration is extreme the cells may become entirely disintegrated.

Slight fatty change is not perceptible to the unaided eye, especially when the vessels are full of blood, as in renal engorgement. Where the change is more marked the parenchyma assumes a grayish-white, white, or yellow tint.

In phosphorus-poisoning and in yellow fever the fatty degeneration may reach an extreme degree without other textural change. And in like manner we may have extreme fatty change uncomplicated with other conditions, the cause of which is as yet unrecognized. This is however rare, inasmuch as sooner or later inflammation is sure to be set up. A kidney which is uniformly of an opaque white through fatty transformation (**white or fatty kidney**) is always either inflamed or amyloid in some degree.

The inflammatory condition is in many cases secondary to the fatty change (as in anæmia, phosphorus poisoning, and yellow fever). In other cases it is antecedent or concomitant; so that the process is throughout inflammatory, and the fatty change is to be regarded as an accompaniment or result of the inflammation (Art. 544).

Fatty change may issue in complete recovery if the initiating cause be checked or removed, the lost epithelium being replaced by regenerative multiplication of the uninjured cells. This is especially true of non-inflammatory change, inflammatory conditions leading in general to destruction or atrophy of the tissues. It is of course immaterial whether the inflammation is primary or secondary.

Degeneration of the vascular connective tissue occurs to a serious extent only in cases where there is simultaneously a wide-spread degeneration of the epithelial structures; it is most marked in the inflammatory varieties. The capillaries are in general the most affected, their endothelium at times appearing crammed with oil-globules.

In the fibrous structures the connective-tissue cells are the parts which become fatty. The droplets of oil met with in the meshes of the tissue are for the most part derived by absorption from the affected tubules.

les maladies du foie et des reins Paris 1877: JOHNSON, *Med. chir. Trans.* XLII. (1853); WHIPHAM and others, *Trans. Path. Soc.* X., XIII., XIX.; RICKARDS, *Brit. Med. Journ.* 2, 1883.

537. **Amyloid degeneration** of the kidney often appears in what is known as the "**large white kidney**;" it may however in other cases present an appearance that has little in common with this form.

Slight degrees of the affection frequently give rise to no characteristic change. The cortex may be more or less red according to the quantity of blood it contains; but it is usually paler and softer than in health, and somewhat yellow. If the change is greater the cortex is generally pale and anæmic, with a grayish or yellowish tint, and more or less swollen. The color is also rather spotty, numerous small white opaque patches being sprinkled over a grayish-white translucent ground. The interlobular veins, if distended with blood, may cause the cortex to be streaked with red. The glomeruli are seen as pale or reddened nodules, occasionally somewhat translucent. The medullary zone is usually streaked with red, but it is not infrequently pale. The surface of the kidney is smooth, or here and there slightly granular and shrunken.

In a third variety, where the amyloid change has reached its highest intensity, the kidney is also pale and spotted with white or yellow, but its consistence is much denser and firmer than in the second variety. On section a number of semi-translucent patches and streaks appear, looking like bits of boiled bacon, and scattered through the medulla as well as the cortex. In extreme cases these may coalesce into continuous areas. Between the soft and the hard (or lardaceous) amyloid kidney there are of course many transitional forms.

The white patches are due to fatty degeneration, which always accompanies the amyloid change, but varies much in its extent.

Simple amyloid change gives the renal tissue the semi-translucent lardaceous aspect, which is well seen in the larger continuous patches. It affects first of all the glomerular capillaries, whose walls become thickened and homogeneous (Fig. 208 *b*). At first the altered patches are scattered irregularly, but soon they coalesce so that at length the entire glomerulus is transformed into an aggregation of homogeneous flakes or blocks. When the degeneration is complete the vessels become impermeable.

After the glomeruli the parts most affected are the walls of the vasa afferentia (*i*) and interlobular arteries, and those of the vessels of the medullary zone. Lastly the change may extend over the greater part of the venous and capillary system of the cortex, and even attack the membrana propria of the urinary tubules. These parts all become thickened, homogeneous, and translucent, and yield the familiar amyloid reactions.

The whole of the epithelial elements of the kidney—tubular, glomerular, and capsular—may simultaneously become more or less fatty

(*d e f*). The extension of the fatty change is not proportionate to that of the amyloid change: it may be extreme when the latter is slight, and inversely.

The convoluted tubules are frequently the most affected. Their epithelium is not only fatty, but loosened and disintegrated (*f*). When this change is marked, and some of the glomeruli become at the same time impermeable, small patches of the renal parenchyma may atrophy and disappear, and so give rise to contractions. If these lie near the surface they appear as small cicatricial depressions.

The loose epithelial cells naturally fall into the lumen of the tubules, and may there form cylindrical masses of fatty cells or fatty detritus. Others of the tubules contain hyaline cylinders, which are soft and

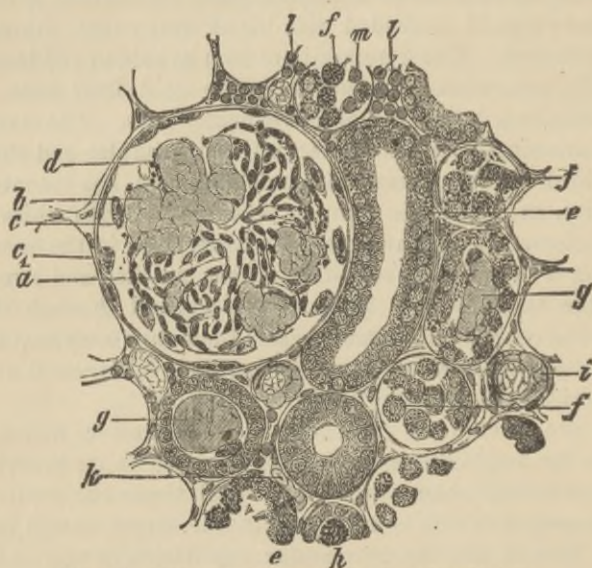


FIG. 208. AMYLOID KIDNEY WITH FATTY DEGENERATION.

(Treated with Müller's fluid and perosmic acid: $\times 300$.)

- | | |
|--|---|
| a, normal capillary loop | g, hyaline tube casts |
| b, amyloid capillary loop | h, fatty tube-cast |
| c, fatty glomerular epithelium | i, amyloid arteriole |
| c ₁ , fatty capsular epithelium | k, amyloid capillary |
| d, oil-globules lying on the capillaries | l, cellular infiltration of the connective tissue |
| e, fatty epithelium <i>in situ</i> | m, round-cells within a urinary tubule |
| f, loosened fatty epithelium | |

transparent, or firm and waxy. The firmer kinds stain with iodine a somewhat deeper brown than the surrounding structures, but do not usually give the typical amyloid reactions.

In the meshes of the intertubular connective tissue we frequently find cellular infiltrations (*l*), a sign that a certain amount of inflammation accompanies the other changes. Sometimes too there is a certain amount of fibrous hyperplasia and induration.

We have already discussed (Arts. 57-62) the ætiology and the significance of the amyloid degeneration. As to the fatty degeneration which accompanies the amyloid change in the kidney we must assume that it is mainly the effect of the same agencies as the latter, though no doubt the disturbances of the circulation occasioned by the amyloid deposits have something to do with it. The accompanying inflammatory changes too are probably a third effect of the same causes. In support of this view it is to be noted that now and then (NAUWERCK) the presence of bacteria in the vessels of the amyloid kidney can be demonstrated.

References :—Arts. 61, 62; FEHR, *Die amyloide Degeneration* Berne 1867; GRAINGER STEWART, *Bright's diseases* Edinburgh 1871; LITTEN, *Berl. klin. Woch.* 1878; *Med. Times and Gaz.* 2, 1878; DICKINSON, *Diseases of the kidney* II. London 1877; STRAUSS, *Soc. méd. des hôpitaux* 1881; CORNIL, *Practitioner* XXXII. (1882), *Pathologie du rein* Paris 1884.

CHAPTER LXIX.

HÆMATOGENOUS NEPHRITIS.

538. The term **hæmatogenous nephritis** includes all the inflammatory affections of the kidney the exciting cause of which reaches the organ by way of the circulation.

The anatomical condition for the existence of nephritis is the presence of an inflammatory alteration of the blood-vessels. As this is incapable of direct demonstration the evidence of it appears in the presence of an inflammatory exudation.

In glandular organs an inflammatory exudation lodges either in the connective-tissue stroma, or in the lumen of the acini and ducts; in the latter case it mingles with the specific glandular secretion, whose composition is thereby altered.

The kidney is no exception to the rule. But the determination of many points in connection with renal inflammation is rendered difficult by the fact—that the kidney normally contains a large quantity of liquid transuded from the blood-vessels, and thus inflammatory exudations entering the tubular system are frequently not at once distinguishable from non-inflammatory transudations.

Our decision as to whether for example the contents of a Bowman's capsule or a uriniferous tubule are inflammatory or not depends on their composition. Inflammatory exudations are always highly albuminous; they usually contain blood-cells, and often fibrinous coagula. The altered secretion of an inflamed kidney also contains albumen, and generally blood-cells and coagula. If then we are sometimes in doubt as to the nature of a given renal affection it is owing to the fact that a simple degeneration of the glomerular or tubular epithelium, or a transitory disturbance of the circulation, may occasion the escape of albumen from the blood into the urine. If other decisive marks are absent we may fall back on this—that the quantity of albumen in the urine in inflammatory affections of the renal vessels is greater than in simple degeneration or hyperæmia. But after all is said it must be granted that it is impossible to draw an absolutely sharp line between renal inflammations and renal degenerations.

539. Clinical authorities describe three chief types of nephritis.

The first is **acute nephritis**, distinguished by diminution in the

quantity of urine, which is of high specific gravity, contains much albumen, is of acid reaction, and is dark or occasionally smoky or blood-stained in color. The sediment contains white blood-cells, and when the urine is smoky or bloody red blood-cells, also tube-casts which are hyaline or occasionally granular and mingled with red blood-cells or their detritus, epithelial cells from the collecting tubes, turbid swollen and broken-down cells from the convoluted tubules, and sometimes concavo-convex epithelium from the glomeruli.

Scarlatina, diphtheria, croupous pneumonia, relapsing fever, septicæmia, pyæmia, typhoid, endocarditis, and articular rheumatism are frequent causes or concomitants of acute nephritis, though it also arises idiopathically. Anasarca is usually present, but not always, especially in the secondary varieties.

The usual issue of the affection is in recovery, though death may occur from uræmia. Only in rare instances does it pass into chronic indurative nephritis with hypertrophy of the heart and polyuria. More rarely still does it lead to chronic parenchymatous nephritis, and though many cases are of long duration the process does not usually end in a fatal chronic disease, but in ultimate recovery.

The clinical term acute nephritis includes a number of anatomically distinct types of renal inflammation. There is in almost all cases some disorder of the glomeruli, and this may by itself give rise to all the symptoms of acute nephritis; but in many cases the uriniferous tubules or the intertubular stroma or both are also affected, and these changes give rise to corresponding peculiarities in the anatomical aspect of the disease.

The second form recognized by physicians is **chronic parenchymatous nephritis**. Its characters are these:—onset insidious or subacute, and invariably accompanied by anasarca, which may be the first symptom attracting the patient's notice to his condition; urine highly albuminous, slightly diminished in quantity, of a turbid yellow tint, of increased specific gravity, and usually free from blood, though hæmorrhagic varieties occur; in the sediment numerous tube-casts of various sizes, white blood-cells, fatty epithelial cells, granular and fatty detritus, and fat-granule cells. Red blood-cells are usually few or absent, being abundant only in the hæmorrhagic forms.

Recovery is rare. As a rule after the disease has lasted for months or years death ensues from increasing dropsy, cerebral œdema, pleurisy, pericarditis, uræmia, or other cause. Sometimes however the aspect of the case changes: cardiac hypertrophy and rise of the arterial blood-pressure cause the flow of urine to increase, its specific gravity and proportion of albumen diminish, the dropsy disappears, and the case presents the features of renal cirrhosis.

The third form is **renal cirrhosis or indurative nephritis**. It is characterized by the following features:—increased flow of pale slightly

albuminous urine of low specific gravity; sediment containing few formed elements, pale hyaline casts, white blood-cells, and occasionally a few red blood-cells; anasarca absent; the heart hypertrophied; the fundus of the eye affected by a special form of neuro-retinitis. The onset is usually very gradual, and the first symptoms of the malady are disorders of digestion or of vision, palpitation, cardiac distress, etc. After a duration of years death ensues from such causes as cardiac failure, dropsy, cerebral hæmorrhage, uræmia, purulent inflammations of serous membranes, etc.

Rarely are the essential symptoms of renal cirrhosis presented by a case commencing as an acute nephritis; such cases when they occur are usually marked by their rapid course.

Chronic parenchymatous nephritis is characterized anatomically by great degeneration of the renal epithelium: renal cirrhosis by marked changes in the connective tissue of the vascular system. The two forms are thus distinguishable anatomically as well as clinically, and the pathological anatomist may therefore accept the clinical classification. It is however to be kept in mind that the two forms are by no means antithetic; the distinction is rather one of degree than of kind. In the former affection the connective-tissue elements undergo some morbid change, in the latter there is always some epithelial degeneration. There are in fact numerous intermediate and transitional forms partaking of the characters of both.

The attempt has often been made to interpret the several forms of nephritis as stages of a single morbid process. But apart from the fact that acute nephritis does not usually pass into any of the chronic forms, there is this insuperable objection—that a given condition of the kidney in chronic nephritis may have been arrived at in several very different ways. There is no doubt at least that the mode of beginning of the disease differs in different cases. There is as little ground for the view that all forms of nephritis begin with glomerular changes, as that they all begin with epithelial degeneration or interstitial infiltration. And if the mode of beginning varies so also does the further course of the disease; we are in fact unable to say of a given advanced renal affection either how it began or what stages it has passed through. We can in general as little forecast how a given acute inflammation of the kidney would have terminated had the patient lived. We must therefore content ourselves with describing as accurately as possible the several forms that offer themselves for examination, and suggesting the possible ways in which these forms may have arisen.

The modern investigations of the affections included under the term nephritis begin with the observation of BRIGHT (*Report of medical cases selected with a view of illustrating the symptoms and cure of diseases by a reference to morbid anatomy* I. London 1827) that certain cases of dropsy depended on disease of the kidney, and were distinguished by albuminous urine. BRIGHT himself de-

scribed various forms of renal disease leading to albuminuria. These affections have since been included under the term **Bright's disease** (*Morbus Brightii*); but the term has been variously applied by various authors—some including under it all renal affections associated with albuminuria, others excluding the simple degenerations and disorders of circulation and including only the inflammatory affections.

ROKITANSKY (*Handb. d. path. Anat.* II. 1842) distinguished eight forms. FRERICHS (*Die Bright'sche Nierenkrankheit* Brunswick 1851) regarded the different forms merely as different stages of one and the same process. This process, he held, began with hyperæmia, passed on to exudation and parenchymatous degeneration, and ultimately issued in atrophy and contraction.

The works of BRIGHT and FRERICHS have given rise to a vast number of memoirs of which the following may be particularly mentioned:—CHRISTISON, *On granular degeneration of the kidneys* Edinburgh 1839; RAYER, *Traité des maladies des reins* Paris 1840; WILKS, *Cases of Bright's disease, Guy's Hosp. Reports* VIII. (1853); VIRCHOW, *Virch. Arch.* vol. 4; JOHNSON, *Diseases of the kidney* London 1852; *Lectures on Bright's disease* London 1873; GULL and SUTTON, *Med. chir. Trans.* IV. (1872); BEER, *Die Bindesubstanz d. menschl. Niere* Berlin 1859; FÖRSTER, *Hand. d. path. Anat.* 1863; DICKINSON, *Med. chir. Trans.* XLIII., XLIV. (1860-61), *Pathology of Albuminuria* London 1868, *Renal and urinary affections* London 1877-85; TRAUBE, *Gesamm. Abhandl.* II. (1871); KLEBS, *Handb. d. path. Anat.* Berlin 1870; GRAINGER STEWART, *Bright's diseases of the kidney* Edinburgh 1871; RINDFLEISCH, *Path. Hist.* II. (New Syd. Soc.) London 1873. BARTELS, *Ziemssen's Cyclop.* XV.; KELSCH, *Arch. de physiol.* 1874; GALABIN, *Bright's disease and changes in the vascular system* London 1874; MAHOMED, *Med. chir. Trans.* LVII. (1874), *Lancet* 1, 1879; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1886; LECORCHÉ, *Traite des maladies des reins* Paris 1875; CHARCOT, *Leçons sur les maladies du foie et des Reins* Paris 1877; BUHL, *Mitth. a. d. path. Inst. zu München* Stuttgart 1878; AUFRECHT, *Die diffuse Nephritis* Berlin 1879, *Cent. f. med. Wiss.* 47, 1882 and *Deutsch. Arch. f. klin. Med.* XXXII.; WEIGERT, *Sammlung klin. Vorträge* 162, 163 (1879); RIBBERT, *Nephritis u. Albuminurie* Bonn 1881; HORTOLÈS, *Etude du processus histologique des nephrites* Paris 1881; BAMBERGER, *Sammlung klin. Vorträge* 173 (1879); WAGNER, *Deutsch. Arch. f. klin. Med.* XXV., XXVII., XXXVIII., *Ziemssen's Handbuch* (3d German edition) IX. Leipzig 1882; ROSENSTEIN, *Path. u. Therap. d. Nierenkrankh.* 1870; FISCHL and SCHÜTZ, *Prag. Zeitschr. f. Heilk.* III. (1882); LETZERICH, *Virch. Arch.* vol. 55; LANGHANS, *ibid.* vol. 76; THOMA, *ibid.* vol. 71; SENATOR, *ibid.* vol. 73; GRAWITZ and ISRAEL, *ibid.* vol. 73; POSNER, *ibid.* vol. 79; SAMUEL, *ibid.* vol. 73; EWALD, *ibid.* vol. 71; PLATEN, *ibid.* vol. 71; EBERTH, *Zur Kenntniss bacter. Mycosen* Leipzig 1872; HOFMEIER, *Zeit. f. Geburtshilfe* III.; ZIEGLER, *Deutsch. Arch. f. klin. Med.* XXV.; LITTEN, *Charité-Annalen* IV., *Berl. klin. Woch.* 1873; WEISSGERBER and PERLS, *Arch. f. exp. Path.* VI.; LANCEREAUX, *Dict. encyc.* Paris 1881; LEYDEN, *Zeitschr. f. klin. Med.* III.; Discussion, *Trans. internat. med. congress* II. London 1881; Discussion, *Congress f. innere Medicin* Wiesbaden 1882; FRIEDLÄNDER, *Arch. f. Anat. u. Physiol.* 1881, *Fortschritte d. Med.* I. (1883); BRAULT, *Des formes anatomo-path. du mal de Bright*, *Arch. générales de méd.* 1882; CORNIL and BRAULT, *Journ. de l'anat.* XIX. (1883), *Practitioner* XXVII., XXVIII., XXXII. (1881-84); DUNIN, *Virch. Arch.* vol. 93; FISCHL, *Beiträge z. Histol. d. Scharlachniere*, *Zeitschr. f. Heilk.* IV.; Discussion on Albuminuria, *Glasg. Med. Journ.* 1884; BIERMER, *Breslau ärztl. Zeitschr.* 1, 1882; SEMMOLA, *Revue médicale française* 1883; NAUWERCK, *Beiträge zur Kenntniss des Morbus Brightii* Jena 1884 (with a critical account of various theories); SENATOR, *Albuminuria in health and disease* (New Syd. Soc.) London 1884; ROBERTS, *Urinary*

and renal diseases London 1885; HOLSTI, *D. Arch. f. klin. Med.* XXXVIII. (1885) SAUNDBY and GREENFIELD, *Trans. Path. Soc.* XXXI.

KLEBS excludes the non-inflammatory renal degenerations from the category of Bright's disease, and identifies the latter with primary interstitial nephritis; the associated changes in the epithelium he regards as secondary. JOHNSON regards the presence or absence of epithelial degeneration and desquamation as an essential feature, and treats of nephritis as desquamative or non-desquamative, each form having its subordinate varieties. GRAINGER STEWART speaks of 'Bright's diseases,' and distinguishes three forms—the inflammatory form, the amyloid form, and the cirrhotic or contracting form. Of the first he describes three stages—that of inflammatory exudation, of fatty change, and of atrophy. VIRCHOW (*Cellular Pathology* London 1860) also distinguishes three forms—parenchymatous nephritis, indurative interstitial nephritis, and amyloid degeneration. BARTELS divides Bright's disease into—acute parenchymatous, chronic parenchymatous, and interstitial nephritis. LECORCHÉ distinguishes only a parenchymatous and an interstitial form. CHARCOT on grounds partly clinical, partly anatomical, makes three—the first characterized clinically by its rapid course, scanty urine with abundant albumen, and dropsy, and anatomically by its large white kidney; the second by its chronic course, abundant urine with little albumen, absent or slight dropsy, and contracted kidney; the third form is the amyloid degeneration. WEIGERT divides Bright's disease into parenchymatous degenerations and true nephritis; the former are all acute affections; the chronic forms are but modifications of one and the same process: he deems it impossible to distinguish interstitial from parenchymatous forms, inasmuch as all forms begin with degeneration and loss of epithelium, and then pass into the stage of reactive interstitial inflammation. DICKINSON makes three classes—tubal nephritis (acute and chronic), granular degeneration with hyperplasia and contraction of the stroma, and depurative disease (or amyloid degeneration). AUFRECHT speaks of an acute, a subacute, and a chronic nephritis, and maintains that the primary change is an affection of the tubular epithelium, the vessels and the fibrous structures being affected secondarily: he describes amyloid disease as a nephritis. WAGNER considers that Bright's disease is a clinical term, implying a disease in which the urine exhibits certain morbid changes: he treats it under the four heads of (1) acute Bright's disease, (2) chronic Bright's disease, (3) contracted kidney, (4) amyloid kidney. LEYDEN defines the term Bright's disease from the clinical or physiological point of view (*Congress f. innere Med.* Wiesbaden 1882) as an affection characterized by albuminuria and dropsy, including in the term renal degenerations, pyelonephritis, amyloid change, etc. ROSENSTEIN (*ibidem*) thinks on the other hand that the term must be defined according not to clinical but to pathological and anatomical characters. CORNIL uses the term albuminous nephritis as equivalent to Bright's disease and treats the various forms under the heads of acute nephritis, parenchymatous or epithelial nephritis, and interstitial nephritis.

The above summary shows how widely authorities differ as to the content of the term Bright's disease, and as to the anatomy and pathogenesis of nephritis. We might easily carry our references further and so bring out still greater differences. This is true not only of the older authorities, but even of the most recent, the latest discussions on the subject showing clearly that on the basis of our present knowledge no reconciliation of the conflicting views is possible.

This being the case the author has thought it best in dealing with the pathological anatomy of the nephritic process to refer as little as possible to the existing literature of the subject, and to be guided mainly by the results of his own investigations. This he has done with less hesitation inasmuch as for some years he has given considerable attention to the subject and has collected an extensive

series of observations on it. During the last two or three years he has had the further advantage of watching the results of a research on nephritis carried out in his presence by Dr. NAUWERCK. His work has thrown much light on the subject, and some of the figures hereafter given are taken from his admirable preparations. The experimental researches on nephritis made by GRAWITZ and ISRAEL, PONFICK, LASSAR, MARCHAND, AUFRECHT, BUCHWALD, LITTEN, and others have but slight bearing on the questions raised by the phenomena of nephritis in man. The varieties of renal degeneration set up by the injection or administration of various chemical irritants or by interruptions of the blood-supply, etc. have but distant relation to nephritis proper, and admit of useful comparison with the human affections exactly corresponding to them and with no others. Still less have the degenerations of the kidney induced by ligature of the ureter to teach us concerning the textural changes in human hæmatogenous nephritis. For this latter we must in the first place look to a careful anatomical investigation of the diseased human kidney.

As to the exact significance to be attached to the term Bright's disease we must leave clinical experts to decide. It is essentially a clinical term, and the pathological anatomist may for the present dispense with it.

Acute Nephritis.

540. **Acute glomerulo-nephritis.** The simplest form of acute nephritis is that in which the inflammatory changes are in the main confined to the glomeruli, the intertubular vessels being but slightly affected.



FIG. 209. SECTION THROUGH GLOMERULAR CAPILLARIES IN ACUTE NEPHRITIS FOLLOWING DIPHTHERIA :
AFTER NAUWERCK.

(The glomerulus lies near the surface of the kidney : section hardened in alcohol, stained with alum-carmin and eosin, and mounted in Canada Balsam : $\times 450$.)

- | | |
|---|---|
| a, nucleus in capillary-wall | g, nucleus of a detached epithelial cell |
| b, swollen and loosened endothelial cell | h, vesicular (degenerate) epithelial cell |
| c d, endothelial cells with multiple nuclei | i, coagulated albumen |
| e, glomerular epithelium | k, denuded capillary wall |
| f, disintegrating glomerular epithelium | |

The glomeruli themselves often show no marked histological change; the presence of an albuminous exudation, which coagulates by alcohol or by heat and forms a crescentic areola around the glomerular vessels, being sometimes the only evidence that the vessels have been altered. Other glomeruli may be somewhat swollen, or partially denuded of epithelium (Fig. 209 *g h*; Fig. 213 *e*, Art. 544). In more severe cases some of the capillary loops are entirely denuded (Fig. 207 *d*, Art. 535;

Fig. 209 *k*; Fig. 212 *b*, Art. 543), and the vessels look pale, denucleated, and necrotic; or they are transformed into homogeneous spherules with few or many nuclei, larger than the normal glomeruli and impermeable by the blood or by artificial injections. According to FRIEDLÄNDER the latter is the form most frequent in post-scarlatinal nephritis, and it may extend over a great part of the kidney. It would appear to be due to a hyaline swelling (Art. 63) of the vessel-walls themselves.

Some of the capillaries appear to contain an excess of white blood-corpuscles and it is possible that this may occasionally give rise to thrombosis (RIBBERT). According to LANGHANS and NAUWERCK the endothelial cells of the capillary loops become swollen (Fig. 209 *a*), proliferous, loosened (*b*), and degenerate (*d*), the epithelial cells of the glomeruli (*h k*) also undergoing desquamation. Hæmorrhagic exudation is very common, the capsule of the glomerulus then becoming tightly distended with blood (Fig. 212 *f*, Art. 544).

The tubular epithelium may be altogether unaltered. In other instances single cells may appear degenerate, turbid, fatty, or necrotic, or they may be loosened and disintegrated. Hyaline casts occupy the lumen of some of the tubules.

The intertubular connective tissue is in general entirely unaffected; now and then it appears somewhat swollen from inflammatory œdema, or contains a few scattered patches of cellular infiltration.

The naked-eye appearance of the kidney is not usually altered to any sensible extent. Only when there is great hyaline thickening of the glomerular capillaries do the glomeruli become noticeable by their paleness and increased size (FRIEDLÄNDER).

Glomerulo-nephritis is not a specific disease, as it can be produced by a variety of causes. According to KLEBS, FRIEDLÄNDER, CORNÏL, KLEIN, etc. it is specially apt to follow upon scarlatina. It may also accompany pyæmia, septicæmia, diphtheria, relapsing fever, erysipelas, carbuncle, etc., or arise idiopathically, that is without any antecedent infective disease. It obviously is due to the action of deleterious substances reaching the glomerular vessels by way of the circulation, and damaging the vessels in the process of excretion through their walls. It thus stands ætiologically in close relation with the forms of degeneration described in Arts. 534, 535, and indeed it is difficult or impossible to draw a sharp line separating the histological appearances in the two groups.

Glomerulo-nephritis may cause death by suppression of the urinary secretion. In other cases it issues in recovery, or in chronic change.

References:—KLEBS, *Handb. d. path. Anat.* 1; KELSCH, *Arch. de physiologie* 1874; KLEIN, *Reports to Med. Off. of Privy Council* 1876; LANGHANS, *Virch. Arch.* vols. 76, 99; HORTOLÈS, *Etude d. proc. histol. des néphrites* Paris 1881; LEECH, *Brit. Med. Journ.* 1, 1881; GREENFIELD, *Atlas of Pathology* (New Syd. Soc.) London 1879; RIBBERT, *Nephritis u. Albuminurie* Bonn 1881; COHNHEIM, *Allg. Path.*

II. 1882; FRIEDLÄNDER, *Fortschritte d. Med.* 1 (1883); CORNIL, *Practitioner* XXVIII, XXXII. (1882-84); CORNIL and BRAULT, *Pathologie du rein* Paris 1884; B. C. WALLER, *Journ. of Anat. and Physiol.* XIV. 1879; NAUWERCK, *Beitr. z. Kennt. d. Morb. Brightii* Jena 1884.

541. **Acute diffuse nephritis** with sero-fibrinous exudation, or as we may call it acute inflammatory œdema of the kidney, gives rise to more or less swelling of the organ, in some cases so extreme that it attains a length of 22 to 25 centimetres. The capsule is easily stripped off, the surface smooth, the tint gray or grayish-red speckled with yellowish-red. On section the cortex and medulla appear swollen and sodden, usually pale-gray or grayish-yellow, and occasionally streaked or speckled with red. The whole organ is soft, especially so when the swelling is great.

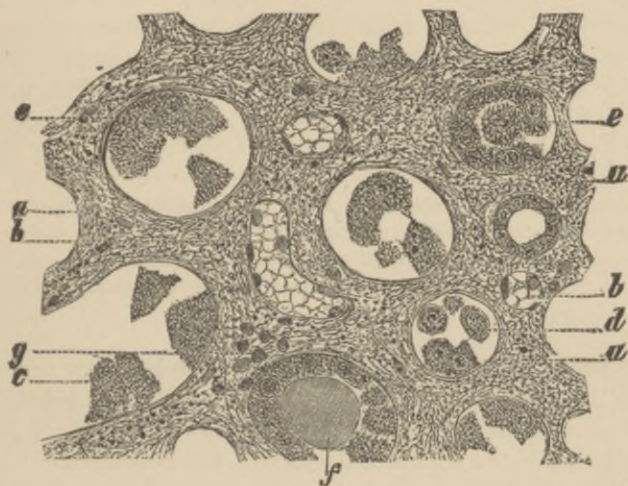


FIG. 210. DIFFUSE NEPHRITIS WITH SERO-FIBRINOUS EXUDATION.

(Section treated with perosmic acid and mounted in glycerine: $\times 350$.)

- | | |
|--|---|
| a, stroma much thickened and beset with fibrinous threads and granules and with oil-globules | d, shed epithelium in a Henle's loop |
| b, capillaries | e, granular and fatty detritus in a Henle's loop, whose epithelium is turbid but remains <i>in situ</i> |
| c, epithelium of the convoluted tubules, partly turbid, partly fatty and desquamating | f, hyaline cast |
| | g, extravasated leucytes |

The swelling is due mainly to the accumulation of liquid in the intertubular connective tissue of the cortex (Fig. 210), and to some extent of the medulla.

The stroma is greatly thickened and contains a liquid which in recent preparations, more commonly however in hardened ones, is mingled with threads and granules of fibrin (a). The vessels may be compressed

by the liquid, but sometimes at least in places appear distended with blood (*b*).

The exudation contains few cells, though it is not unusual to find scattered patches of cellular infiltration (*g*). When the condition is no longer quite recent the intertubular exudation contains oil-globules.

The glomeruli are for the most part not perceptibly altered, though when treated with alcohol traces of coagulable exudation can be made out within their capsules. In some of the glomeruli moreover there is slight swelling and desquamation of the epithelium.

The tubular epithelium of the cortex and medulla is everywhere more or less swollen and loosened (*c*), in many places it is actually detached (*d*). Sooner or later fatty degeneration and disintegration of the epithelium becomes apparent.

The tubules are at first empty, but presently they are filled with hyaline casts (*f*), or with granular and fatty epithelial detritus (*e*).

The slighter forms of inflammatory œdema accompany the various infective diseases, such as typhoid fever, and give rise to some swelling and considerable dropsical saturation of the kidney. The more intense forms are seldom met with: they are most common in affections of the nature of pyæmia.

The drawing in Fig. 210 was made from the kidney of a patient who died on the tenth day of an acute febrile attack. The disorder was obviously of an infective nature, for the renal inflammation was accompanied by enormous swelling of the spleen, with purulent inflammation in the mediastinum, and later on with purulent pleurisy.

542. **Acute disseminated interstitial nephritis** is the most common form of acute renal inflammation. The kidney is swollen but little or not at all, and at first the section shows no discoloration whatsoever. Only when the interstitial changes are accompanied by marked degenerative changes do spots and patches of gray or (in fatty degeneration) white make their appearance. Hæmorrhage is frequently an early symptom, and gives rise to small punctiform dark-red spots.

The diagnosis of this form of nephritis can be made with certainty only by means of the microscope.

The cellular infiltration (Fig. 211 *m*) first makes its appearance around the stellate veins (*g*) and the interlobular veins (*h*), and is usually so marked that in stained sections the affected patches can be seen under very low magnifying powers. These patches are usually most abundant in the outer zone of the cortex, and in the boundary zone between the cortex and medulla; the middle parts of the cortex being seldom much affected. The glomeruli which lie within the region of the inflamed veins may be surrounded with infiltrated cells, the latter often accumulating in a dense mass round the glomerular capsule. The connective tissue not lying within this region may be entirely unaffected, though

cases occur in which other capillary regions, especially those around the glomeruli (Fig. 213, Art. 544 and Fig. 212, Art. 543), show signs of more or less extensive cellular infiltration.

The tubular epithelium may be altogether normal. Even in the centre of the inflamed region the cells occasionally remain unchanged or at most become a little cloudy, their form being retained and their nuclei continuing to stain well. NAUWERCK has observed this condition in the nephritis accompanying infective pneumonia. In other cases the

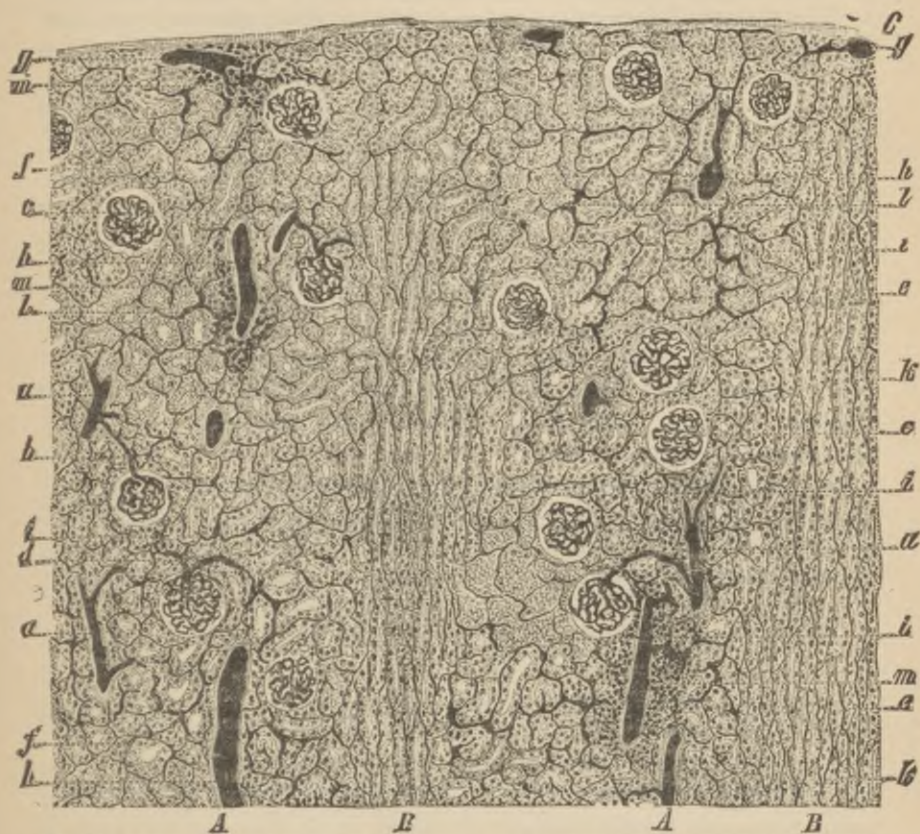


FIG. 211. OUTER HALF OF THE CORTEX IN RECENT ACUTE DISSEMINATED (INTERSTITIAL) NEPHRITIS.
(Injected with Prussian blue and stained with alum-carminé: $\times 32$.)

- | A, labyrinth | B, medullary rays | C, capsule |
|--------------------------------------|--|------------|
| a, interlobular artery | h, interlobular veins | |
| b, vas afferens | i, convoluted tubules | |
| c, glomerulus | k, straight tubules (Henle's loops and collecting tubes) | |
| d, vas efferens | l, degenerate convoluted tubules | |
| e, capillaries of the medullary rays | m, cellular infiltration around the veins | |
| f, capillaries of the labyrinth | | |
| g, stellate veins | | |

epithelium is in parts more obviously affected by the inflammatory process, and cloudy swelling with a tendency to necrosis is observed, espe-

cially in the convoluted tubules (Fig. 211 *l*). According to NAUWERCK this occurs chiefly in cases of diphtheria. The affected epithelial cells sooner or later lose their nuclei.

The degeneration and necrosis of the epithelium may either be confined to the inflamed region, or may extend beyond it. It is worthy of remark that in certain conditions the epithelium in the inflamed region may be little if at all altered, while in other parts epithelial necrosis has set in. Frequently we find that the celis of the collecting tubes are the most altered, being turbid or disintegrated into granular detritus.

The glomeruli themselves are as a rule but little affected, except in those cases which tend to issue in suppuration (Art. 543). Sometimes a few of them are partially denuded of their epithelium. Cases also occur in which at an early stage of the inflammation the epithelia of some of the capillary loops become necrosed and denucleated (Fig. 207, Art. 535), and fall away from their attachments. The capsules of some glomeruli also contain an exudation which coagulates with alcohol into a granular mass, and contains the desquamated and degenerate glomerular epithelium in the form of transparent vesicular spherules. When hæmorrhage takes place, many of the capsules contain blood, which closely surrounds the vascular loops (Fig. 213, Art. 544) and passes down into the corresponding tubules. Varieties of nephritis are met with in which these hæmorrhages are from the outset numerous and abundant, so much so that they may throw the interstitial changes quite into the background.

In the lumen of the tubules, especially in the loops of Henle, are formed hyaline casts, sometimes enclosing a few scattered nuclei. The tubules bordering on the patches of cellular infiltration also contain leucocytes, which have traversed the membrana propria and lie either within the tubules or in their secreting epithelium.

Disseminated interstitial nephritis may coexist with inflammatory œdema. The kidney is then more or less swollen, and mottled with red and gray. This condition is met with in connection with various infective diseases, more especially in pneumonia and erysipelas (NAUWERCK, MOMMSEN); and also in scarlatina, diphtheria, pyæmia, and relapsing fever (PONFICK). It may also occur without any antecedent general infection of the system. It issues in recovery, or in localized induration and atrophy, or in suppuration.

RIBBERT maintains that every interstitial nephritis begins in an inflammatory change of the glomeruli. WEIGERT thinks all forms of nephritis begin in epithelial degeneration. Both views are one-sided and apply only to a limited number of cases; they relegate the essential part of the process to a secondary place. Nephritis may begin in many different ways, and no single scheme can be laid down to which all cases shall conform.

References on nephritis following pneumonia:—WAGNER, *Deut. Arch. f. klin. Med.* xxv.; MOMMSEN, *Deutsch. med. Woch.* 1879; NAUWERCK, *loc. cit.*; JÜRGEN-

SEN, *Croupöse Pneumonie* Tübingen 1883; FRIEDLÄNDER, *Fortschritte d. Med.* II. 1884; DICKINSON, *Renal and urinary affections* III. London 1885.

References on nephritis after diphtheria, scarlatina, etc.:—BOUCHARD, *Rev. de méd.* 1881; CAPITAIN and CHARRIN, *ibid.*; GAUCHER, *Lancet* I, 1881; CORNIL, *Journ. de l'anat.* 1879, *Practitioner* XXVIII., XXXII. (1882-84); EBERTH, *Virch. Arch.* vol. 57, *Zur Kenntniss bacter. Mycosen* Leipzig 1872; JACOBI, *Gerhard's Handb. d. Kinderkrankh.* II.; KANNENBERG, *Zeitschr. f. klin. Med.* I.; KLEBS, *Handb. d. path. Anat.*; KLEIN, *Trans. Path. Soc.* XXVIII. (1877); LÉPINE, *Revue mensuelle* 1880; LETZERICH, *Virch. Arch.* vols. 47, 52, 55, 61; LEYDEN, *Zeitsch. f. klin. Med.* III.; LITTEN, *ibid.* IV.; MARKWALD, *Ueber die Nierenaffection bei acuten Infektionskrankh.* II. Diss. Königsberg 1878; OERTEL, *Ziemssen's Cyclop.* II.; SENATOR, *Virch. Arch.* vol. 56, *Die Albuminurie im gesund. u. krank. Zustande* Berlin 1882, trans. by SMITH (New Syd. Soc.) London 1884; THOMAS, *Gerhard's Handb. d. Kinderkrankh.* IV.; UNRUH, *Jahrb. f. Heilk.* XVII. (1881); P. FÜRBRINGER, *Virch. Arch.* vol. 91; NAUWERCK, *Die Nephritis* Jena 1883; FISCHL, *Beiträge z. Histologie d. Scharlachniere*, *Zeitsch. f. Heilk.* 1883; LEICHTENSTERN, *Deutsche med. Woch.* 1881; BABES, *Arch. de physiol.* II. (1883); FRIEDLÄNDER, *Fortschritte d. Med.* I. (1883); Art. 540.

ATKINSON (*Amer. Journ. med. sciences* 1884) gives a good account (with references) of nephritis from malarial poisoning.

543. Disseminated suppurative nephritis. When a simple disseminated nephritis issues in suppuration, there are formed in various parts of the kidney, especially in the cortex but not infrequently in the medulla also, a number of rounded or linear patches of whitish pus-like matter usually surrounded by a zone of hyperæmia. In other respects the kidney may be almost normal, though there is frequently a certain amount of swelling (from inflammatory œdema) and some gray and red mottling (from disorder of the circulation).

The smallest patches (not larger than a millet-seed) are due to a steadily increasing extravasation of leucocytes, which accumulate either round the venules or round the capsules of the glomeruli.

Suppurative inflammation of the kidney is no doubt in general a result of bacterial invasion. When the micro-organisms settle within the capillary loops of the glomeruli (Fig. 212 *a*) they first block up the lumina of the vessels, then induce necrosis of the glomerular epithelium (*b*), and finally necrosis of the glomerulus itself. An inflammatory reaction is thereupon set up around the glomerulus, the first effect of which is an accumulation of extravasated leucocytes in the surrounding connective tissue (*d*). There is also usually a certain amount of exudation from the intertubular venules (*f*). The epithelium within the affected region as a rule degenerates rapidly (*g h*). Part breaks up into granular detritus, part becomes necrotic and denucleated, and desquamates. The extravasated leucocytes penetrate the tubules (*i*), and in a short time the entire region is thickly infiltrated with them. By and by not only the epithelium but the connective tissue breaks down, and the infiltration becomes an abscess. The size of the abscess depends of course on the extent of the infiltration.

This form of inflammation may result in the breaking down of a large part or even the whole of the kidney, so that at length nothing remains but a sac filled with pus. The latter is however not a common result of the affection now considered; it occurs much more frequently as a sequel of pyelonephritis (Art. 554).

Wide-spread suppuration of the renal tissue gives rise to catarrhal, purulent, or even diphtheritic inflammation of the pelvis of the kidney; and not infrequently abscesses are formed in the surrounding subperitoneal tissue (**perinephritic abscess**).

Suppurative nephritis (not due to pyelonephritis) occurs most frequently in connection with ulcerative endocarditis and with traumatic pyæmia. It may however be associated with a great variety of diseases, such for instance as dysentery, ulcerative phthisis, and actinomycosis (ISRAEL, *Virch. Arch.* vol. 74). The abscesses are usually punctiform or miliary; large abscesses are rare.

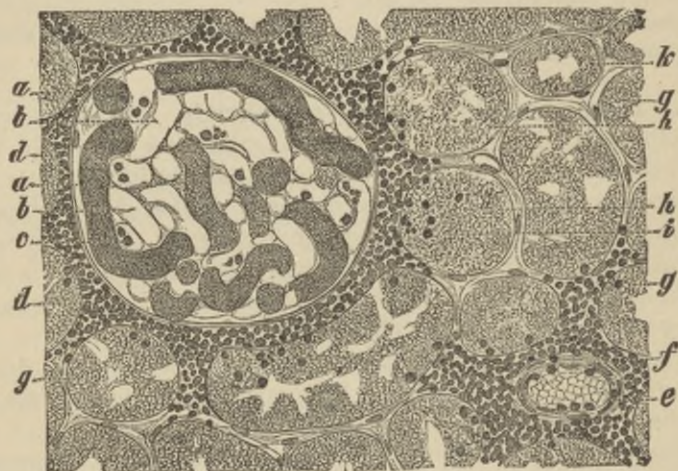


FIG. 212. DISSEMINATED SUPPURATIVE NEPHRITIS.

(Section stained with gentian-violet and mounted in Canada Balsam: $\times 300$.)

a, capillary loop filled with micrococci
 b, empty denudeated capillary
 c, leucocytes in the capillaries
 d, cellular infiltration around the capsule
 e, venule
 f, cellular infiltration around the venule

g, convoluted tubule, with epithelium partly cloudy, partly denudeated and degenerate
 h, convoluted tubule with granular detritus
 i, leucocytes within the tubules
 k, limb of Henle's loop

Suppurative nephritis is not infrequently combined with embolic obstruction of the renal arteries, leading to the formation of infarcts.

According to LITTEK (*Zeitschr. f. klin. Med.* IV.) there are some forms of acute nephritis in which large numbers of micrococci are diffused throughout the whole of the kidney, filling up many of the tubules and Bowman's capsules. AUFRECHT reports similar cases (*Pathologische Mittheilungen* I. 1881. LETZERICH (*loc. cit.*) affirms that in diphtheria masses of micrococci may accumulate to such an extent in the circulatory and secretory channels that the urinary function is gravely interfered with.

ZIEGLER has never been able to discover such extensive accumulations of bacteria in the kidney, even in cases of diphtheria. The suspicion arises that some other appearance has been mistaken for colonies of micrococci. Treatment of the sections with alkalis and alcohol is not sufficient to determine with certainty the presence of these organisms.

BABES (*Arch. de physiol.* II. 1883) has recently described various forms of bacteria discovered by him in the renal blood-vessels in certain forms of nephritis accompanying pyæmic and septicæmic infection, scarlatina, articular rheumatism, yellow fever, etc. In connection with the latter he found chaplets of two to six diplococci, and suggests that they may be the exciting cause of the disease. STEVEN (*Glasgow Med. Journ.* 1884) discusses the suppurative affections of the kidney in a clear and able manner.

Chronic Parenchymatous Nephritis.

544. The inflammations of the kidney comprehended under the term **chronic parenchymatous nephritis** are all characterized by persistent inflammatory exudation from the blood-vessels into the renal tissue, accompanied by marked alteration of the epithelial structures. The persistent exudation takes place partly from the glomeruli and partly from the intertubular capillaries and venules.

The intertubular exudation saturates the renal tissues with inflammatory lymph, varying in quantity at different stages of the process and in different cases.

This inflammatory œdema is always accompanied by a more or less extensive cellular infiltration (Fig. 213 *q r*), which is often remarkably dense around the subcortical and interlobular venules (*q*), often also well-marked in the neighborhood of the intertubular capillaries (*r*) and here and there in exceptional amount round a few of the glomeruli. The extravasated leucocytes (*q*) and the liquid exudation may penetrate directly into the tubules, and the leucocytes gathered around the Bowman's capsules may in like manner penetrate them. Intertubular venous hæmorrhages are occasionally observed, and when the tubules are at the same time ruptured blood may enter these directly (NAUWERCK).

The vessels of certain of the glomeruli permit the escape of albuminous urine, which even during life may coagulate into a granular or homogeneous mass within the capsules. More commonly however coagulation takes place only within the tubules (especially in the loops of Henle), giving rise to the familiar hyaline casts or cylinders.

The glomerular capillaries frequently permit the escape of white (*e*) and red (*f*) blood-cells. The former often accumulate in great quantity in the capillary loops (*b*) before escaping, but they do not usually escape in large numbers into the lumen of the capsule.

Comparatively few of the red blood-cells (*e*) escape into the lumen of the capsules, though not infrequently larger extravasations are observed in which the capsules and their tubules appear widely distended with blood (*f p*).

In many cases the glomerular epithelium looks perfectly normal, but it is more common to find it somewhat swollen, the individual cells standing out clearly from the contours of the capillaries. Multiplication and

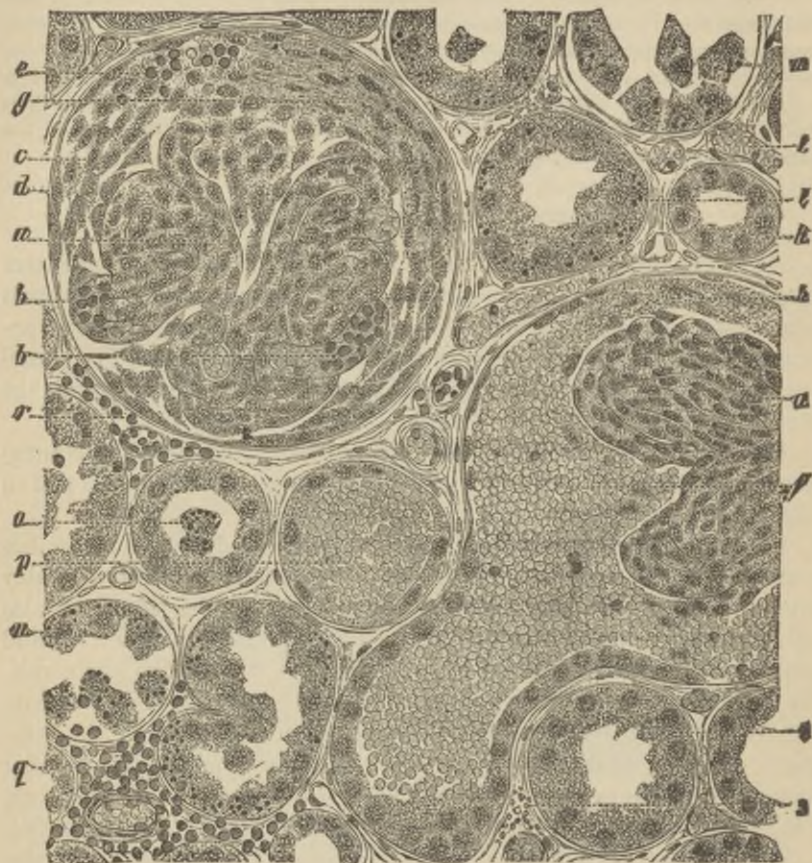


FIG. 213. CHRONIC HEMORRHAGIC (PARENCHYMATOUS) NEPHRITIS.

(Section hardened in Müller's fluid, stained with alum-carmin, and mounted in Canada balsam; the fatty change represented is taken from another preparation treated with perosmic acid: $\times 300$.)

- | | |
|--|---|
| a, normal capillary loop | i, convoluted tubule |
| b, capillary filled with white blood-cells | k, limb of Henle's loop |
| c, desquamated glomerular epithelium | l, tubule with pigmented and fatty epithelium |
| d, capsular epithelium | m, pigmented and desquamated epithelium |
| e, exudation consisting of red and white blood-cells and granular matter | n, fatty cells, some of them desquamated |
| f, hæmorrhage into a capsule and tubule | o, loose fatty epithelial cells in the lumen of a normal tubule |
| g, granular stratified exudation, containing nuclei of desquamated glomerular epithelium | p, tubule filled with blood |
| h, disintegrated blood containing desquamated glomerular epithelium | q r, cellular infiltration around venules and capillaries |
| | s, pigment-granules in stroma |
| | t, capillaries filled with blood |

desquamation usually set in, and epithelial cells are seen in greater or less numbers lying loose within the capsules (*c*). These may be washed out unchanged into the tubules, but at times they accumulate in quantity within the capsule, surrounding the glomerular vessels in successive strata (*c*) and separating or compressing the loops by their intrusion. Frequently too the cells break down or dissolve in the liquid escaping from the glomerular vessels, and homogeneous or granular coagula (*g h*) are thus formed, which more or less completely ensheath the glomerulus. The nuclei enclosed in these coagula often persist for a long time, and occasionally give them the appearance of intracapsular new-formations of connective tissue.

In addition to the swelling and desquamation of the epithelium we often remark a certain amount of fatty change, which gives the cells the look of being powdered or sprinkled with minute globules.

The glomerular capillaries appear for the most part unaltered, though all the changes described in Art. 540 may occasionally be observed.

The capsular epithelium (*d*) is as a rule far less altered than the glomerular, though it too may in certain cases become swollen, break up, and desquamate. It may also undergo fatty degeneration.

The tubular epithelium always shows more or less marked signs of cloudy swelling, fatty degeneration, desquamation, and disintegration. The most striking of these changes, the fatty degeneration (*l m n*), is distinguished by the presence of droplets and globules of oil within the cells, varying in size and number according to the degree of degeneration. The fatty cells (*m o*) are the most apt to be shed, though this happens also in the case of the swollen and cloudy cells. These desquamated cells dissolve *in situ* or are carried into remoter parts of the tubules, where they may coalesce into hyaline cylinders.

The degenerative changes affect chiefly the convoluted tubules, though they are not entirely absent in the loops and collecting tubes. In the latter especially there may be very marked desquamation of the epithelium.

When considerable hæmorrhages have taken place in the glomeruli the corresponding tubules are distended with blood, their epithelium appearing compressed and flattened (*p*). The blood presently disintegrates, forming granules and flakes of pigment: these are usually taken up by the epithelial cells (*l m*), part also appearing in the fibrous stroma (*s*) whither they are carried by the absorbents (Art. 530).

In many cases it is difficult to make out definitely in what way a chronic parenchymatous nephritis has begun. In other cases it is clearly the sequel of an acute affection. So far as microscopical investigation indicates it is possible that all the varieties of acute nephritis above described, except the suppurative form, may occasionally terminate in the chronic parenchymatous form. Moreover the various de-

generative processes described in Arts. 534-537 may be combined with secondary inflammatory changes, and so give rise to the morbid appearances of chronic nephritis.

VIRCHOW, FÖRSTER, LANGHANS, and FRIEDLÄNDER describe in certain cases of nephritis a multiplication of the nuclei of the glomerular capillaries, which may at times become very considerable. NAUWERCK has confirmed this by showing that the endothelial cells of the capillaries swell up and multiply (Fig. 209, Art. 540).

LITTEN (*Charité-Annalen* IV.) states that in the nephritis following scarlatina and relapsing fever concentrically stratified connective tissue is rapidly formed within Bowman's capsules. According to the account in the text this would appear to be, not new connective tissue, but stratified fibrin enclosing nuclei (Fig. 213 g).

545. The textural changes just described pass through various developmental stages, and thus in any given case one or another of them may be the most prominent. We may therefore distinguish certain anatomically distinct forms of chronic parenchymatous nephritis, depending on the stage of the process reached at the time the kidney is examined.

In the first form the connective tissue is but slightly altered (being simply infiltrated) while the epithelium of the tubules and in part of the glomeruli is highly fatty. This form is best described as the **inflamed fatty kidney**, or the kidney of fatty parenchymatous nephritis. The kidney is moderately swollen and soft, the cortex pale-gray and beset with numerous white opaque spots and streaks. The number and magnitude of these fatty patches depends on the degree of degeneration. They may be confined to the outer or to the inner zone of the cortex. The medulla is usually more or less reddened, often indeed cyanotic. If the cortical veins are full they show as red streaks, and the stellate veins show on the pale subcapsular surface as deep-red star-shaped blotches.

In a certain sense the **large mottled kidney** forms an antithesis to the fatty kidney. It is swollen, often considerably, and its surface is mottled with gray and red. On section the cortex looks broadened, moist, soft, and streaked with gray and grayish-red; the medulla is hyperæmic. Corresponding to its external appearance we find the tissue of the kidney in a condition of inflammatory œdema, the intertubular septa being in many places infiltrated with small cells. The glomerular epithelium is here and there swollen and desquamated, and in many of the tubules the epithelial cells are likewise cloudy, swollen, and desquamated. The fatty change is only moderately developed, the amount of fat present not sufficing to whiten the parenchyma.

When the kidney is much infiltrated and at the same time fatty, it is enlarged and the cortex is mottled with white patches; in extreme fatty change it may be all but uniformly white. This is the so-called **large white kidney**.

The differences between the three forms being rather differences of degree than of kind, there are naturally many intermediate varieties.

The external naked-eye appearance of the kidney depends greatly on the amount of blood it contains at the time of examination. Thus when the parenchyma looks red we must not at once conclude that there is no fatty degeneration, for when the latter is slight it may be quite disguised by the presence of hyperæmia. Conversely, mere paleness of the tissue is by no means a certain index of fatty change.

Hæmorrhage may accompany all forms of nephritis, but there is one particular form in which the hæmorrhage amounts to a characteristic; the cortex chiefly, the other parts in a less degree, being studded with red and brown patches of extravasation. This form is therefore described as **chronic hæmorrhagic nephritis** (Fig. 213). The parenchyma may be altered in various ways; the most common change is a considerable degree of fatty degeneration with much infiltration of the fibrous stroma. The kidney is thus as a rule swollen and speckled with white, or almost uniformly white. There is usually much desquamation of the glomerular epithelium.

When the most marked character in a case of chronic nephritis is the morbid change in the glomerular epithelium, we might fitly describe it as **chronic glomerulo-nephritis**. When the accompanying degeneration of the tubular epithelium is slight the kidney may appear but very little altered, even though death has taken place from failure of the renal function; in such cases microscopic examination alone reveals the true character of the disease. The changes in the glomeruli are the same as those described in Arts. 544 and 540. In marked cases many of the glomeruli are obliterated.

546. Terminations of chronic parenchymatous nephritis.

This disease not infrequently passes through the stages indicated in Arts. 544 and 545 and terminates in fatal suppression of the urinary function. In cases that are not speedily fatal the changes above described become more and more marked: which particular one of these changes is the most prominent depends on the individual peculiarities of the case.

The **fatty change** is not rarely the most extensive, the kidney becoming more and more of an unmixed white color as the grayish or reddish regions of fairly sound tissue diminish or disappear; the latter may at last be confined to the parts about the medullary rays. In such cases not only does the renal epithelium become fatty and perish, but oil-globules begin to appear in the walls of the glomerular and intertubular capillaries.

Often too the advancing fatty degeneration is accompanied by increased **cellular infiltration** of the connective tissue, so that the intertubular stroma becomes transformed into a series of swollen cellular columns.

At an early stage **atrophy of the secreting structures** begins in

the regions most affected. The tubular epithelium may in consequence of the degenerative changes be lost altogether, the denuded tubules becoming therefore collapsed and functionless. This is however by no means invariably the case, for it frequently happens that in the absence of other complications the fatty and desquamated cells are replaced by the regenerative multiplication of the remaining ones. Destruction of the glomeruli is a more serious danger, for it involves not only the suppression of the urinary secretion but also the partial interruption of the intertubular circulation. The glomeruli may be rendered functionless by an excessive accumulation of loose epithelium and exuded liquid within their capsules, leading to compression of the capillaries. More commonly however the injury is primary, and due to hyaline swelling of the capillary-walls and in part to thrombosis of their channels. The epithelium always perishes, partly by desquamation, partly by fatty degeneration and disintegration. Sometimes a certain amount of fibrous hyperplasia occurs in the neighborhood of the obliterated glomeruli, and the capsules thus appear abnormally thickened.

These localized atrophic changes in the secreting structures are sooner or later followed by **cicatricial contractions** of the external surface. They are seldom quite absent in the large white kidney, and in some cases are so numerous as to give the organ a granulated appearance while its volume becomes less than normal. This is of course possible only in cases of long standing, in which the changes in the parenchyma have spread so gradually that its functions have at no time been interrupted. Such cases both in their clinical course and histological characters approach those which we class under the head of renal cirrhosis or indurative nephritis with contraction.

Chronic Indurative Nephritis.

547. **Chronic indurative nephritis** or **renal cirrhosis** is distinguished anatomically by the fact—that the inflammatory process issues in hyperplasia of the renal connective tissue, and consequent induration or cirrhosis of the parenchyma.

In chronic parenchymatous nephritis there is a certain amount of fibrous overgrowth, but this is of altogether minor importance in comparison with the other results of the inflammatory process. In indurative nephritis on the other hand it is this fibrous overgrowth and the resulting cirrhosis which is the essential characteristic of the affection.

The disease sometimes commences acutely, but its onset is usually very gradual and insidious. In either case the appearance in the stroma of small patches of cellular infiltration is the most important of the initial changes. This infiltration is moreover always accompanied by degeneration of the epithelium, though the extent and intensity of this varies much in different cases, a fact which in the main explains the

diverse clinical phenomena exhibited in connection with the onset of the disease.

In like manner there are differences in the amount of inflammatory cedema accompanying the infiltration, and corresponding differences in the extent to which the kidney is swollen.

When the interstitial hyperplasia has continued for some weeks or months cicatricial patches appear, and as they contract give rise to depressions and puckerings of the outer surface of the kidney. These contractions are more or less numerous and extensive according to the extent of the original infiltration. The kidney is either anæmic and pale-gray in tint, or hyperæmic when it appears grayish or brownish red; its size may be normal or increased or diminished; at a later stage it is harder, tougher, and denser than in health.

The cortex is always thinned at the site of the cicatrices; elsewhere its thickness may be normal or even increased, but it is never very much increased. The cortex on section has the same tint as the surface. The pale white patches of fatty degeneration may be entirely absent, though not infrequently they may be detected in varying number within the cortical zone. The medullary zone is usually redder than is normal.

The connective tissue is hardened and overgrown not merely within the cicatrices but also at various points in the deeper layers of the cortex: the secreting structures are atrophied (Fig. 214).

The indurated patches lie chiefly in the neighborhood of the small veins, though they may be distributed irregularly throughout the region of the labyrinth.

The first stage of the indurative change is the appearance of the disseminated cellular infiltration (*l*) of the stroma. Then the intertubular tissue (*k*) becomes more or less notably increased and fibrous: it often becomes thickly beset with small round-cells, or at least the nuclei are much more numerous than usual.

The capsules of the glomeruli in the affected region are in general considerably thickened, and appear to be made up of nucleated fibrous tissue arranged in concentric layers (*a*). It is however to be noted that the amount of thickening varies greatly: in some cases it is enormous, in others very slight. The latter is observed in instances where the infiltration is mainly around the small veins, the former where it is more uniformly diffused over the whole of the labyrinth.

The tunica adventitia of the blood-vessels (*n o*) is usually more or less thickened. Sometimes the thickening extends to the inner coats also, and leads to obstruction of the vessel. A certain number of the capillaries always become impermeable as the change progresses.

The glomerular epithelium in recent cases is seen to be swollen or loosened and desquamated (*f*), though this change is seldom so marked as in the forms of nephritis already described: it is also rare for the capsular epithelial cells to show signs of any great degree of multiplication

or of desquamation. When there is much thickening of the capsule, or much disturbance of the circulation through obstruction of the capillaries or narrowing of the vasa afferentia, the glomeruli begin to atrophy. The capillary loops lose their epithelium (*c*), and are transformed into pale hyaline or finely-granular denuded (*d*) structures, which are impermeable by the blood or by artificial injections.

During the progress of the disease the glomeruli excrete albuminous urine, which usually flows off into the tubules; sometimes however it coagulates in the presence of the shed epithelial cells and gives rise to the stratified fibrinous and nucleated masses (*e*), which we have already described as surrounding the glomerular vessels. The albuminous urine often contains extravasated red and white blood-cells.



FIG. 214. INFLAMMATORY INDURATION AND ATROPHY OF THE RENAL TISSUE.

(Section treated with alcohol and alum-carmin, and mounted in Canada balsam; $\times 250$.)

- | | |
|---|---|
| a, capsule of Bowman thickened and fibrous | g, capsular epithelium |
| b, normal glomerulus | h, collapsed tubule with atrophied epithelium |
| c, glomerulus with vessels partly obstructed and hyaline, the epithelium being nearly all destroyed | i, collapsed and denuded tubule |
| d, obliterating glomerulus | k, hyperplastic fibrous stroma |
| e, nucleated coagulum composed of fibrinous exudation and shed epithelium | l, cellular infiltration |
| f, glomerular epithelium loosened and shed | m, normal tubule somewhat dilated |
| | n, vas afferens. |
| | o, small vein |

The tubular epithelium undergoes the same forms of degeneration as we have described in connection with parenchymatous nephritis, though the degeneration is usually less intense and less wide-spread: in cases of no very long standing we therefore find the greater number of the tubules still healthy.

By the time that new fibrous tissue has been formed at a particular spot, the corresponding tubules are usually advanced in atrophy. The lumen is narrowed, the secreting epithelium represented by small cubical cells lining the walls or lying loose within the lumen (*h*). Many tubules are empty and collapsed, their epithelium having altogether disappeared (*i*).

The degeneration and atrophy of the tubules is due partly to the disturbances of circulation and nutrition caused by the inflammatory changes, partly to the destruction of the glomeruli (Art. 524).

The contents of the unaffected tubules are the same as in parenchymatous nephritis, though fewer of them contain casts and masses of epithelial detritus. Hæmorrhages and pigmentary deposits are likewise less common.

Indurative nephritis and the cirrhotic contracted kidney (Art. 548) correspond partly to the form described by clinical observers as true contracted kidney, partly to so-called secondary contracted kidney. The term "true contracted kidney" has been made to include the arteriosclerotic contracted kidney (Art. 526), whose mode of origin is totally different from that of the cirrhotic contracted kidney. Confusion thus arises, and it may therefore be well in future to avoid the use of the clinical term.

The term "secondary contracted kidney" is applied to cases which begin acutely. This distinction is valueless from the point of view of the morbid anatomist, as such cases differ in no essential respect from those whose onset is gradual or undiscerned.

548. Terminations of chronic indurative nephritis. When this affection is not speedily fatal from the extension of the accompanying epithelial degeneration, it may lead in the course of months or years to very extreme induration and obliteration of the secreting structures. The kidney is then always diminished in size, often remarkably so; the capsule is adherent; the surface granulated. The 'granulations' may be coarse or fine, regular or irregular (Fig. 215 *A*).

The tint of the protuberant **granulations** varies greatly, depending on the amount of blood present in the cortex and on the degree of fatty change in the epithelium. It is usually grayish-red, sometimes however it is gray or mottled gray and white, or almost entirely white and opaque. The depressions and contractions are usually somewhat redder.

The renal tissue is dense and tough, the cortex thinned, the papillæ often truncated or stunted. The tint of the cut surface corresponds with that of the external surface: the medulla is generally somewhat redder, but not infrequently it has much the same tint as the cortex.

The cortical zone is always traversed by fibrous bands with small islands of less altered or persistent normal tissue lying between them (Fig. 215 *A*).

The fibrous bands start from the intergranular depressions of the surface (*B*) and run towards the bases of the medullary papillæ, be-

ing interconnected by numerous transverse bands; the islands of normal tissue are therefore more frequently rounded or oval than elongated. The fibrous bands run in general along the course of the veins, though they frequently ramify without any apparent regularity through the labyrinth. The more numerous they are the smaller of course are the islands enclosed in their meshwork. Cases are met with in which the greater part of the labyrinth is thus indurated and obliterated, the only parts retaining their function being parts of the medullary rays and the tissue immediately adjoining. In such cases the surface granulations

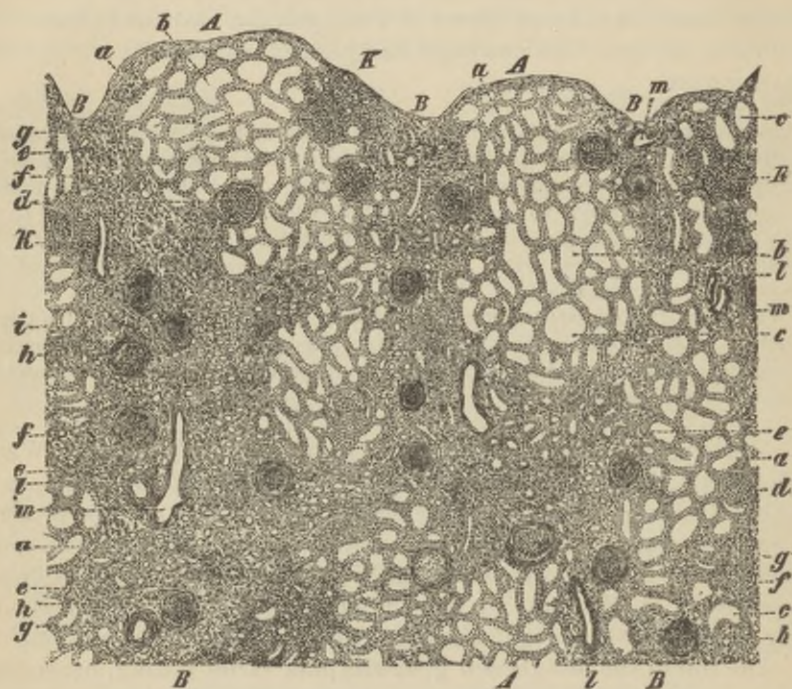


FIG. 215. CIRRHOTIC CONTRACTED (OR 'GRANULAR') KIDNEY.

(Vertical section through the outer zone of the cortex, stained with alum-carminé and mounted in Canada balsam $\times 40$.)

A, persistent renal tissue giving rise to 'granulations.'

B, cicatricial bands giving rise to depressions and contractions.

- | | |
|---|---|
| <i>a</i> , normal tubules | <i>g</i> , hyperplastic fibrous tissue |
| <i>b</i> , dilated tubules | <i>h</i> , atrophied glomeruli with thickened capsule |
| <i>c</i> , cysts | <i>i</i> , the like with normal capsules |
| <i>d</i> , normal glomeruli | <i>k</i> , cellular infiltration |
| <i>e</i> , atrophied and collapsed tubules filled with loose epithelium | <i>l</i> , arteriole |
| <i>f</i> , atrophied empty tubules | <i>m</i> , venule |

are naturally very fine and regular; where the cirrhosis is confined to the course of the veins the irregularities of the surface are usually much

more marked. The course and mode of extension of the indurative change are in fact very similar to what is observed in cirrhosis of the liver (Art. 496).

The fibrous bands of the cortex always enclose atrophied and collapsed tubules (*e f*) and obliterated glomeruli whose capsules are more or less thickened (*h i*). These bands are thus simply portions of renal tissue of which the secreting structures are rendered functionless and the stroma hyperplastic by chronic inflammation. Here and there a tubule or a glomerulus may persist within the indurated region, while some of the tubules are dilated into cysts by the retention of already secreted urine (*c*).

The islands of persistent secreting tissue may present a normal appearance (*a*). More frequently some of the tubules and glomeruli show signs of compensatory hypertrophy (*b*). Some of the epithelial cells are fatty, though the extent of this change varies much in different cases. Here and there too we find patches of cellular infiltration (*k*), a sign that the inflammatory process is kept up.

Both in the cortex and in the medulla are seen tubules containing hyaline cylinders, or masses of shed epithelium and extravasated leucocytes.

The induration of the intertubular stroma and the loss of the glomeruli involve the obliteration of a considerable portion of the vascular system of the cortex. The vessels passing into the medullary zone (Art. 526) consequently become dilated, though the channels thus opened up never fully compensate for the loss of the cortical channels.

Tuberculous and Syphilitic Nephritis.

549. **Tuberculosis of the kidney** is in most cases due to embolic infection. In rare instances primary tuberculosis of the bladder, prostate, spermatic duct, or testicle may extend to the kidney by way of the ureter.

Acute miliary tuberculosis and chronic localized tuberculosis are the two forms of the affection.

Miliary tuberculosis of the kidney is merely a part of a general eruption of tubercle in the various organs of the body. Wherever the tuberculous virus lodges, in cortex or medulla, there appears a small semi-translucent grayish speck, which presently grows into a gray nodule. This then becomes whitish, and is often surrounded by a hæmorrhagic areola. The whitish tinge is due partly to infiltrated leucocytes, partly to turbid swelling and necrosis of the epithelium set up by the action of the bacilli. When the cellular infiltration becomes great the renal tissue-elements within the infiltrated area perish.

The number of tubercles appearing in the kidney is sometimes very

great, sometimes small. Occasionally the tubercles are confined to the region supplied by a single twig of the renal artery.

Chronic localized tuberculosis of the kidney begins, like the miliary form, at the spot whither the bacilli have been carried by the bloodstream. This may be either within the parenchyma or in the mucous membrane of the calices or pelvis.

At this spot gray nodules are formed, and presently become caseous. In the course of weeks or months they grow into large irregular nodes by progressive marginal infiltration, while new nodules develop in the tissue around. In the mucous membrane of the pelvis the process extends partly as a diffuse infiltration, partly as a nodular eruption. The nodules and the infiltrated tissue ultimately become necrosed and caseous, and presently disintegrate.

After a time the kidney appears studded with gray nodules and white opaque nodes, the larger of these being softened and excavated. The medullary papillæ are many of them caseous and broken down, the pelvis appears enlarged by the excavations, and in places is continuous with the tuberculous cavities of the parenchyma. The mucous membrane is infiltrated, thickened, and gray, its surface here and there necrotic and covered with yellow sloughing ulcers; or the deeper layers being uniformly infiltrated and thickened, the entire mucous membrane may be transformed into a cheesy broken-down ulcerous mass.

The tuberculous process frequently extends to the ureter, transforming it into a more or less gristly tube with thickened walls. The inner surface is either white necrotic and ulcerated throughout its entire extent, or it is gray and infiltrated, and studded with scattered patches of necrosis and ulceration.

In the more advanced stages of the disease the kidney appears somewhat enlarged, the capsule adherent, and the surface often rough and irregularly nodulated. Cheesy and granular detritus occupies the pelvis, which latter by excavation or by retention of urine is abnormally large. In extreme cases the entire kidney is destroyed, nothing remaining but a thick-walled sack containing cheesy or puriform detritus.

As a rule both kidneys are affected, though it is common to find the process much more advanced in one kidney than in the other.

550. Syphilitic affections of the kidney exhibiting any special or characteristic features are not common. Renal inflammation referable to the influence of the syphilitic poison is however occasionally met with, and is characterized by the formation of coarse cicatricial bands and of caseating gummata.

In congenital syphilis induration and contraction of the kidney has in somewhat rare instances been observed.

References on renal tuberculosis:—**RAYER**, *Maladies des reins* Paris 1840; **VIRCHOW**, *Krankhafte Geschwülste* II.; **SCHMIDTLEIN**, *Deutsche Klinik* 1863; **KUSSMAUL**, *Würzburger med. Zeitschr.* IV.; **ROSENSTEIN**, *Berl. klin. Woch.* 1865;

COLIN, *Gazette hebdom.* x.; SOUTHEY, *Brit. Med. Journ.* 1, 1867; MOSLER, *Arch. d. Heilk.* 1863; E. HOFFMANN, *Deutsch. Arch. f. klin. Med.* III.; HUBER, *ibid.* IV.; KLEBS, *Handb. d. path. Anat.*; EBSTEIN, *Ziemssen's Cyclop.* xv.; ARNOLD, *Virch. Arch.* vol: 83; GAULTIER, *La tuberculose rénale primitive* Thèse de Paris 1882; DICKINSON, *Renal and urinary affections* III. London 1885; STEINTHAL, *Virch. Arch.* vol. 100; HILTON FAGGE, *Principles and practice of medicine* II. London 1886.

On renal syphilis see VIRCHOW, *Krankhafte Geschwülste* II.; CORNIL, *Journ. de l'anat.* 1865; MOXON, *Guy's Hosp. Rep.* 1868; LANCEREAUX, *Treatise on syphilis* I. (New Syd. Soc.) London 1868; GREENFIELD, *Atlas of Path.* (New Syd. Soc.) London 1879; NEGELL, Thèse de Paris 1884; KLEBS, *loc. cit.*; CORNIL and RANVIER, *Man. d'hist. path.* Paris, 1878, *Man. Path. Hist.* II. London 1886; the latter found in one case a number of gummata, some of them as large as a pea.

In syphilitic patients we not infrequently find the kidney in a state of amyloid degeneration (MOXON, *loc. cit.*).

In tuberculosis of the urinary organs ROSENSTEIN and BABES (*Cent. f. d. med. Wiss.* 1883) have demonstrated the presence of tubercle-bacilli in the urine.

CHAPTER LXX.

RENAL CYSTS AND HYDRONEPHROSIS.

551. **Renal cysts.** When a urinary tubule is obstructed by a uratic deposit, a tube-cast, a cicatricial band, or other cause, the urine may accumulate behind the obstruction and distend its lumen into a cyst. The like may happen to a glomerular capsule when the mouth of its tubule is blocked.

Kidneys otherwise normal occasionally contain smooth-walled cysts varying in size from that of a pea to that of a walnut and protruding more or less above the surface of the organ. Cysts are however much more frequently met with in diseased kidneys, and especially in the contracted forms due to cirrhosis and arteriosclerosis. THORN states that cysts may also be due to inflammation of the pelvis or calices of the kidney extending by continuity to the stroma of the medullary papillæ. In fact it would appear that the compression and obstruction of the tubules resulting from inflammatory change in the tissue about them lead much more frequently to the formation of cysts than internal blocking of the lumen by concretions or deposits. Where a certain amount of constriction has already taken place such internal obstruction may no doubt make the occlusion complete.

The number of these cysts found in a single kidney varies greatly. Cases occur in which they are so numerous as to occupy the whole organ, mere shreds or septa of renal tissue separating the contiguous cavities (cystic degeneration).

The largest cysts met with in kidneys altered by nephritis are about the size of a cherry, the smallest are microscopic. It frequently happens that none are larger than a pea, though in exceptional instances two or more coalesce to form a single cavity.

The larger cysts have thin translucent walls, the inner surface being smooth, and the contents clear or yellowish-brown or slightly blood-stained liquid generally containing urinary salts. The smaller cysts met with in contracted kidneys not infrequently contain a colloid substance. All cysts are lined with epithelium, the cells being usually flattened, rarely columnar.

When the cysts are both large and numerous the kidney may have the look of a large tumor. This condition is sometimes developed before birth, the child being born with kidneys transformed into relatively

enormous honeycombed tumors representing an extreme degree of cystic degeneration: this is referred to as **foetal cystic disease**. The tumors may be so large as to interfere with delivery. According to VIRCHOW the condition is sometimes due to inflammatory occlusion and atrophy of the papillæ; but THORN thinks it is more frequently brought about by inflammation extending to the substance of the papillæ from the calices. Absence of the pelvis or occlusion of the ureters may also have the like effect. Some authorities hold that the condition is due to a primary fault of development.

References:—BRIGHT, *Memoirs on abdominal tumors* (New Syd. Soc.) London 1860; ROKITANSKY, *Lehrb. d. path. Anat.* III. 1861; BECKMANN, *Virch. Arch.* vol. 9; FRERICHS, *Die Bright'sche Nierenkrankheit* Brunswick 1851; SIEBOLD, *Monatsschr. f. Geburtskunde* 1854; VIRCHOW, *Gesam. Abhandl.* Frankfurt 1856, *Virch. Arch.* vol. 46; BRÜCKNER, *ibid.*: HERTZ, *ibid.* vol. 30; SIMON, *Med. chir. Trans.* XXX.; KOSTER, *Dublin Quart. Journ.* XLVI.; EVE, *Trans. Path. Soc.* XXXI. (1860); THORN, *Beitrag z. Genese d. Cystenniere* In. Diss. Bonn 1882; CHOTINSKY, *Ueber Cystennieren* In. Diss. Bonn 1882 (this author affirms that in foetal cystic kidney the occlusion of the tubules is to a great extent due to excessive multiplication of the epithelial cells); CORNIL and BRAULT, *Path. du rein* Paris 1884; DICKINSON, *Renal and urinary affections* III. London 1885 (with cases); CORNIL and RANVIER *Man. Path. Hist.* II. London 1886. A number of cases are described in the *Transactions of the Pathological Society*.

552. **Hydronephrosis.** When the escape of the urine from the pelvis of the kidney is prevented or obstructed, it accumulates and distends that cavity, giving rise to what is called hydronephrosis or dropsy of the kidney.

Renal calculi impacted in the ureter, stricture or twisting of the ureter, valvular folds of mucous membrane, or compression by the gravid uterus or by uterine ovarian and vesical tumors, enlarged prostate, urethral stricture, and phimosis—are all possible causes of the condition. In new-born infants the cause of the obstruction is usually some anomaly of the ureter, malposition of the kidney, valvular folds in the ureter, constriction or occlusion of the urethra, enlargement of the prostate or colliculus seminalis, or phimosis.

The pelvis and calices are sometimes enormously distended, forming a sack large enough to fill the greater part of the abdomen and containing 10 to 20 litres of liquid. The part of the ureter above the obstruction is dilated in like manner.

The first result of this accumulation of liquid is the flattening of the papillæ and thinning of the cortex of the kidney. The parenchyma persists for a considerable time but at length undergoes atrophy, the tubules being reduced to flattened or cleft-like channels lined with compressed epithelium, and ultimately with the glomeruli becoming functionless and obliterated. In extreme cases the renal tissue is reduced to a thin film or in part disappears altogether, the sack consisting in great

measure merely of fibrous tissue, which in cases of old standing may be of remarkable thickness.

At first the liquid is simply urine; but as the pressure increases less and less urine is excreted, and when the renal tissue atrophies the excretion ceases altogether. The sack however continues to increase in size, owing to the secretion of liquid by the mucous membrane of the pelvis and calices. This liquid contains no urinary matters, but is albuminous; and sometimes it is tinged with blood. Colloid masses and cholesterin are also found in some cases.

Hydronephrosis is usually confined to one side, it is rarely bilateral. When the obstruction affects only a part of the pelvis of the kidney, or when there are two pelves, the hydronephrosis may be partial.

References:—VIRCHOW, *Gesamm. Abhandl.* Frankfort 1856; SÄXINGER, *Prager Vierteljahrsschr.* 1867; ACKERMANN, *Deut. Arch. f. klin. Med.* I.; HELLER, *ibid.* V.; HILDEBRAND, *Sammlung klin. Vorträge* 5; GUSSÉROW, *ibid.* 18; SIMON, *ibid.* 88; STADFELDT, *Monatsschr. f. Geburtskunde* 1862; FARRE, *Lancet* 2, 1861; MORRIS, *Med. chir. Trans.* LIX. (1876); EBSTEIN, *Ziemssen's Cyclop.* XV.; AUFRECHT, *Die diffuse Nephritis* Berlin 1879 (this author tied the ureter in animals, and observed degeneration of the renal epithelium and afterwards multiplication of the connective-tissue cells); DICKINSON, *loc. cit.*; ROBERTS, *Urinary and renal diseases* London 1885 (with references and cases).

CHAPTER LXXI.

PYELITIS AND PYELONEPHRITIS.

553. When irritant substances are excreted by way of the kidney they frequently set up inflammation in the mucous membrane of the pelvis (**pyelitis**) and ureter. Thus catarrhal, croupous, and diphtheritic inflammation of this membrane may follow or accompany typhoid, scarlatina, small-pox, pyæmia, diphtheria, cholera, nephritis, etc. and the use of drugs like cantharides, copaiba, cubebs, turpentine, etc. When the irritant matter ceases to be excreted the inflammation usually comes to an end also.

These secondary or symptomatic inflammations are not so serious as the more independent and progressive inflammations set up and maintained by the presence in the renal pelvis of parasitic organisms or urinary concretions.

In speaking of parasitic pyelitis we note in passing that tuberculous pyelitis, already described (Art. 549), is due to the invasion of a bacillus. In like manner micro-organisms give rise to the pyelitis which sometimes accompanies suppurative or septic nephritis. Another purulent or suppurative variety is caused by the action of micro-organisms reaching the pelvis from the bladder through the ureter. The latter micro-organisms are usually micrococci, though bacilli and filamentous fungi may also reach the kidney by this channel. They enter the bladder as a rule through the urethra, but cases occur in which they break into it from abscesses in the rectum, uterus, vagina, or pelvic connective tissue.

Bacteria are often introduced into the bladder by means of dirty catheters. In other instances they attack the urethra primarily (as in gonorrhœa), and extend gradually as far as the bladder.

Their lodgment in the bladder is favored if there be any interference with the evacuation of the urine, such as is caused by stricture or paralysis. When the bladder is incompletely emptied so that some urine remains in it for a considerable time the bacteria which enter it find time to multiply and set up changes in the urine. As the urine accumulates and the ureters become dilated the bacteria find ready access to the pelvis of the kidney through these channels.

Animal parasites, as well as vegetable, may induce inflammation in the pelvis and ureter. This is especially true of *Bilharzia* or *Distoma*

hamatobium (Art. 239), whose eggs are deposited and embryos hatched in the urinary tract. *Eustrongylus gigas* (Art. 231) is much less dangerous.

All the forms of concretion described in Arts. 531 and 532 are capable of exciting more or less intense pyelitis. They give rise to continuous mechanical irritation, which in the case of the hard and spiny oxalate-calculi is often very great, and is not slight in the case of the other forms. They produce mischief in another way when they become impacted in the ureter and cause retention of urine as well as local lesions.

554. Pyelitis, set up in the various ways just described, varies much in its symptoms and course. In catarrhal inflammation the mucous membrane is red and swollen, often studded with small extravasations, and secreting a liquid abounding in epithelial cells or pus according to the stage of the disorder. The lymphadenoid tissue existing in variable quantity in the submucosa is often swollen, and appears in the form of gray nodular swellings in the reddened mucous membrane. In chronic cases ulceration and thickening takes place. When the inflammation is diphtheritic patches of the mucous membrane rapidly slough. Bacteria have a very destructive action, as the urine becomes alkaline owing to their multiplication in it, and the products of the decomposition corrode the inflamed tissue. Sooner or later the bacteria invade the renal parenchyma. According to KLEBS they advance along the collecting tubes and tubules destroying the epithelium and exciting inflammation.

As a result of this invasion the kidney swells up, often enormously, and looks as if soaked or sodden. At the same time in the cortex and medulla appear a number of small yellow patches surrounded by a zone of hyperæmia, which are simply small patches of suppuration. Purulent pyelitis thus gives rise to **purulent pyelonephritis** (or so-called 'surgical kidney'). The process may issue in induration, but more commonly the suppurating patches grow into large abscesses which burst into the pelvis of the kidney. Not infrequently abscesses form in the tissue immediately surrounding the kidney, and are called **perinephritic abscesses**. If the suppuration within the kidney goes on large pus-secreting cavities communicating with the renal pelvis are produced, and in extreme instances the whole of the kidney is thus destroyed, its place being occupied by a mere pus-containing sack. This condition is referred to as **pyonephrosis**.

Parasitic pyelonephritis may be unilateral or bilateral; in the latter case it is usually more advanced on one side than on the other.

555. **Calculous pyelitis** leads partly to thickening and induration of the affected tissues, partly to ulceration. Not infrequently the inflammation, at least during some part of its course, becomes purulent: occasional hæmorrhages are also common.

The inflammation sooner or later extends to the renal parenchyma

and leads to swelling and cellular infiltration, terminating in suppuration or in fibroid induration. In either case some portion of the renal tissue is destroyed. The whole of it may perish in extreme cases, leaving nothing but a fibrous sack surrounding the original calculus. Perinephritic abscesses also are frequently produced.

When calculi of some size become wedged in the ureter the outflow of urine may be interrupted. If in consequence of this a considerable accumulation of urine takes place in the pelvis of the kidney we may have hydronephrosis (Art. 552) superimposed on pyelitis. The retained urine often decomposes and thus intensifies the inflammation so that it becomes purulent: in this way pyonephrosis succeeds hydronephrosis.

The impacted stone may be gradually urged forward into the bladder by the pressure of the accumulating urine, giving rise to hæmorrhage, erosion, and inflammation on its way.

The ulcers, whether of the ureter or pelvis, may break through externally and thus enable pus to escape into neighboring parts, such as for instance the intestine or the bladder. More often however the pus escapes into the perinephric (subperitoneal) cellular tissue, and gives rise to wide-spread suppurative or septic inflammation.

Calculous pyelitis is usually unilateral, rarely bilateral.

References:—MICHAELIS, *Wien. med. Presse* XI.; EBSTEIN, *Ziemssen's Cyclop.* XV.; BRIGHT, *Abdominal tumors* (New Syd. Soc.) London 1860; Discussion, *Internat. med. congress* London 1881 and *Lancet* 1, 1882; J. B. ROBERTS, *Amer. Journ. med. sciences* April 1883 (on perinephritic abscess); ROBERTS, *Urinary and renal diseases* London 1885.

CHAPTER LXXII.

RENAL TUMORS AND PARASITES.

556. Of the various primary **connective-tissue tumors** of the kidney **sarcoma** presents the greatest interest. Renal sarcoma is usually congenital, and is apparent at birth or becomes noticeable in the first months or years of life. The tumor is sometimes very large (4 to 6 kilogrammes), and consists of soft whitish tissue interspersed with patches of hæmorrhagic softening. The mass of the tissue is made up of round, spindle-shaped, and multiform cells. It sometimes contains large transversely-striated spindles (rhabdomyoma, Art. 153). These last have a special interest, for they are evidence that the tumor has arisen in tissue the early stages of whose development have in some way been disturbed (Art. 516).

Cellular **fibromata** are frequently met with in the kidney, and take the form of nodules of the size of a pea or smaller. Large fibrous tumors are very rare, as are also myxomata, lipomata, angiomatica, and their combinations. They all of them take the form of nodes seated in the parenchyma or on the capsule of the kidney, or in its pelvis or calices. GRAWITZ has investigated certain small subcapsular tumors, from the size of a pea to that of a cherry, and of a white marrow-like appearance, which have been described as lipomatous: he regards them as simply aberrant and proliferous portions of the suprarenal body. In their structure they are very like the degenerate suprarenals described in Art. 565, consisting of a fibrous stroma with rows and groups of cells containing a variable amount of fat. GRAWITZ has named them "*strumæ lipomatodes aberratæ renis.*" Telangiectatic tumors (angiomatica) in the renal pelvis sometimes give rise to severe hæmorrhage.

Adenomata of the kidney appear as well-defined white nodes of the size of a walnut or less, and with a structure like that of ovarian adenomata. WEICHELBAUM and GREENISH distinguish a papillary and an alveolar variety. The former they say starts in the collecting tubes, and consists of gland-like tubules and acini, studded internally with papillæ and lined with cylindrical epithelium. The alveolar form is said to start in the convoluted tubules and is lined with epithelium like theirs. It is very probable that these growths may develop into carcinomata.

Cancers of the kidney are either soft or hard, and lead to greater or less enlargement of the organ; sometimes the enlargement is very great. In the larger tumors the whole of the renal epithelium may be destroyed by the cancerous growth. The latter may extend into the pelvis. The

smaller tumors affect only a portion of the parenchyma and are often fairly well marked off from the sound tissue. The tumors commonly enclose softened and hæmorrhagic patches, whence blood and cancerous detritus may reach the urine. Renal carcinoma occurs at all ages, but is relatively frequent in children. In general it is unilateral, though cases are recorded in which a smaller tumor has been found in the second kidney.

Sarcoma and carcinoma are not infrequent as secondary or metastatic growths: they form rounded nodes.

References on myosarcoma:—EBERTH, *Virch. Arch.* vol. 55; COHNHEIM, *ibid.* vol. 65; BRODOWSKI, *ibid.* vol. 67; MARCHAND, *ibid.* vol. 73; BROSIN, *ibid.* vol. 96; KOCHER and LANGHANS, *Deut. Zeitschr. f. Chir.* IX.; LANDSBERGER, *Berl. klin. Woch.* 1877; OSLER, *Journ. of Anat. and Physiol.* XIV.; HUBER and BOSTRÖM, *Deut. Arch. f. klin. Med.* XXIII.; EVE and WILLIAMS, *Trans. Path. Soc.* XXXI. (1882); on primary sarcoma—WINDLE, *Journ. of Anat. and Physiol.* XVIII. (with index of cases); SMITH, *Amer. Journ. med. sci.* 1886.

On lipoma and 'struma':—VIRCHOW, *Krankh. Geschwülste* II.; KLEBS, *Handb. d. path. Anat.*; STURM, *Arch. d. Heilk.* 1875; SABOURIN, *Arch. de physiol.* IX.; GRAWITZ, *Virch. Arch.* vol. 93; EBSTEIN, *Ziemssen's Cyclop.* XV.; RICKARDS, *Brit. Med. Journ.* 2, 1883.

On adenoma and carcinoma:—ROBIN, *L'epithelioma du rein* Paris 1855; WALDEYER, *Virch. Arch.* vols. 51, 54; KLEBS, *loc. cit.*; PEREWERSEFF, *Virch. Arch.* vol. 59; WEIGERT, *ibid.* vol. 67; KÜHN, *Deut. Arch. f. klin. Med.* XVI.; STURM, *Arch. d. Heilk.* XVI.; NEUMANN, *Essai sur le cancer du rein* Paris 1873; ROHRER, *Das primäre Carcinom d. Niere* In. Diss. Zurich 1877, *Virch. Arch.* vol. 67; WEICHSELBAUM and GREENISH, *Wien. med. Jahrb.* 1883; MOORE, *Trans. Path. Soc.* XXXI. (1882); Report, *Brit. med. Journ.* 1, 1884.

557. Of the **animal parasites** inhabiting the kidney *Echinococcus* is the most important. It forms hydatid cysts from the size of a hazelnut to that of a child's head, with or without daughter-cysts. The cysts may burst into the pelvis of the kidney. When the scolices die the cyst may contract, and its contents become inspissated and cretaceous.

Cysticercus cellulosæ and *Pentastoma denticulatum* are very rare. When the blood contains *Filaria* a number of the parasites reach the kidney, lying both without and within the vessels. Their presence in the kidney and in the thoracic duct gives rise to intermittent hæmaturia and chyluria, the urine in the latter case being milky from the admixture of excessively fine oil-globules (Art. 235).

Eustrongylus gigas and *Bilharzia* or *Distoma hæmatobium* have already been alluded to (Art. 553). The eggs of the latter when deposited in the mucous membrane of the pelvis or ureter excite inflammation resulting in ulceration and induration. The more superficial may become encrusted with urinary salts and form sandy grains on the mucous membrane.

When ulceration of the intestine and of the ureter or renal pelvis leads to the formation of abnormal communications between these parts, round-worms occasionally wander into the kidney.

CHAPTER LXXIII.

DISORDERS OF THE BLADDER.

558. **The urinary bladder** is the temporary receptacle of the renal secretion. When the urine is mingled with abnormal exudations from the blood-vessels, or the products of morbid change in the kidney or its pelvis, these are naturally detained for a certain time in the bladder. Of the formed matters thus occurring in its contents the following are the most important.

Red blood-cells or their detritus come either from the kidney or from its pelvis. In the former case they have in general escaped from the glomeruli as a result of disordered circulation (Arts. 523, 527) or of inflammation (Art. 544). They are rarely derived from intertubular hæmorrhage. Vascular tumor-growths in the kidney (such as carcinoma or angioma) may also give rise to hæmorrhage and hæmaturia.

When a part of the extravated blood coagulates in the tubules the urine contains dark and opaque granular cylinders containing blood-cells or their remains and known as **blood-casts**.

Hæmorrhage from the pelvis of the kidney is generally due to inflammation and erosion caused by renal concretions.

White blood-cells appear in the urine in inflammatory conditions of the kidney and its pelvis, especially in purulent pyelitis. In chronic suppuration they are for the most part fatty and disintegrated. In tuberculous and other necrotic affections we find bacilli and necrotic detritus in the urine.

Epithelial cells come from the pelvis and from the collecting tubes of the kidney, perhaps too from the loops of Henle and the intercalary tubules. The statement* sometimes made—that entire and unaltered epithelial cells from the convoluted tubules escape into the urine—is erroneous. Degenerate cells from the cortex and their detritus are however met with.

The pelvic epithelial cells are polymorphous, resembling exactly those of the bladder itself. The renal cells are cylindrical or cubical: when they are in great numbers and cohere into cylinders we have the so-called **epithelial casts**.

In rare cases **cancer-cells** from a renal tumor are found in the urine.

When albuminous matters escape into the tubules with the urine and there coagulate, we have formed, as already described (Art. 533), the cylindrical masses known as **tube-casts**; and some of these are usually washed out and reach the bladder. They are either entirely colorless and hyaline, or granular, or waxy in appearance and tint. Casts of each of these forms may have adhering to them epithelial cells or their detritus (albuminous and fatty granules), free nuclei, white and red blood-cells, granular deposits of urinary salts, and crystals of calcium urate or oxalate.

When there are **bacteria** in the urine some of them may adhere to the casts: it is however to be noted that the granular masses enveloping some of the casts have of late been erroneously taken for micrococci.

All the urinary deposits and concretions described in Arts. 531 and 532 are ultimately carried into the bladder, unless their size prevents them passing through the ureter. **Scolices** and daughter-cysts occasionally escape from a renal hydatid. And when the ova of *Bilharzia* or *Filaria* are deposited in the mucous membrane of the urinary tract we are apt to find both **ova** and **embryos** in the urine.

559. When the urine has reached the bladder it is liable to be mingled with abnormal products derived either from the diseased bladder-wall or the parts adjoining, or from the exterior.

Blood is one of the most common admixtures, and is met with in cases of intense inflammation, ulceration, or engorgement of the wall of the bladder, and in the vascular lesions accompanying scurvy, hæmorrhagic small-pox, scarlatina, etc. Not infrequently traumatic lesions such as are caused by stone or external violence, and tumors such as papilloma, sarcoma, and cancer, are the cause of vesical hæmorrhage.

Vesical epithelium is shed into the urine in inflammation (cystitis) and in cases of papillomatous (so-called villous) tumor. In the latter instance villous fragments of the growth are also occasionally found. Masses of **cancer-cells** are frequently found in the urine in cancerous ulceration of the bladder.

In all the forms of cystitis we find **pus-cells** in the urine.

When rupture and perforation of the bladder-wall has taken place matters of very various kinds may reach its interior. A pelvic abscess may yield pus, and ulcerating uterine carcinoma putrid detritus and cancer-cells, a rectal ulcer or fistula fæces, a dermoid cyst its characteristic contents, and so on.

The most common matters entering the bladder from without are **bacteria**, and less frequently **yeast-cells**. If the urine offers them suitable conditions for growth and they are not forthwith removed from the bladder, they proceed to multiply; micrococci and sarcinæ do so most readily, bacilli less frequently.

Children and others sometimes pass solid objects (such as pencils, hair-pins, straws, etc.) through the urethra into the bladder, and pieces

of catheters are occasionally broken off and lost in like manner. Now and then shot and bullets which have penetrated the surrounding parts are found loose in the bladder.

560. The causes which give rise to the formation of concretions in the kidney and its pelvis may also give rise to **concretions** within the bladder. As we pointed out in Arts. 531 and 532 acid and alkaline fermentations of the urine are frequently the cause of these deposits, in other cases the cause lies in the nature of the food taken. Not uncommonly however we are unable to detect any sufficient cause.

Very often indeed the basis of a vesical calculus is a concretion which has passed from the pelvis of the kidney into the bladder, or a foreign body introduced from without. On such a basis solid deposits are formed, usually of triple phosphate and acid phosphate of calcium. The foreign bodies in fact set up vesical inflammation and the products of this undergo alkaline decomposition. Deposits of uric acid and urates are much less common.

These deposits take the form of **gravel**, or of **stone**. The stone is usually single, and sometimes reaches a very large size.

A stone is usually spherical or ovoid, and may be smooth, nodular, tuberculated, rough, or even spiny. When more than one are present they are occasionally faceted or polyhedral. Some stones are hard, some soft and friable. They are often stratified or laminar, and made up of a number of different substances.

The presence of a stone generally causes inflammation of the bladder, occasionally ulceration and hæmorrhage. As it irritates the bladder it causes it to contract, and sometimes at the same time hinders its evacuation; in this way a stone often leads to hypertrophy of the bladder-wall. At times the stone lies in a diverticulum or sacculation of the bladder, and may there become impacted.

Vesical calculi are classified according to their composition.

(1) Uric-acid and uratic calculi. Pure uric-acid stones are generally small and hard, and of a yellow red or brown tint. Uratic stones (containing urates of ammonium and magnesium) are seldom pure. The superficial layers are usually composed of calcium oxalate and ammonium-magnesium (triple) phosphate.

(2) Phosphatic and calcareous calculi. These consist mainly of calcium phosphate, or of ammonium-magnesium phosphate. Stones consisting entirely of calcium carbonate are very rare. All these stones are white or grayish white. Triple-phosphate stones are soft and friable, the others are hard.

(3) Oxalatic calculi, consisting of calcium oxalate, are hard and spiny; they are brown in color.

(4) Cystine-calculi are soft brownish-yellow and waxy.

(5) Xanthine-calculi are red, with a smooth surface and earthy fracture.

561. Inflammation of the bladder or **cystitis** is in most cases caused by the presence of irritant matters in the urine (Arts. 558-560), whether

due to morbid admixture or to decomposition; it may also be a result of traumatic injury, or of irritant impurities in the blood.

Catarrhal cystitis is characterized by the occurrence of shed epithelium, pus-cells, mucus, and generally red blood-cells, in the urine. In recent cases the mucous membrane appears but little altered. When the secretion is purulent the membrane is covered with a film of pus, and is sometimes very much swollen. When hæmorrhage has occurred the surface is of a uniform gray tint, or mottled with gray black and reddish-brown patches. If the inflammation has extended to the submucous and muscular coats, so that these are infiltrated, the whole wall becomes more or less thickened. In extreme cases the serous or peritoneal surface may be stained with bloody or slaty-gray patches, and at length purulent or putrid exudations may make their appearance in the subperitoneal tissue (**pericystitis**) and on the peritoneum itself. This of course happens only in very intense suppurative or septic inflammations, such as are set up by septic (bacterial) decomposition of the contents of the bladder.

Certain irritants, such as cantharidin, lead from the outset of the affection to superficial sloughing of the epithelium, which becomes detached in the form of necrotic flakes and shreds. Such infective disorders as measles, scarlatina, typhoid, septicæmia, etc. are occasionally accompanied by superficial diphtheritic desquamations in the form of isolated yellowish patches; in other instances the exudation is croupous.

When the urine becomes ammoniacal and putrid the epithelial layers, the connective tissue of the mucosa and submucosa, and even the muscular coat may in parts become necrosed and ulcerated, and at length gangrenous and putrid. In this way ulceration, gangrene, and abscess of the bladder-wall are developed, and ultimately perforation may occur at one or more points, with the result of secondary suppuration and necrosis in the neighboring tissues.

In the severer forms of cystitis the mucous surface is frequently rough and sandy with incrustated salts, chiefly triple-phosphate.

As we have already pointed out (Art. 553) inflammation of the bladder may extend to the ureters and the kidney, especially when there is retention of urine ('surgical kidney').

In **chronic cystitis** fibrous hyperplasia of the coats of the bladder, with true hypertrophy of its muscular coat (Art. 563), is a common occurrence.

Tuberculosis of the bladder begins with the formation of gray nodules surrounded by a zone of hyperæmia; these enlarge and turn yellow, and sooner or later break down into ulcers. The ulcers have a cheesy infiltrated floor and their borders are hyperæmic. They increase in size by progressive marginal disintegration and by coalescence, and in this way are formed large sinuous ulcerations, involving a considerable part of the mucosa and submucosa. Vesical tuberculosis is usually accompanied by

tuberculosis of the pelvis of the kidney (Art. 550) or, in the male, of the genital apparatus: it is indeed probable that the process starts in some part of the latter system.

The mucous membrane of the urinary tract, and especially that of the bladder, frequently contains a number of small aggregations of lymphadenoid tissue, and in catarrhal cystitis these become perceptibly swollen. They then look very much like tubercles, especially when they are surrounded by a hyperæmic zone.

Long-continued engorgement of the vesical blood-vessels leads to varicose dilatations of the veins, chiefly those near the neck of the bladder. They are sometimes referred to as **vesical hæmorrhoids**, and now and then obstruct the evacuation of the bladder or give rise to hæmorrhage.

Amyloid degeneration of the vesical mucous membrane is not rare, but as a rule it is not apparent without the aid of the microscope. In very rare instances the amyloid deposits may lead to induration of the mucosa and submucosa.

References:—VIRCHOW, *Krankhafte Geschwülste* II.; EBSTEIN, *Ziemssen's Cyclop.* xv.; KLEBS, *Handb. d. path. Anat.* I.; MAAS, *Krankh. d. Blase (König's Handb. d. Chirurgie)*; CHAVASSE, *Étude sur la tuberculose des organes urinaires* Paris 1872; VOISIN, *Tuberculose des organes génito-urinaires, Bulletin de la soc. anat. de Paris* XLIX. (1874); KIRMISSON, *Cystite, ibid.* L. (1875); DURAND, *Cystite chronique, ibid.* LII. (1877); STEINTHAL, *Virch. Arch.* vol. 100; DU CASAL, *Cystite chronique, Gaz. hebd. de méd.* 1877; W. ROBERTS, *Brit. Med. Journ.* 2, 1881; HARRISON, *Internat. encyclop. of surgery* VI. London 1886.

562. The commonest of the **tumors** of the bladder is the so-called '**villous cancer**' or vascular papillomatous **fibroma**. It consists of a number of long and slender villi or papillary growths, springing from a comparatively narrow base: each villus consists of a delicate stroma containing wide and thin walled vessels and covered with stratified epithelium. The growth does not extend into the deeper layers of the mucous membrane, and sometimes attains the size of a small apple. It is single or multiple, and is usually situated towards the base of the bladder not far from the neck, so as sometimes to obstruct the channel during micturition. The vessels and the stroma being alike delicate and fragile, the tumor is very apt to bleed and may thus prove very dangerous to the patient. From time to time fragments of the villi are detached and passed with the urine. The growth is not malignant and should not be described as a 'cancer.'

Primary **carcinoma** of the bladder is a very rare growth; it occurs both in men and women and takes the form of a nodular or fungous or papillary tumor, at times extending over a considerable part of the bladder, and penetrating the submucous and even the muscular coat. The cancerous infiltration may thence extend into neighboring parts.

Secondary carcinoma is more frequently met with, the infection reaching the bladder from the uterus, vagina, rectum, or prostate.

Other neoplasms of the bladder are very rare indeed.

LANGHANS recently described a case of vesical angioma (*Virch. Arch.* vol. 86); GUSSENBAUER (*Arch. f. klin. Chir.* XVIII.) and VOLKMANN (*ibid.* XIX.) cases of myoma, SCHATZ (*Arch. f. Gynäk.* X.) of fibromyxoma, POSNER (*Berl. klin. Woch.* 1883) of primary carcinoma. See also STEIN, *Tumors of the bladder Philadelphia 1881, New York Med. Rec.* 1885 (with references to the recorded cases).

563. **Dilatation of the bladder** takes place when its evacuation is interfered with through occlusion or stricture of the urethra or paralysis of the muscular wall of the bladder itself. When the evacuation is rendered difficult, or when frequent contraction of the bladder is induced by the stimulus of a stone, the muscular coat may **hypertrophy**. The wall becomes thickened and the overgrown muscle-bundles stand out from the inner surface in a reticulum of bands or fasciculi.

Diverticuli are produced either by the simultaneous sacculation of all the coats, or by the protrusion of the mucous and submucous coats through the meshes of the fasciculated muscular coat. These diverticula are seldom larger than a walnut. They frequently are the seat of concretions, and sometimes are first caused by the pressure of a calculus.

Displacements of the bladder are rare, though occasionally a part of the viscus prolapses into a hernial sac. The base of the bladder may also fall down into the vagina (vaginal cystocele), or the posterior wall may prolapse through the dilated female urethra and appear at the external orifice.

Rupture of the bladder results from traumatic injury, excessive distention, or morbid change in the wall. Rupture into the peritoneum usually leads to fatal peritonitis. After perforations into the pelvic cellular tissue urinary infiltration takes place, leading to gangrene or supuration in the tissue invaded. Ulceration or local necrosis sometimes leads to the opening of abnormal communications¹ between the bladder and the vagina, uterus, rectum, or external cutaneous surface. These are called **urinary fistulæ**, and are kept open by the constant escape of urine through them.

CHAPTER LXXIV.

MORBID CHANGES IN THE URETHRA.

564. The inflammations of the urethra correspond generally with those of other mucous membranes. Croupous and diphtheritic inflammations are rare, but catarrh is very frequently met with. The most important form of catarrh is **gonorrhœa**, which is set up by a specific micrococcus (NEISSER, HAAB, MARTIN). The micrococcus is conveyed to the urethra in the secretion from another mucous membrane affected with gonorrhœa, and multiplying sets up an inflammation characterized by its purulent catarrhal exudation, which is yellowish or greenish-yellow and sometimes slightly blood-stained. The inflammation may extend from the urethra to other parts of the urinary tract and to the neighboring genital organs, and ultimately affect (by metastasis) remote regions like the joints, as in gonorrhœal rheumatism.

The inflammation may also extend in the urethra from the mucous to the submucous strata, and thence to the periurethral connective tissue and the lymphatics.

It usually ends in recovery, though in places it may lead to ulceration and abscess, to fibrous hyperplasia, corrugation and thickening of the mucous membrane, or cicatricial contraction. These are most common in chronic cases (*gleet, goutte militaire*).

Other forms of urethral inflammation are the soft chancre or **chancreoid** (Art. 391), the **hard chancre** or initial sclerosis of syphilis (Art. 391), and lupous and tuberculous disease. Ulceration is frequent behind the site of strictures, and it readily extends to the urethra from prostatic ulcers. When the ulceration goes deeply fistulous tracts may be formed, leading to urinary infiltration of the surrounding tissue and ultimately to abscesses and permanent urinary fistulæ. In the male these fistulæ have sometimes a very irregular almost labyrinthine course, and open either on the exterior or into the rectum.

A not uncommon after-effect of chronic inflammation is the development of polypous and papillary growths, such as the '**cauliflower excrescences**' (*condylomata acuminata*) or 'caruncles' which appear round the orifice of the urethra in women.

Varices, resembling rectal hæmorrhoids, are sometimes formed at the site last-named in consequence of long-continued inflammatory hyperæmia.

The most common **tumors** affecting the female urethra are sarcoma, myxoma, fibroma, and carcinoma. Fibroma gives rise to nodes and nodules, or to vascular papillomatous growths. In males cancer of the prostate or of the glans penis frequently attacks the urethra. Small **cysts** of retention are occasionally formed in the mucous glands of the female urethra.

Stricture of the urethra is proximately due to inflammatory swelling of the mucous membrane, to nodular or diffuse unilateral or annular fibrous hyperplasia, to cicatrices, to valvular folds of membrane, or to polypus growths. Gonorrhœal inflammation and traumatic injury are the most common exciting causes. Inflammatory strictures are oftenest seated in the membranous and in the contiguous spongy part of the canal. In old men the **enlarged prostate** frequently obstructs and even occludes the urethra. In infants and young children the colliculus seminalis is sometimes so excessively developed as to interfere with micturition.

Traumatic rupture of the urethra arises in various ways; a very common cause is careless catheterization by which 'false passages' are produced. They are usually situate at the deeper end of the canal, and either end blindly or lead into the urethra again or into the bladder.

Such ruptures give rise to urinary infiltration and abscess, or to fistulæ surrounded by dense fibrous tissue and partially lined with epithelium.

References on the micrococcus of gonorrhœa (*gonococcus*):—NEISSER, *Cent. f. med. Wiss.* 28, 1879, *Deut. med. Woch.* 20, 1882; BOKAI, *Pest. med.-chir. Presse* 1880; CHEYNE, *Brit. Med. Journ.* 2, 1880; HAAB, *Corresp. f. Schweizer Aerzte* 1881, *Der Mikrokoccus d. Blenorrh. neonatorum* (*Horner's Festschrift* 1881); KRAUSE, *Cent. f. prakt. Augenheilk.* 1882; MARTIN, *Recherches sur les inflam. métast. suppur. à la suite de la gonorrhée* Geneva 1882; BOCKHART, *Vierteljahrsschr. f. Derm. u. Syph.* 1883; STERNBERG, *Philad. Med. News* 1883-84; WELANDER, *Gaz. méd. de Paris* 1884; LOMER, *Deut. med. Woch.* 1886.

CHAPTER LXXV.

MORBID CHANGES IN THE SUPRARENALS.

565. **Malformations** of the suprarenals are not common: though sometimes there are more than two or there are small accessory bodies of like structure; or on the other hand they are imperfectly developed or absent altogether. The latter is usually the case only when other malformations of the viscera are present.

Fatty degeneration is a normal phenomenon in the adult; it is apparent chiefly in the cells of the cortical layer, which thereby acquire a pale-yellow tint.

Amyloid change of the blood-vessels is not infrequent as an accompaniment of amyloid disease in other organs; it may give rise to induration.

Pigmentation is a very common occurrence in old age, affecting chiefly the deeper layers of the cortex. The cells are either of a uniform yellow tint or beset with pigment-granules.

Hæmorrhage is somewhat uncommon, though cases occur in which the extravasation is so great as to cause the organ to swell enormously. It is then due either to mechanical injury, or to vascular disorder. VIRCHOW describes an acute hæmorrhagic form of inflammation of the suprarenals.

Inflammation of the suprarenals is not frequently observed, though it does occur in various forms. Thus in acquired and in hereditary syphilis cellular infiltrations and gummatous inflammations are described. And in other cases inflammation ending in suppuration or in cicatricial induration has been noted.

The commonest as well as the most important variety of inflammation is that which terminates in **caseous and fibroid degeneration** of the gland: in most cases it is apparently of a tuberculous nature. The suprarenals are more or less enlarged, the capsule thickened and adherent to the neighboring structures. The surface is either smooth or nodular and mishappen: on section the parenchyma appears in great part replaced by dense fibrous tissue enclosing caseous foci of various sizes. These latter may contract or be absorbed, whereupon the organ becomes distorted and shrunken; in other instances they become calcified. The disease is usually bilateral. Sometimes abscesses are formed.

The **tumor** oftenest observed in the suprarenals is that described by

VIRCHOW as *struma lipomatosa suprarenalis*: it is a nodular growth consisting essentially of fatty glandular tissue. Carcinoma and sarcoma also occur, the latter often reaching a very large size.

Suprarenal cysts have also been described by various observers. They are formed either by the softening of hæmorrhagic patches, or by the dilatation of the cortical acini (KLEBS). These true cysts must not be confounded with the cavities very frequently observed in the glands, which are due to post-mortem softening of the inner layers of the cortex.

The *Echinococcus* is the only animal parasite met with in the suprarenals.

Disease of the suprarenals, especially the caseous fibroid degeneration, is often accompanied by bronzing of the skin (*cutis cænea*) and buccal mucous membrane, and by a profound and fatal cachexia. The pigmentation is sometimes uniform and diffuse, sometimes in patches and streaks. The bronzing and the cachexia are supposed to depend on the suprarenal lesion; the affection being referred to as *melasma suprarenale* or Addison's disease. In many cases changes in the abdominal sympathetic nerves and ganglia have been observed. No satisfactory explanation of the relation of the several phenomena has yet been given.

References:—ADDISON, *On the constitutional and local effects of disease of the suprarenal capsules* London 1855, reprint (New Syd. Soc., 1868); HECKER, *Monatschr. f. Geburtskunde* XXXIII. (1869); VIRCHOW, *Krankh. Geschwülste* II.; KLEBS, *Path. Anat.* I.; AVERBECK, *Die Addison'sche Krankheit* Erlangen 1869; WOLF, *Berl. klin. Woch.* 1869; GREENHOW, *Croonian lectures* London 1875, *Trans. Path. Soc.* (many papers), *Trans. inter. med. congress* II. London 1881; BURGER, *Die Nebenniere u. d. Morbus Addisonii* Berlin 1883; CHIARI, *Wien. med. Presse* XXI. (1880); FLEISCHER and PENZOLDT, *Deut. Arch. f. klin. Med.* XXVI. (1880); HUBER, *ibid.* IV.; GOODHART, *Atlas of Pathology* (New Syd. Soc.) London 1879, *Trans. Path. Soc.* XXXIII. 1883; DA COSTA and LONGSTRETH, *Amer. Journ. med. sciences* July 1880; SAUNDBY, *Brit. Med. Journ.* 1, 1883; BARLOW and COUPLAND, *Trans. Path. Soc.* XXXVI. 1885.

MARCHAND (*Virch. Arch.* vol. 92) has recently pointed out that accessory suprarenals are not uncommonly to be found in the broad ligament near the ovary. On suprarenal tissue in and about the kidney see Art. 556.

SECTION X.

THE RESPIRATORY ORGANS.

SECTION X

THE RESPIRATORY ORGANS

CHAPTER LXXVI.

INTRODUCTORY.

566. The **organs of respiration** fall naturally into two groups distinguished by differences both of structure and of function. The one includes the **lungs**, in which chemical interchanges between the blood and the air are effected; the other is the system of **air-passages** by which the lungs are placed in communication with the exterior.

The air-passages include the nose, larynx, trachea, and bronchi. From the point of view of morbid anatomy these are regarded simply as cavities lined with mucous membrane, and the morbid changes they undergo are conditioned chiefly by changes in this membrane. Certain parts of this system of passages perform functions other than that of air-conduction—for instance, the nasal mucous membrane contains the peripheral olfactory apparatus, and the larynx the mechanism of voice—but the fact affects but little the pathological relations of these parts. These functions involve the presence of certain structures in the epithelial wall of the air-passages, and these are sometimes secondarily (sometimes also primarily) affected when the latter is morbidly altered.

The general considerations set forth in Section VI. (Arts. 414-431) are accordingly in the main directly applicable to the case of the mucous membranes of the nose, larynx, trachea, and bronchi.

The pathological relations of the lungs themselves (*i. e.* of the respiratory tissues) are however of an essentially different kind. The peculiar structure of this part of the respiratory apparatus gives a special and peculiar character to its morbid anatomy and to the clinical course of the diseases affecting it.

The disorders of the respiratory organs are for the most part due to deleterious influences affecting their tissues through the medium of the respired air. The affections which are traceable to disturbances of the circulation or to alterations in the blood are however by no means insignificant. Affections due to extension of morbid processes from contiguous parts are comparatively infrequent.

CHAPTER LXXVII.

THE NASAL CAVITIES.

567. Congenital **malformations of the nose** which are at all extreme are met with only in combination with other malformations of the face. Thus in *Cyclopia* (Art. 7) the nose may be wanting or represented by a snout-like projection beneath the single orbit. Minor anomalies are—the absence of some of the nasal muscles, defects of the septum, of the ethmoid, or of the nasal bones, constriction or closure of the posterior nares, obliquity or distortion of the septum, and clefts of the *alæ nasi* or of the floor of the nostrils. The latter occur in connection with cleft-palate and cleft-face (Art. 8).

Hæmorrhage from the nasal mucous membrane (**epistaxis**) is very common, and may be due either to diapedesis or to rupture of blood-vessels. In many persons epistaxis is habitual: in others it occurs most frequently in connection with the hæmorrhagic diathesis, and in various infective diseases, menstrual disorders, venous engorgement, inflammatory conditions, etc.

Inflammation of the nasal mucous membrane (**rhinitis**) is one of the commonest affections. It usually takes the form of a mucous or purulent catarrh (Art. 420); the croupous, diphtheritic, phlegmonous, and ulcerative varieties are much less common.

Acute nasal catarrh is spoken of as **coryza**, and may result from a great variety of causes, such as cold, inhalation of irritant matters, micro-organisms, etc.

Chronic nasal catarrh occurs chiefly in persons who are scrofulous, phthisical, or syphilitic: it is comparatively rare in persons otherwise healthy. Sometimes it results in thickening, sometimes in thinning or even atrophy, of the mucous membrane. In the latter case the nasal cavity appears abnormally large, and its walls secrete a yellowish or greenish pus which undergoes putrid decomposition and gives rise to a fœtid odor (**ozæna simplex**) and to the formation of dirty greenish crusts and scales. FRÄNKEL points out that in this form of atrophy the Bowman's glands disappear, and it is very probable that the alteration in the nasal secretion thereby occasioned makes it possible for septic organisms to lodge in the mucous membrane. In many chronic cases the bone underlying the mucous membrane likewise undergoes atrophic change.

FRÄNKEL thus speaks of simple ozæna as *rhinitis chronica atrophica fetida*.

Croupous and diphtheritic inflammation of the nose is usually secondary to the like affection in the throat (Arts. 423-426). Phlegmonous inflammation (Art. 427) is usually due to extension from neighboring parts, though it is sometimes confined to the nose.

Ulcerative inflammation is in most cases due to syphilis (Art. 429) or to glanders (Art. 430). Lupous (Art. 392), tuberculous (Art. 428), and leprous (Art. 430) infiltration and ulceration are also met with, but they are rare. The syphilitic and tuberculous affections of the nose frequently begin in the periosteum of the nasal bones and give rise to more or less extensive destruction of the osseous tissue.

All the inflammatory affections of the nose may extend by continuity to the cavities and sinuses connected with it and there take on a more or less independent character, the cavities becoming filled with mucous or purulent secretion. From the frontal or ethmoidal sinuses the inflammation may extend into the interior of the cranium and so give rise to meningitis.

References on ozæna:—HUPPERT, *Begriff und Ursachen der Ozæna* In. Diss. Strasburg 1879; B. FRÄNKEL, *Ziemssen's Cyclop.* IV.; MICHEL, *Krankh. d. Nasenhöhle und d. Nasenrachenraumes* Berlin 1876; E. FRÄNKEL, *Virch. Arch.* vols. 79, 87, 90; HARTMANN, *Deutsche med. Woch.* 13, 1878; GOTSTEIN, *Breslauer ärztl. Zeitschr.* 17, 1879; KRAUSE, *Virch. Arch.* vol. 85, *Trans. internat. med. congress* III. London 1881; B. ROBINSON, *Nasal Catarrh* New York 1880; FRANKS, *Dublin Journ. med. science* 1881, 1882; MARTIN, *De l'ozène vrai* Thèse de Paris 1881; MORELL MACKENZIE, *Diseases of the throat and nose* II. London 1884 (with full references), LÖWENBERG, *Deut. med. Woch.* 1885.

References on nasal lupus:—HEBRA and KAPOSÍ, *Diseases of the skin* IV. (New Syd. Soc.) London 1875; MOINEL, *Le lupus scrofuleux des fosses nasales* Paris 1877.

References on nasal tuberculosis:—WEICHELBAUM, *Allg. Wiener med. Zeitung* 27 and 28, 1881; TORNWALDT, *Deut. Arch. f. Ohrenheilk.* x., *Deut. Arch. f. klin. Med.* XXVII.; BRESGEN, *Der chron. Nasen- und Rachencatarrh* Vienna 1883; ZUCKERKANDL, *Norm. u. path. Anat. d. Nasenhöhle u. ihrer pneum. Anhänge* Vienna 1882; DEMME, *Berl. klin. Woch.* 1883 (states that tuberculosis may attack the nose primarily); VOLKMANN, *Samml. klin. Vorträge* 168, 169.

References on phlegmonous inflammation of the nasal cavities:—WEICHELBAUM, *Wiener med. Jahrb.* 1881; KOHTS, *Gerhardt's Handb. d. Kinderkr.* III.; B. FRÄNKEL, *Ziemssen's Cyclop.* IV.

568. The nasal mucous membrane is not infrequently the seat of hyperplastic growths and of tumors, due partly to chronic inflammation, partly to unrecognized causes. They take the form of polypous excrescences and are usually referred to as **nasal polypi**.

Soft or mucous polypi resemble the mucous membrane in structure, but are somewhat more cellular. Sometimes the included mucous glands are dilated into cysts (cystic polypi) especially in the antrum of High-

more, or these glands are enlarged and multiplied as in glandular or adenomatous polypi, or traversed by numerous thin-walled blood-vessels (telangiectatic polypi or 'erectile' tumors).

Other polypi consist of œdematous connective tissue and mucoid tissue, and are therefore classed as fibromata and myxomata. They are more translucent than the former, and are usually of a yellowish tint, the mucous polypi being gray or grayish-red.

Sarcoma, dense fibroma, osteofibroma, chondroma, osteoma, carcinoma, and mixed tumors of the connective-tissue group, have been met with in the nose. Many of these start not in the mucous membrane but in the periosteum of the nasal bones. The connective-tissue tumors, especially those originating in the periosteum, may reach a considerable size, distending the cavity in which they grow, sometimes protruding from the anterior and posterior nares, and much distorting the face.

Carcinoma of the nose is most frequently met with about the anterior nares and is therefore to be classed with the cutaneous forms of cancer. The cancers which originate in the mucous membrane take the form of irregularly nodulated growths, which sooner or later ulcerate.

Rhinoliths are calcareous concretions, formed as a rule round some foreign body which has become impacted in the nasal cavity. In rare instances they are due to the inspissation of nasal secretions.

Maggots or larvæ are sometimes hatched in the nose from eggs deposited by various species of *Diptera*. They may give rise to extensive inflammation and sloughing. (See MORELL MACKENZIE, *Diseases of the throat and nose* II. London 1884.) Of **vegetable parasites** bacteria and the *Saccharomyces albicans* are the commonest. The former are usually innocuous, though in certain cases, as in ozæna, they set up decomposition in the nasal secretions. In tuberculosis and in glanders the characteristic bacilli are found.

References on nasal tumors:—VIRCHOW, *Krankhafte Geschwülste* I., III.; BILLROTH, *Ueber den Bau der Schleimpolypen* 1855; MATHIEU, *Les polypes muqueux* Thèse de Paris 1875; THUDICHUM, *Polypus in the nose* London 1877; DURHAM, *Holmes's Syst. of surgery* II. London 1883; KOHTS, *Gerhard's Handb. d. Kinderkrankh.* III.; HOPMANN, *Virch. Arch.* vol. 93, *Wien. med. Presse* 1883; ZUCKERKANDL, *Norm. u. path. Anat. d. Nasenhöhle* Vienna 1882; LEFFERTS, *Internat. encyclop. of surgery* V. London 1885; MORELL MACKENZIE, *Diseases of the throat and nose* II. London 1884: the last two give many references to published cases.

CHAPTER LXXVIII.

THE LARYNX.

569. **Malformations.** Entire absence of the larynx is very rare as a congenital anomaly; it is met with only in amorphous and acephalous acardiac monsters in whom the lungs are undeveloped (Art. 13). Congenital defects, as of the epiglottis or of part or the whole of one of the laryngeal cartilages, are much commoner. Asymmetry and abnormal largeness or smallness of the larynx are also met with: abnormal smallness frequently accompanies aplasia of the testicle or early castration. Sometimes the laryngeal cartilages are abnormal in number, and the epiglottis more or less deeply cleft. The ventricles of the larynx or sinuses of Morgagni are not uncommonly of abnormally great capacity, and occasionally we find extra-laryngeal pouches communicating with them. This anomaly is of special interest, inasmuch as it is a normal feature in the *Quadrumana*.

Of acquired deformities **laryngeal stenosis** is the most noteworthy. It may be due to pressure from without, but more commonly to disease of the larynx; for example, to inflammation by which the mucous membrane becomes swollen and covered with a solid exudation or undergoes cicatricial contraction, or to the growth of intra-laryngeal tumors. Functional stenosis may be brought about by paralysis of the muscles which open the glottis or spasm of the muscles which close it. Foreign bodies impacted in the glottis may have the same effect.

The morbid anatomy of the larynx has been very thoroughly discussed by EPINGER (*Klebs's Handb. d. path. Anat.* part 7 vol. II. Berlin 1880).

Numerous references to the pathology of laryngeal affections will be found in the following text-books:—RAUCHFUSS, *Gerhardt's Handb. d. Kinderkrankh.* III. Tübingen 1878; VON ZIEMSSSEN, *Ziemssen's Cyclop.* IV., VII.; TÜRCK, *Klinik d. Krankheiten d. Kehlkopfes* Vienna 1866; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; P. BRUNS, *Die Laryngotomie* Berlin 1878; MORELL MACKENZIE, *Diseases of the throat and nose* I. London 1880.

570. **Affections of the laryngeal mucous membrane.** Laryngeal catarrh is very common, and is characterized by redness and swelling of the mucous membrane together with a mucous, purulent, or serous exudation. Serous exudation is observed chiefly in catarrhs due to persistent passive hyperæmia. The inflammation may extend over the entire

organ or be limited to certain parts such as the vocal cords or the epiglottis. It may be induced by very various causes.

In **chronic catarrh** the blood-vessels are sometimes permanently dilated. The epithelium desquamates freely and often accumulates round the vocal cords in whitish films and patches, which form a nidus for bacteria. The mucosa and submucosa are infiltrated with leucocytes. The fibrous strata frequently become hypertrophied and thickened. When the papillary structures of the glottis also are hypertrophied they assume the form of papillomatous or warty growths. The mucous glands of the posterior surface of the epiglottis, the false cords, and the sinuses of Morgagni may become enlarged and dilated, and give the surface a granulated appearance (**granular laryngitis**). Loss of epithelium and rupture of the dilated and extended glands give rise to small erosions and ulcerations. Loss of continuous patches of epithelium is most frequently observed about the vocal cords and their posterior attachments, and is often due to the action of bacteria or of the thrush-fungus (Fig. 76, Art. 198).

In chronic catarrh of long standing and in consequence of ulceration the glandular structures become obliterated and the mucous membrane thinned and atrophied. Slight but often-repeated irritation is sometimes followed by hypertrophy of the squamous epithelium, which gives the affected spots a white or pearly appearance. The vocal cords are the parts most commonly affected, and they are sometimes the seat of polypous excrescences at the same time (Art. 575).

Croupous inflammation of the laryngeal mucous membrane is sometimes primary, sometimes secondary to inflammation in neighboring parts. It is most common in connection with diphtheria, small-pox, typhoid, and cholera, though it may also result from the inhalation of hot or irritant gases and vapors or from the introduction of foreign bodies. The interior of the larynx is covered with white or yellowish more or less coherent false membranes or only with white curdy flakes; these are sometimes readily removed, sometimes slightly adherent. The latter is the case when the epithelium of the affected part is stratified and squamous (Arts. 423-426).

The false membranes consist in part of fibrinous filaments and meshes enclosing pus-corpuscles, in part of lustrous homogeneous flakes. When they are stripped off the underlying mucous membrane is red and raw-looking.

Diphtheritic inflammation with sloughing and gangrene of the mucous membrane occurs most frequently in connection with diphtheria and typhoid, though it is rare even in these diseases.

References:—EPPINGER, and RAUCHFUSS, *loc. cit.*; VON ZIEMSSSEN and STEINER, *Ziemssen's Cyclop.* IV.; RHEINER, *Virch. Arch.* vol. 5; E. WAGNER, *Arch. d. Heilk.* VII. (1866); STEUDENER, *Virch. Arch.* vol. 54; WEIGERT, *ibid.* vol. 70; SCHOTTELIUS, *Gesellsch. d. Naturwissenschaften zu Marburg* XII.; Report, *Brit. Med. Journ.* 2,

1878; MORELL MACKENZIE, *op. cit.*, *Diphtheria* London, 1878; Report, *Lancet* 1, 1879, and *Med. chir. Trans.* LXII. (1879); MONTI, *Croup u. Diphtherie* Vienna 1884; VIRCHOW, *Berl. klin. Woch.* 1885; ORTH, *Path. Anat.* II. Berlin 1885.

It will be seen that we make no pathological distinction corresponding to that implied in the clinical terms *croup* and *diphtheria*. The specific infective disease diphtheria, when it is accompanied by croupous or superficial diphtheritic inflammation of the larynx and trachea, is the same as the affection clinically described as 'membranous croup,' a term which the pathologist may well dispense with (Arts. 204, 443, 444).

571. **Œdema of the glottis** is a more or less intense swelling of the laryngeal mucous membrane, due to infiltration of the mucosa and especially of the submucosa. The swelling is usually greatest on the posterior surface of the epiglottis, the aryteno-epiglottic folds, and the false vocal cords, the submucosa of these parts being exceptionally loose in texture. The œdema may be so great as to occlude the superior orifice of the larynx.

Œdema of the glottis may be acute or chronic. The former is due to inflammatory exudation, and occurs chiefly as a concomitant of catarrhal, croupous, or diphtheritic inflammation, and around syphilitic and tuberculous ulcers and submucous or perichondritic abscesses. It may also accompany suppurative inflammations of the pharynx, thyroid gland, and cervical connective tissue. It is often unilateral or confined to one of the parts above mentioned, according to the exciting cause.

Chronic œdema is usually the result of venous engorgement from cardiac disease, pulmonary emphysema, compression of the cervical veins, etc., and of non-inflammatory affections of the blood or vessels: it is generally symmetrical and limited to the posterior surface of the epiglottis and the aryteno-epiglottic folds, though in a less degree it may affect the vocal cords. Chronic inflammatory conditions of the larynx (as in laryngeal ulcer or perichondritis) may of course give rise to inflammatory œdema of a somewhat chronic kind.

Phlegmonous Inflammation of the larynx (*phlegmon laryngis*) is a sero-purulent and sero-fibrinous infiltration of the submucosa and mucosa, whose seat is generally the same as that of acute œdema: it is not common.

Suppuration of the tissue succeeds the infiltration, and abscesses are formed which on rupturing give rise to ulcers. When the inflammation extends to the cartilages purulent perichondritis is set up (Art. 576). These abscesses may also burrow in among the cervical muscles, or break into the pharynx or œsophagus. When the pus is evacuated the abscess-cavity may close up and become cicatrized.

Phlegmonous laryngitis sometimes follows upon croupous, diphtheritic, and gangrenous inflammations, and upon tuberculous and syphilitic ulcerations. In other cases inflammations of the perichondrium or of the pharynx or tonsils, or mechanical injury, are the inducing

cause. The forms of laryngitis which sometimes accompany typhoid, scarlatina, and pyæmia occasionally issue in suppuration.

572. **Specific forms of laryngitis.** We thus observe that the various forms of laryngeal inflammation result from very various causes, some of them being specific. Certain specific forms are distinguished by no definite characters from the non-specific; but there are others, notably those accompanying some of the infective diseases, which exhibit anatomical lesions more or less definite. The diseases in question are typhoid, small-pox, tuberculosis, syphilis, glanders, and lupus.

Typhoid is frequently accompanied by a catarrhal laryngitis marked by epithelial desquamation, ecchymoses, and superficial erosions, and by linear cracks in the mucous membrane, especially about the edges of the epiglottis. Sometimes the posterior surface of the epiglottis, the anterior wall of the larynx, and the vocal cords are covered with a branny slightly adherent 'fur' consisting of dead epithelium, leucocytes, micrococci, and microbacteria. Sometimes too on the false and true vocal cords there are ulcers, the floor and edges of which are beset with bacteria.

EPPINGER regards these bacteria as the specific organisms of typhoid, and thinks they are the cause of the epithelial necrosis and ulceration: he therefore describes the affection as *necrosis mycotica typhosa*. The bacteria are very probably the cause of the local destruction of tissue, but it seems highly doubtful that they are the virus of typhoid.

Different forms of bacteria are found in the affected spots, and the like changes are produced in affections other than typhoid (Fig. 76, Art. 198). It is therefore probable that different organisms are carried from the mouth, settle in the catarrhal mucous membrane, and there set up destructive changes.

Less frequently than the above we find in the larynx of typhoid patients diffuse swellings or miliary nodules, due to intense cellular infiltration of the mucous membrane. EPPINGER regards these as specific typhoid lesions analogous to those of the intestine. They occur chiefly at the base of the epiglottis, the false vocal cords, the inner aspect of the arytenoid cartilages, and the anterior attachment of the vocal cords: by disintegration of the infiltrated tissue they give rise to erosions with raised borders resembling typhoid ulcers. These ulcers, whether bacterial or infiltrated, may extend both in breadth and in depth, affecting ultimately the perichondrium of the several cartilages. In consequence of this we not infrequently observe large losses of substance with necrosis of the affected cartilages. The latter occurs chiefly when as sometimes happens the perichondritis becomes suppurative or gangrenous.

The laryngitis of **small-pox** is characterized by the appearance on the reddened mucous membrane of minute whitish spots or small lentil-like nodules. According to EPPINGER the former are due to cloudy

swelling and granular degeneration, the latter to cellular infiltration, of the epithelium. Sometimes a branny coating of dead epithelium and pus-corpuscles, or coherent croupous membranes, cover the affected parts. In all of these micrococci can be found (ÉPPINGER), and are probably the exciting cause of the local affection. Epithelial hæmorrhages make their appearance in cases of hæmorrhagic small-pox; and in the latter stages small abscesses may form in the connective tissue. Larger perichondritic abscesses and necrosis of cartilage are however comparatively rare.

Scarlatina gives rise to catarrhal laryngitis, seldom to the croupous or diphtheritic forms: and the like is true of measles and typhus.

References:—LOUIS, *La fièvre typhoïde* Paris 1841; TROUSSEAU, *Clinical Medicine* II. (New Syd. Soc.) London 1869; EPPINGER, *loc. cit.*; TOBOLD, *Laryngoscopie* Berlin 1874; HEINZE, *Die Kehlkopfschwindsucht* Leipzig 1879; JOFFROY, *Arch. de physiol.* 1880; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; MURCHISON, *Continued fevers* London 1884; KÜHLE, *Sammlung klin. Vorträge* 6; GRAVES, *Clinical Lectures* (New Syd. Soc.) London 1884-85. **Erysipelas** may extend from the face and mouth to the pharynx and larynx, and give rise to œdematous and phlegmonous inflammation (CORNIL *Arch. générales* XIX. 1862; MORELL MACKENZIE, *op. cit.*; MASSEI, *D. primäre Erysipel d. Kehlkopfes* Berlin 1886).

573. **Tuberculous laryngitis** is a very common complication of tuberculous disease of the lung (laryngeal phthisis), though it also occurs independently. In the former case the specific infection is doubtless conveyed by the sputum; in other cases the virus reaches the mucous membrane by way of the blood or lymph.

The process begins with the development of small subepithelial cellular infiltrations, projecting somewhat above the surface as grayish nodules. These either caseate rapidly and breaking through the epithelium give rise to minute ulcerations, or extend beneath the surface in the form of a diffuse granulomatous infiltration containing typical tubercles and giving rise to irregular protuberances of the mucous membrane. Sooner or later caseation and disintegration set in, and ulcers are formed whose floor and margins are infiltrated or even caseous. Secondary changes presently appear in the form of disseminated patches of inflammatory infiltration in the mucosa, submucosa, or perichondrium, sometimes in the mucous glands or more rarely between the laryngeal muscles. These patches may also coalesce into larger masses of granulomatous tissue containing tubercles simple or caseous. This is most apt to happen about the perichondrium of the various cartilages.

Large tuberculous granulations are very commonly met with on the under surface and edges of the epiglottis, or on the posterior and anterior walls of the larynx. In the vocal cords on the other hand disintegration usually sets in before granulations of any size are developed. There is however no invariable rule in the matter: the extent of the tuberculous

infiltration and of the ensuing ulceration varies greatly in different cases. Sometimes there are only a few punctiform ulcers on the vocal cords or posterior laryngeal wall, in other cases large areas of mucous membrane are destroyed and the cartilages also are involved in the necrotic process.

Tuberculous ulceration is always accompanied by a certain amount of catarrh: œdema of the glottis or phlegmonous inflammation are also occasional complications.

References:—EPPINGER, *loc. cit.*; HEINZE, *Die Kehlkopfsschwindsucht* Leipzig 1879; VON ZIEMSEN, *Ziemssen's Cyclop.* VII., and supplement 1881; MORELL MACKENZIE, *op. cit.*, and *Brit. Med. Journ.* 1, 1879; BIEFEL, *D. Arch. f. klin. Med.* XXX. 1882; SOLIS COHEN, *Amer. Journ. med. sci.* 1883. HEINZE believes that the tuberculous metastasis from the lungs to the larynx takes place through the blood and not by means of the sputa. This is however very unlikely: the sputa from a tuberculous lung contain bacilli and are infective, they may therefore very well convey the specific infection to the larynx.

RINDFLEISCH affirms that the tuberculous ulceration starts from the mouths of the mucous glands. This may sometimes be the case, but it is not the rule.

574. The first symptoms of **syphilitic laryngitis** may be those of a simple catarrh, though the accompanying infiltration of the mucous membrane is often extreme. The affection usually follows upon syphilitic disease of the pharynx, and is doubtless an extension of the latter.

At a later stage deep erosions appear, whose floor and edges are densely infiltrated. Prominent grayish-white or red patches are formed on the surface of the mucous membrane (*condylomata lata, plaques muqueuses*), which also ulcerate as a rule; sometimes however the infiltration is re-absorbed and they disappear.

These erosions or ulcers vary much in extent and in depth. The floor of the larger ulcers is covered with a gray film: when this is removed the characteristic whitish exudation appears beneath. The epiglottis, the vocal cords, and the posterior wall of the larynx are the most frequent seats of ulceration. In rare cases the whole of the interior of the larynx is denuded and the cartilages laid bare.

A second form of syphilitic ulceration is due to the breaking down of gummata; these are usually seated in the submucosa and are not due to direct infection from the pharynx. They are most common in the epiglottis and vocal cords, and may be so large and numerous as to obstruct or occlude the larynx.

Small gummatus nodes may be re-absorbed, but the large ones usually soften in the centre and break through into the larynx, giving rise to flask-shaped ulcers with infiltrated edges. The ulceration may extend into the laryngeal wall and cause perichondritis and necrosis of cartilage: in this case the inflammation takes on a purulent or suppurative character.

The syphilitic process may come to a stand-still at any stage, the ulcers healing up by cicatrization. If the healing is delayed consider-

able portions of the larynx, such as the epiglottis or vocal cords, may be entirely destroyed. The greater the loss of substance the larger is the cicatrix, and the distortion of the parts due to its contraction may be extreme: sometimes indeed the cavity of the larynx is constricted to a narrow and tortuous passage. The vocal cords occasionally become adherent, or the glottis is encroached on by protuberant bands of scar-tissue.

The islands of mucous membrane lying between the cicatrices are often thrust or bulged out in the process, and if they become inflamed and infiltrated or hyperplastic they take the form of outgrowths and papillomatous or polypous excrescences (*condylomata acuminata*) which still further obstruct the air-passage.

Lupus of the larynx may accompany lupus of the pharynx and of the nose. It gives rise to nodular infiltrations and ulcers with a thickened edge and granulating floor, which yield a scanty secretion. Cicatricial contractions are formed, causing distortion and obstruction as in the case of syphilis.

Leprosy likewise gives rise to nodes and nodules in the larynx which coalesce into larger tumor-like growths. The subsequent ulceration, cicatrization, and cicatricial contraction may cause very great distortion of the parts.

In **glanders** disseminated inflammation is set up, which is characterized by the formation of subepithelial cellular nodules. These break down and ulcerate, and in this way extensive destruction of the mucous membrane takes place.

References:—EPPINGER, *loc. cit.*; VON ZIEMSEN, *loc. cit.*; VIRCHOW, *Krankhafte Geschwülste* II.; GERHARDT and ROTH, *Virch. Arch.* vols. 20, 21; SOMMERBRODT, *Wiener med. Presse* 20, 1870, *Berl. klin. Woch.* 1878, *London Med. Record* 1878; TÜRCK, *Atlas d. Kehlkopfkrankheiten* Vienna 1866; SCHECH, *Deut. Arch. f. klin. Med.* xx., *D. Zeitschr. f. pract. Med.* 1877; WHISTLER, *Med. Times and Gaz.* 2, 1878; HAUFF, *Die Rotzkrankheiten beim Menschen* Stuttgart 1855 (glanders); BOLLINGER, *Ziemssen's Cyclop.* III., and supplement 1881; J. MACKENZIE, *Amer. Journ. med. sci.* 1880 (congenital syphilis), LEWIN, *Berl. klin. Woch.* 41, 1881; CHIARI and RIEHL, *Viertelj. f. Derm. u. Syph.* 1882 (lupus); THIN, *Brit. Med. Journ.* 2, 1884 (leprosy).

575. **Mucous polypi** of the larynx are not common; but now and then we meet with polypous thickenings of the false vocal cords, whose structure is exactly similar to that of the mucous membrane.

Papillary or villous growths are much more common and are described as **papillomata** or papillary fibromata. Some of them are of inflammatory origin, others appear to be non-inflammatory or simply hyperplastic. They generally grow from the true vocal cords and sometimes extend over a considerable area. They take the form either of compact nodulated tumors, or warty growths, or 'cauliflower' excrescences.

These latter are not infrequently multiple and are especially common in young persons (P. BRUNS).

Fibromatous nodules are also most frequently met with on the vocal cords. They have broad or narrow bases, and are smooth or warty, usually of the size of a lentil or small pea but sometimes as large as a hazel-nut. Some are pale, others vascular, some hard, others soft.

Lipoma and myxoma are very rare. Sarcoma is somewhat more frequent; it generally resembles a nodular fibroma, but is rather softer. Chondromata have been several times described: they start from the cartilages and form small knotty growths.

Primary **carcinoma** is most apt to arise about the vocal cords and the laryngeal sinuses. It takes the form of nodular or papillary growths or of diffuse infiltrations, which break down and leave sinuous ulcers with an irregular floor. The ulceration is usually accompanied by purulent inflammation. The destruction of tissue is sometimes very extensive, going far beyond the limits of the larynx.

Secondary cancerous growths are more common, extending into the larynx by continuity from the œsophagus, pharynx, or thyroid gland. True carcinomatous metastasis is somewhat rarer.

A few cases of adenoma have been noted; the growth takes the form of an irregular nodose tumor.

Cysts due to retention of secretion in the mucous glands are usually met with in the laryngeal sinuses and about the epiglottis; but they are not very common.

Of the **parasites** of the larynx other than the specific and other bacteria already mentioned we need only refer to the *Saccharomyces* or *Oidium albicans* (Arts. 224, 436) or thrush-fungus, and the *Trichina spiralis* (Art. 232). The fungus gives rise to the characteristic white films; the *Trichina* lodges in the laryngeal muscles. Now and then round-worms (*Ascaris lumbricoides*, Art. 228) find their way into the glottis and give rise to attacks of dyspnoea.

References on laryngeal tumors:—EPPINGER, *loc. cit.*; VON ZIEMSEN, *loc. cit.* (for recent bibliography by LEFFERTS see supplement London 1881); FAUVEL, *Traité d. maladies d. larynx* Paris 1877; VON BRUNS, *Neue Beobacht. üb. Kehlkopf-polyphen* Tübingen 1873, 1878; QERTEL, *Deut. Arch. f. klin. Med.* xv.; MORELL MACKENZIE, *Growths in the larynx* London 1876, and *op. cit.*; BURROW, *Berl. klin. Woch.* 13, 1877, *Laryngoskopisch. Atlas* Stuttgart 1877; BESCHORNER, *Berl. klin. Woch.* 42, 1877; P. BRUNS, *Die Laryngotomie zur Entfernung intralaryngealer Neubildungen* Berlin 1877 (the latter and also VON ZIEMSEN describe laryngeal tumors consisting of thyroid-gland tissue); ZIEGLER, *Virch. Arch.* vol. 65 (tumors consisting solely of amyloid substance); BUTLIN, *Malignant disease of the larynx* London 1883; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; ASCH, *New York Med. Journ.* 1884 (chondroma, with references); CERVELATO, *Lo Sperimentale* 1881 (cysts, with cases); SCHROETTER, *Monatschr. für Ohrenheilkunde* 1884 (lipoma).

According to P. BRUNS out of 1100 tumors of the larynx 602 were papillomata,

346 fibromata, 73 mucous polypi, and 27 cysts. 76 per cent of the tumors were situated on the true vocal cords or at their anterior attachment.

On round-worms in the larynx see KÜCHENMEISTER and ZÜRN (*Die Parasiten d. Menschen* Leipzig 1883), FÜRST (*Wien. med. Woch.* 1879), MOSLER (*Zeitschr. f. klin. Med.* vi. 1883).

576. The **laryngeal cartilages** are apt in old age to undergo certain degenerative changes which we may perhaps describe as physiological. These are fibrillation, partial solution, and transformation into spongy osseous tissue. The process corresponds in details to the metaplasia or pathological ossification of the other cartilages of the body. The spongy bone thus produced may afterwards be partially replaced by fatty myeloid tissue or marrow.

This softening and ossification also occurs as a morbid change at an earlier age, especially in cases of chronic laryngitis. The transformation into bone begins in the deeper parts of the cartilages and thence extends towards the surface.

Bile-pigment is deposited in the cartilages in cases of jaundice, and urates in gout.

The most important affection is however the inflammation of the perichondrium, referred to as **laryngeal perichondritis**. It is usually a secondary affection, occurring in connection with suppurative and ulcerative disease and with carcinoma, and is especially frequent in pyæmia, small-pox, typhus, and severe typhoid. Sometimes it originates in the decubital necroses met with in aged and debilitated bedridden patients at the posterior aspect of the cricoid cartilage (Art. 450), and due to the persistent pressure of the larynx on the vertebral column. Perichondritis may also be set up by mechanical violence.

The inflammation is usually purulent, but tuberculous, caseous, and indurative varieties are met with. It is nearly always localized to some part of the cartilaginous framework of the larynx, most commonly to parts of the cricoid and arytenoids. The accumulated exudation lying on the surface of the cartilage gives rise to more or less marked swelling of the parts, and presently portions of the cartilage become necrosed. When the perichondritic abscess bursts either outwards or inwards the dead sequestrum may be exfoliated and extruded. Abscesses bursting inwards usually give rise to inflammation of the bronchi and lungs, those which burst outwards to perilaryngeal suppuration.

After the abscess is evacuated and the dead cartilage removed the wound may heal by granulation and cicatrization. When the loss of substance is large much contraction and distortion ensue. Smaller defects are filled up with fibrous tissue, actual regeneration of the lost cartilage taking place only to a very slight extent. So too in fracture of the cartilages from external violence repair takes place by means of new formations of fibrous tissue not of cartilage.

Now and then cartilaginous excrescences, or **ecchondroses**, make

their appearance, and in cases where the cartilages have already become ossified exostoses have been described. They are usually found about the articulations, but are nearly always very small, not exceeding the size of a pea. A few instances of still larger growths are however on record.

References:—SCHOTTELIUS, *Die Kehlkopfknorpel* Wiesbaden 1879; TÜRK, *loc. cit.*; EPPINGER, *loc. cit.*; MORELL MACKENZIE, *Trans. Path. Soc.* XXII. (1871); GERHARDT, *Deut. Arch. f. klin. Med.* XI.; BRIEGER, *Zeitschr. f. klin. Med.* III.; JAHN, *Virch. Arch.* vol. 72; LITTEN, *ibid.* vol. 66; VON ZIEMSEN, *Ziemssen's Cyclop.* VII.

CHAPTER LXXIX.

THE TRACHEA.

577. **Malformations** of the trachea are not common. In acephalous monsters it is sometimes absent, the larynx and the lungs being sometimes present, sometimes not. Occasionally we meet with cases of abnormally short trachea, and of atresia or narrowness of this or one of the main bronchi. As a result of imperfect separation of the air-passage from the alimentary canal we may have a persistent communication between the trachea and the œsophagus, usually a little above the bifurcation of the former. When the two ends of the communicating passage become closed, it is transformed into a mucous cyst lined with ciliated epithelium.

Not infrequently some of the rings of the trachea are wanting; and in other cases they are abnormally coherent, or subdivided, or multiplied. The bifurcation may take place at an abnormally high level, or the first branch of the right bronchus may arise directly from the trachea.

Lastly we may have persistent remnants of the branchial clefts opening into the trachea, giving rise to so-called cervical fistulæ (Art. 8). These have recently acquired considerable interest inasmuch as VOLK-MANN has shown that they may be the starting point of carcinomatous growths.

Acquired **dilatations** of the trachea are not very common; though we occasionally meet with cylindrical, fusiform, or sacculate dilatations due probably to expiratory pressure, when expiration is obstructed and the tracheal wall more yielding than usual. Sacculate dilatations are commonly situated on the posterior aspect of the tube.

Stenosis of the trachea is in general caused by compression from without; more rarely it is due to structural changes, or to growths and tumors of the tube itself. Goitre and other tumors of the neck, peritracheal abscesses, and aneurysms of the aorta may be the cause of compression: cicatrices and other hyperplastic formations may give rise to obstruction from within.

Compression may be unilateral or bilateral. When it is very chronic it may induce atrophy of the cartilages (ROSE) or lead to their transformation into fibrous tissue: it is however worthy of remark that sometimes no degenerative change is observed even when the compression has been extreme.

Perforation of the trachea, apart from mechanical injury, is most frequently due to cancerous and sarcomatous ulceration of the œsophagus or thyroid gland, and to aortic aneurysm, peritracheal abscess, or suppurating lymphatic glands: it is much less commonly caused by ulceration within the trachea. In cases of aneurysm the thinned-out wall of the sack pushes in the inter-annular spaces; and this is observed also in the case of carcinomatous and sarcomatous and of goitrous tumors.

Foreign bodies which become impacted in the trachea in general speedily set up inflammation and ulceration.

Wounds of the trachea are repaired by cicatricial tissue: regeneration of cartilage takes place only to a very slight extent.

References:—EPPINGER, *loc. cit.*; CRUVEILHIER, *Traité de l'anat. path.* II.; GRUBER, *Virch. Arch.* vol. 47; VIRCHOW, *Krankhafte Geschwülste* III.; DEMME and FÜRST, *Gerhardt's Handb. d. Kinderkrankh.* III.; WEIL, *Deut. Arch. f. klin. Med.* XIV. (1873); ROSE, *Langenbeck's Arch. f. klin. Chir.* XXII.; RIEGEL, *Ziems-sen's Cyclop.* IV.; ELDRIDGE, *Amer. Journ. med. sci.* 1879 (sacculations); SCHOT-TELIUS, *Die Kehlkopfknorpel* Wiesbaden 1879 (repair of wounds); BRISTOWE, *St. Thomas's Hosp. Reports* III.; VOLKMANN, *Cent. f. d. med. Wiss.* 1882.

578. The **inflammations of the trachea** have few special features, and are frequently associated with inflammatory affections of the larynx. Catarrh is sometimes due to non-specific irritation, sometimes it is a complication of infective diseases such as measles, small-pox, whooping-cough, influenza, syphilis, etc. Laryngitis or bronchitis (Art. 579) usually accompanies this latter form. Croupous inflammation is most common in diphtheria, and is characterized by the formation of a white fibrinous false membrane. Diphtheritic denudation or ulceration of the mucous membrane is not common.

Miliary tuberculosis of the tracheal mucous membrane is rare. Chronic tuberculosis is more frequent: it gives rise to extensive subepithelial infiltrations, which afterwards break down and form ulcers of various sizes. Sometimes it extends to the deeper structures, laying bare and partially destroying (by perichondritis) the cartilaginous rings. In rare cases the greater part of the mucous membrane is destroyed by ulceration.

Syphilitic disease produces lesions resembling those of the larynx; indeed it frequently extends from the latter downwards; it may however appear in the trachea independently. In this case it is usually deep-seated, and is often associated with syphilis of the bronchi. The specific inflammation may give rise to extensive destruction of tissue, extending to the cartilaginous structures: the cicatrices which result often cause by their contraction very remarkable distortion and stenosis of the tube, which may be beset in every direction with coarse fibrous bands. The edges of the syphilitic ulcers are sometimes the seat of papillary excrescences partly covered with stratified squamous epithelium.

After tracheotomy **granulations** sometimes spring from the internal wound, and seriously obstruct the air-passage.

Primary **tumors** of the trachea are rare. Fibroma, sarcoma, chondroma, osteoma, adenoma, and carcinoma, have been observed. Secondary growths due to extension from the œsophagus or thyroid gland are more common.

Cysts arise from retention of secretion in the mucous glands. They are usually situated on the posterior wall and may be as large as a walnut: as a rule they protrude into the space between the trachea and the œsophagus. EPPINGER asserts that the mucous glands may become distended with air forced into them through their ducts.

References on tracheal syphilis:—GERHARDT, *Deut. Arch. f. klin. Med.* II., III. (1867); BEGER, *ibid.* XXIII.; MORELL MACKENZIE, *Trans. Path. Soc.* XXII. (1871), and *op. cit.*; RAUCHFUSS, *Gerhard's Handb. f. Kinderkrankh.* III.; TÜRCK, *loc. cit.*; KOCH, *Langenbeck's Arch. f. klin. Chir.* XX.; BERGER, *Schmidt's Jahrbücher* 1881 (with a summary of the literature).

References on tracheal tumors:—ROKITANSKY, *Path. Anat.* IV. (Syd. Soc.) London 1852; STÖRCK, *Pitha u. Billroth's Handb. d. Chirurg.* III.; SCHRÖTTER, *Wien. med. Jahrb.* 1868, 1870; STEUDENER, *Virch. Arch.* vol. 42; SIMON, *ibid.* vol. 57; LANGHANS, *ibid.* vol. 53; VIERLING, *Deut. Arch. f. klin. Med.* XXI.; KOPP, *ibid.* XXXII.

CHAPTER LXXX.

THE BRONCHI.

579. The morbid changes affecting the larger bronchi in general correspond closely to those of the larynx and trachea. There are however certain peculiarities connected with them, arising partly from their anatomical structure and partly from their relation to the lungs.

Hyperæmia and **anæmia** of the bronchi have no very distinctive characters. We may however note that both in engorgement and in congestion the bronchial mucous membrane may appear of a very deep red or purple tint.

Hæmorrhage from the mucous membrane is not uncommon: it takes the form of small ecchymoses or of larger effusions which mingle with the bronchial secretion. These are due to disturbance of the circulation or to morbid changes in the vessels or tissues. In hæmophilia, whether congenital or acquired (purpura), and more rarely in catarrhal inflammations, the hæmorrhage may be much more considerable and may partially fill the bronchi, while extensive suffusions appear in the mucous membrane. When the menses are suppressed it is said that hæmorrhage from the bronchi sometimes occurs. The blood effused into the bronchi may be aspirated into the lung and simulate pulmonary hæmorrhage.

The commonest of all bronchial affections is **bronchitis**. In catarrhal bronchitis the secretion from the inflamed mucous membrane is mucous, serous, purulent, or mixed. The mucus so abundantly secreted in the acute stage comes partly from the lining epithelium, partly from the mucous glands of the bronchial wall. Little plugs of mucus (which sometimes simulate tubercles) may be seen protruding from the orifices of these glands. The cellular elements contained in the bronchial secretion are nearly all pus-corpuscles. Epithelial cells are never abundant, inasmuch as they do not readily desquamate and when they do they usually become mucoid and dissolve (Arts. 420, 421).

When the secretion is very abundant, serous, and containing few cellular elements, the affection has been called serous **bronchorrhœa**; when the secretion is more puriform **bronchoblennorrhœa**. Sometimes the secretion decomposes and becomes foul-smelling under the influence of septic micro-organisms, and we have then foetid or **putrid bronchitis**. In all forms of bronchitis the mucous membrane is more or less densely

infiltrated with cells: this is most marked however in the purulent or putrid forms, in which the infiltration extends even to the peribronchial tissue. The causes of bronchitis are very numerous, some of them acting through the inspired air, some through the blood. Fœtid bronchitis is most frequently associated with dilatation of the bronchi (bronchiectasis) or with gangrene of the lung, but it also occurs independently of these.

Croupous bronchitis is usually an accompaniment of croupous tracheitis, and is almost always due to the specific virus of diphtheria: it may however be set up in other ways, as for example by the aspiration of liquid from the mouth. In croupous pneumonia there is always a certain amount of croupous inflammation of the smaller bronchi. The mucous membrane is covered over with whitish films whose thickness (except in croupous pneumonia) is not great in any but the larger bronchi: in the smaller tubes mere specks and shreds of fibrin are formed, and as we pass to the finest bronchioles these gradually disappear and are replaced by catarrhal secretion.

There is also a chronic fibrinous or **plastic bronchitis** in which



FIG. 216. TUBERCULOSIS OF THE BRONCHIAL MUCOUS MEMBRANE. ($\times 25$)

a, columnar epithelium

b, fibrous tissue of the mucosa infiltrated with leucocytes

c, tubercle

d, margin of a small tuberculous ulcer

from time to time firm coherent membranes form in the bronchi, and are coughed up as continuous tree-like casts of the ramifying tubes.

Diphtheritic and gangrenous inflammation of the bronchial mucous membrane are rare. They are generally set up by gangrenous or necrotic detritus coughed up from the lung, or by powerfully irritant matters which have been inspired. The inflammation thus induced is sometimes hæmorrhagic, and patches of the mucous membrane and of the deeper structures of the bronchial wall become gangrenous and are thus destroyed.

Tuberculous inflammation of the bronchi is a common accompaniment of tuberculous disease of the lung. It is usually most marked in the smaller tubes communicating with the diseased region: in other cases it is diffused over the greater part of the bronchial system. Here as elsewhere the affection begins with the formation of gray cellular nodules (Fig. 216), which project somewhat above the surface. These caseate and break down, and in this way small ulcers (*d*) are formed, whose floor and edges are usually covered with a whitish necrotic film and surrounded by a zone of hyperæmia.

The disintegration of the infiltrated margins of the ulcer steadily advances, and the ulcer grows and coalesces with others, so that at length large irregularly-shaped erosions are formed which sometimes extend to the cartilages of the bronchial wall. In the smaller tubes we frequently find the entire wall invaded and ulcerated away.

Syphilitic inflammation of the bronchi is not often seen: it presents the same appearances as in the trachea and larynx. Extensive loss of substance is occasionally caused by it; as recovery takes place coarse puckered cicatrices are formed, and these may give rise to notable contraction and distortion of the bronchi.

The bronchi are provided with a stratified epithelium, consisting of flat basal cells, transitional cells, and columnar cells. Some of the latter are ciliated cylindrical cells, others are mucus-producing goblet-cells, which in catarrhal conditions undergo mucoid degeneration. The capillaries of the mucous membrane empty themselves chiefly into the pulmonary veins, not into the bronchial veins: to this fact is due the readiness with which the membrane becomes engorged when the pulmonary circulation is overloaded (KÜTTNER, *Virch. Arch.* vol. 73).

The tissue of the bronchial wall contains lymphoid elements, and in the larger bronchi these are in places aggregated into groups lying between the muscular coat and the cartilages: in this way lymphadenoid nodules are formed which look not unlike tubercles.

References:—FRANKENHÄUSER, *Bau der Tracheebronchialschleimhaut* St. Petersburg 1879; J. ARNOLD, *Virch. Arch.* vol. 80; KÖLLIKER, *Zur Kenntniss d. Baues d. Lunge* Würzburg 1881; ROSSBACH; *Ueber d. Schleimbildung in d. Luftwegen* (Festschrift) Würzburg 1882; RIEGEL, *Ziemssen's Cyclop.* IV.; WEIL, *Gerhardt's Handb. d. Kinderkrankh.* III.; SOKOLOFF, *Virch. Arch.* vol. 68; HAMILTON, *Path. of bronchitis* London 1883.

CURSCHMANN recently described (*Deut. Arch. f. klin. Med.* XXXII.) under the name of 'exudative bronchiolitis' a peculiar form of bronchitis in which tough hyaline or grayish or yellowish coagula are formed, 0.5-1 mm. thick and 1-2 cm. long, and consisting of spiral or convoluted filaments and strings enclosing a variable number of cells. They are due to an exudative process affecting the bronchioles, which is neither simple catarrh nor croupous inflammation. According to VIERORDT (*Berl. klin. Woch.* 1883) similar coagula are occasionally met with in other inflammatory affections, as in croupous pneumonia.

In various forms of bronchitis, but especially in the croupous and exudative varieties, the secretion contains slender acicular colorless octahedra of various sizes, which are known as Leyden's crystals: they are probably identical with Charcot's crystals (compare Art. 260), and seem to consist of some substance containing mucin (SALKOWSKI). Their occurrence is accidental, and it is possible that they are formed in or from lymphoid cells: they may form in the sputum after it has left the body (UNGAR).

References:—PEACOCK, *Trans. Path. Soc.* v. 1854; CHARCOT, *Gaz. hebdom.* 47, 1860; LEYDEN and SALKOWSKI, *Virch. Arch.* vol. 54; ZENKER, *Deut. Arch. f. klin. Med.* XVIII., XXXII.; CURSCHMANN, *loc. cit.*; UNGAR, *Cent. f. klin. Med.* 1880, *Congress f. innere Med.* Wiesbaden 1882; PRAMBERGER, *Ueber fibrinöse Bronchitis* Graz 1881.

580. **Stenosis and occlusion** of the bronchi are generally the result

of inflammation. When the bronchial wall is infiltrated and the mucous membrane covered with exudations and secretions, the air-passage is always to a certain extent obstructed, and some of the smaller bronchi are frequently blocked up entirely. As a rule this obstruction passes away, the morbid accumulations (mucus, pus, croupous exudations, etc.) being removed by absorption and expectoration, while the swelling of the bronchial wall gradually goes down.

Sometimes however the secretions are only imperfectly removed, and the obstruction persists for a considerable time. This is most frequently the case in the apices of the lungs, where the respiratory movements are less marked than in other parts. Secretions which are rich in cells or which become inspissated and viscid are apt to cause chronic obstruc-

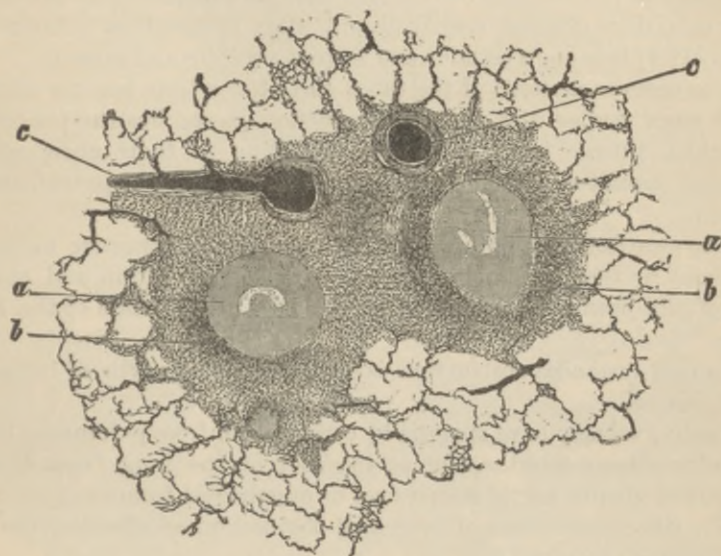


FIG. 217. TWO OCCLUDED BRONCHIOLES FROM A TUBERCULOUS LUNG.

(Preparation injected with Prussian Blue, and stained with ammonia-carminé: $\times 25$.)

a, caseous contents of the bronchioles

b, bronchial wall and peribronchial tissue thickened and infiltrated with cells

c, arterioles

tion. Chronic thickening of the bronchial wall, whether from cellular infiltration or fibrous hyperplasia, has much the same effect.

Persistent obstruction of the bronchi may result from simple acute or chronic inflammation, but it is far more commonly due to tuberculous inflammation. This is owing to the fact that in tuberculosis we have not only thickening and infiltration of the bronchial wall but also a secretion which contains many cells and little liquid.

In chronic pulmonary tuberculosis the bronchi are always affected, and hence there are always a certain number of obstructed bronchioles

in the diseased region (Fig. 217): in many cases indeed most of the smaller tubes are occluded, and this fact contributes essentially to produce the characteristic appearance of the consolidated lung.

The contents of an occluded bronchus always become caseous (*a*), so that on section it looks like a round encapsulated caseous node. Only when a considerable length of the tube is filled with caseous detritus and when the section cuts it more or less longitudinally does it present the appearance of a cylindrical or elongated deposit. The boundary between the caseous contents and the bronchial wall is sometimes sharp and distinct, sometimes ill-defined. The former appearance is more characteristic of obstruction from catarrhal bronchitis, the latter of tuberculosis. The bronchus and the tissue around it are generally thickened in the neighborhood of the caseous deposit. The thickening after catarrh is oftenest simply fibroid, after tuberculous inflammation (Fig. 217 *b*) it is more cellular and in part necrotic and caseous.

The caseous contents of the tubes may after a time become calcified.

Foreign bodies also may by impaction cause obstruction of the bronchial tubes. They give rise, according to their chemical and physical character, to indurative, purulent, or it may be putrid, inflammation.

The cicatricial formations which follow upon destructive inflammation may by their contraction cause marked constriction and obstruction of the bronchi: this is well seen in syphilitic disease of the larger tubes.

In rare instances obstruction is caused by the growth of intrabronchial tumors.

Lastly, we may have stenosis by compression from pulmonary tumors or inflammatory growths, and at the root of the lung from enlarged lymphatic glands, aortic aneurysms, or œsophageal tumors.

For the consequences of bronchial obstruction as affecting the lung see Chapter LXXXIII.

581. **Hyperplasia and induration.** After long-enduring bronchial catarrh thickening and papillary overgrowth of the mucous membrane is sometimes though not frequently observed. The change is never extensive, and is of small importance.

The induration and thickening of the entire bronchial wall, which results from certain forms of inflammation, is much more important. The change is most frequently observed in the neighborhood of plugs of inspissated secretion, though it occurs also in unobstructed tubes and sometimes extends over a considerable number of their ramifications. It may also affect the peribronchial fibrous tissue and even extend to the contiguous parenchyma of the lung. From what we may call endobronchitis is developed indurative mesobronchitis and **peribronchitis** with peribronchial lymphangitis.

Indurative peribronchitis may also arise from the like change (cir-

rhosis) commencing in the lung, the process either being of the nature of direct extension or advancing from the bronchioles of the indurated parenchyma by way of the peribronchial lymphatics to the peribronchial fibrous tissue of the larger tubes. In like manner the inflammatory change may extend from inflammation of the pleuræ or of the interlobular septa. In rare instances the induration extends from the fibrous tissue

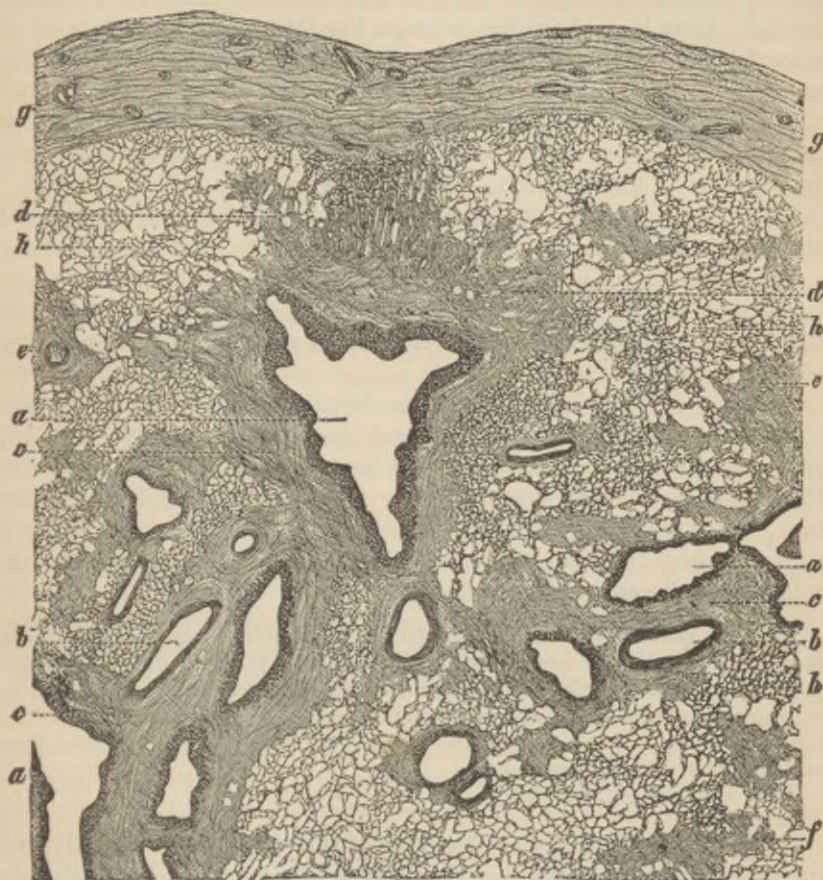


FIG. 218. INDURATIVE PERIBRONCHITIS.

(Section stained with picrocarmine: $\times 4$.)

- | | |
|--|--|
| a, bronchi, some of them dilated | f, fibroid indurations in which the bronchi have not been cut across |
| b, arteries | g, thickened pleura |
| c, thickened peribronchial fibrous tissue | h, pulmonary tissue, partly emphysematous |
| d, radiating bands of fibrous tissue | |
| e, thickened bronchioles blocked up with secretion | |

and lymphatic glands at the root of the lung, and proceeds radially along the peribronchial structures.

The appearance of a bronchus thus thickened and indurated varies

greatly according to the way in which the process has been set up. If the tube is unobstructed (Fig. 218) it looks on section like a thick-walled aperture, sharply defined against the pulmonary tissue or surrounded by radiating fibrous bands (*d*), and projecting above the cut surface. If the tube is filled with inspissated secretion (Fig. 218 *e*, Fig. 217 *a*), the wall looks like a thickened capsule surrounding it. When the adjacent parenchyma of the lung is devoid of air, collapsed (Fig. 218 *e*) and indurated, there is no sharp line between the thickened bronchus and the altered lung: a slight difference in tint and in consistence is all that appears.

Inflammations issuing in suppuration or in caseation extend to the peribronchial tissues and lymphatics in the same way as the indurative variety: they often extend both widely and deeply.

In tuberculous bronchopneumonia with caseation caseous peribronchitis is always present, and in suppuration of the lung there is always a certain amount of purulent peribronchial lymphangitis. Of course the tubes immediately connected with the seat of disease in the lung are the first and most affected, but the process often spreads to the bronchi of other regions.

Peribronchitis being thus a secondary affection, and usually associated with bronchitic and pneumonic processes, it is always accompanied by changes in the lung or in the pleura (Fig. 218 *g*). Indeed these latter changes are frequently the most apparent, and overshadow to a great extent the peribronchial lesions (Art. 614). Cases however occur in which these are so marked that they form the essential character of the disease.

The term peribronchitis is used in the text in a much more restricted sense than is usual. Most writers include under it the nodular indurations of bronchopneumonia. It is thought best however to distinguish between the finer terminal or respiratory bronchioles, and those which serve simply as air-passages. The former are essentially elements of the parenchyma of the lung, and their inflammations are essentially pneumonic.

For references see Art. 582.

582. **Bronchiectasis** or dilatation of the bronchi results partly from increased internal pressure on the bronchial wall, partly from changes in its structure and in that of the surrounding pulmonary tissue.

The dilatation is either uniform and extending over one or more branches, or local and fusiform or saccular: it may be single or multiple. Frequently we meet with several varieties of dilatation in the same patient.

Most frequently the dilatation is due to long-standing inflammatory affections by which the strength and elasticity of the bronchial wall is considerably diminished, so that it yields to the internal pressure of the respired air. Such dilatations are usually cylindrical, and are most marked in the lower lobes. When the wall yields unequally, the dilated

tube appears sacculated, and its inner surface is irregularly corrugated with annular, oblique, or reticulate ridges and bands. These are simply the circular fasciculi of the bronchial wall, which retain to some extent their form in spite of the dilatation, the mucous membrane bulging and yielding between them. The mucous membrane is moreover more or less atrophied and infiltrated, the cartilages are often partially disintegrated and replaced by fibrous tissue, and the orifices of the mucous glands are dilated into small funnels. The epithelium is sometimes little altered; but in other instances it is seen that the columnar cells have become mucoid or detached, so that the surface is lined only with short cubical or club-shaped cells devoid of cilia. This is especially the case where there is much catarrh.

Bronchiectasis is especially apt to occur when the branches of an inflamed bronchus are partially impermeable to air, so that the corresponding portion of the lung is collapsed and functionless. The result is that on inspiration the air entering the bronchus is not uniformly distributed; and even if the neighboring portions of the lung should dilate by way of compensation, as the thorax expands the air which rushes in is still unequally distributed and bears abnormally on the obstructed tube. Adhesions and thickenings of the pleura and of the interlobular fibrous tissue have often a like effect, inasmuch as they interfere with the equable expansion of the lung, and lead to irregularities in its distribution within the bronchi. Partial atelectasis (Art. 591) persisting after birth acts in the same way. When the pulmonary tissue round a bronchus undergoes contraction, it may in certain circumstances exercise traction on the bronchial wall and cause it to dilate. Lastly, when the bronchial secretion accumulates abnormally in an obstructed tube, it may give rise to considerable distention and dilatation.

The bronchiectases brought about in the ways just enumerated are seldom fusiform or cylindrical. They are often saccular, globular, or irregular in form, or arranged in a moniliform series. Sometimes in an indurated lung they are so numerous that the latter appears excavated in all directions. In very rare instances we meet with regular cysts filled with mucus, behind a bronchial obstruction.

In these dilatations the mucous membrane undergoes changes similar to those just described.

Papillary outgrowths are very rarely met with. The exterior layers of the bronchial wall, and the peribronchial fibrous tissue, are frequently much thickened, especially where there is inflammatory induration or cirrhosis of the lung. These are sometimes distinguished as hypertrophic bronchiectases.

References:—CORRIGAN, *Dublin Med. Journ.* 1838; BIERMER, *Virchow's Handb. d. spec. Path.* v., *Virch. Arch.* vol. 19; BUHL, *Lungenentzündung, Tuberculose und Schwindsucht* Munich 1872; LEBERT, *Klinik d. Brustkrankheiten* I.; TROJANOWSKY, *Beiträge z. Lehre von d. Bronchiectasie* In. Diss. 1864; FITZ, *Virch.*

Arch. vol. 51; JÜRGENSEN, *Ziemssen's Cyclop.* IX.; LICHTHEIM, *Arch. f. exp. Fath.* X. 1878; GRANCHER, *Gaz. méd. de Paris* 1878; LEROY, *Arch. de physiol.* 1879; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; RIEGEL, *Ziemssen's Cyclop.* IV.; HAMILTON, *Path. of bronchitis* London 1883; HELLER, *D. Arch. f. klin. Med.* XXXVI. 1885.

Some authors (BIERMER, RIEGEL, RINDFLEISCH) state that in bronchiectasis the mucous membrane and the muscular coat frequently become hypertrophied and form papillary outgrowths, but this ZIEGLER has not been able to verify. The prominent ridges occasionally observed are not of new formation, but are simply those parts of the wall which have not yielded to the dilating forces.

583. **Ulceration and perforation** of the bronchial wall is due either to inflammation of the internal surface or to ulcerative affections in the surrounding tissues. Purulent, putrid, and tuberculous inflammations are those most apt to lead to ulceration and perforation from within (Art. 579).

Suppuration is especially likely to occur when septic matters are inhaled with the inspired air or when the bronchial secretion undergoes putrefactive changes. The latter takes place in bronchiectases, where the secretion is apt to linger for a considerable time.

When perforation occurs and the originating inflammation extends to the surrounding parts, the peribronchial tissue and the adjacent lung-tissue become infiltrated, and according to the character of the inflammation undergo caseous or suppurative and putrid disintegration. Caseous or purulent bronchitis thus issues in caseous or purulent peribronchitis, and bronchiectasis becomes an ulcerated **bronchiectatic vomica**. The peribronchial excavation either lies beside the primary dilatation or surrounds it more or less completely.

The destruction of the bronchial wall is at first usually partial, but in time it becomes complete; and the bronchus then appears to open into and terminate at the cavity.

The walls of the cavity may appear gangrenous, caseous, or infiltrated and indurated, according to the mode in which it has arisen and the point of time at which the examination is made. Its liquid contents are puriform, putrid, or mixed with fragments of caseous detritus. The putrid liquid contains bacteria, and often spherules of leucin and needles of tyrosin and margarin.

The cavity usually increases in size, and that most rapidly when the process is suppurative or gangrenous; less rapidly when caseation takes place; and least rapidly when the lung is already indurated by chronic inflammation. The destructive process may advance not only peripherally but also along the course of the peribronchial lymphatics: in this way suppurative and caseous peribronchitis are not infrequently set up.

Ulceration and perforation of the bronchi from without are associated with suppuration, gangrene, and caseation of the parenchyma of the lung: they are extremely common. Caseous or suppurating lymph-

atic glands, peribronchial tumors, and aneurysms, occasionally break through the bronchial wall.

When a bronchus is thus perforated the broken-down tissues and detritus pass into its lumen and are either coughed up or aspirated into other parts of the lung. Air on the other hand may enter the excavation from the bronchus.

On the **tumors** of the bronchi see Art. 619.

CHAPTER LXXXI.

STRUCTURE AND FUNCTION OF THE LUNGS.

584. The **parenchyma of the lung** is composed essentially of the terminal bronchioles and alveoli and of blood-vessels, together with a certain amount of connective tissue which unites the ultimate branches of the bronchi into lobules and marks them off one from another.

The transition from the air-tubes to the respiratory parenchyma is very gradual, the bronchial walls changing in structure by slow degrees and ultimately becoming sacculated. The bronchi subdivide dichoto-



FIG. 219. TERMINATION OF A BRONCHIOLE AND OF A PULMONARY ARTERIOLE.

(Prepared by corrosion: magnified by a hand-lens.)

A, bronchiole

B, pulmonary arteriole

mously into ever finer branches, and it is the finest terminal branches or bronchioles which go to form the respiratory parenchyma. At first the sacculations or **alveoli** occur singly (Fig. 219 B), and then in small groups on one side of the bronchiole. The tubes which are thus partially transformed into respiratory tissue are known as **respiratory bronchioles**. Each respiratory bronchiole divides into two or three smaller branches, which are surrounded on all sides by alveoli (B) and

are known as **alveolar ducts**. The terminal alveoli are called **infundibula**.

As the smaller bronchi pass into the respiratory bronchioles they alter notably in structure. The cartilages disappear, and the epithelium is reduced to a single layer of low non-ciliated cells, which ultimately take the form of broad polygonal pavement cells (KÖLLIKER).

As the respiratory bronchiole changes to an alveolar duct these modified columnar cells in turn disappear, and the epithelium takes the form of small nucleated granular-looking pavement cells interspersed with larger hyaline plates some with and some without nuclei. The muscular fibres of the bronchioles persist as annular bands surrounding the orifices of the lateral alveoli and of the terminal infundibula.

The epithelium of the alveoli is like that of the alveolar ducts. Their walls consist of a delicate membrane strengthened by scattered

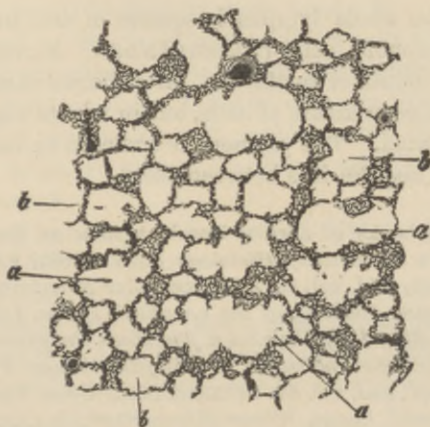


FIG. 220. SECTION OF AN INJECTED HEALTHY LUNG ($\times 20$).

a, longitudinal, *b*, transverse sections of respiratory bronchioles, alveolar ducts, and infundibula.

filaments and bundles of elastic tissue. They are devoid of muscular fibres.

The clustered alveoli belonging to each bronchiole are not quite contiguous, but are separated by spaces which are filled by other groups of alveoli and infundibula. The contiguous groups are bound together by connective tissue.

In preparations made by maceration or corrosion the alveolar ducts of each bronchiole appear thus to stand apart from each other; while in sections (Fig. 220) the alveolar tissue looks like a continuous meshwork, interspersed with transverse and longitudinal sections (*a*, *b*) of bronchioles, alveolar ducts, and infundibula. At the boundaries of the several bronchiolar systems we find broader bands of connective tissue marking off the so-called **lobules**.

The pulmonary parenchyma derives its blood-supply almost entirely from the **pulmonary artery**. Its capillaries surround the walls of each air-cell or alveolus (Fig. 220), and their loops project into its cavity covered only by the thin epithelial lining. The terminal branches of each arteriole are not distributed to a single bronchiolar system only (Fig. 219 *A*), but supply several contiguous systems: they anastomose freely with the branches of neighboring arterioles (Fig. 220) and form a continuous network of vessels. The blood from the capillaries is collected into **interlobular veins** which run between the several arterial areas.

The **lymphatics** arise in clefts and spaces lying in the interalveolar septa. The radicles unite and run in the peribronchial and circumvascular tissue, or in the interlobular, subpleural, and pleural connective tissue. Both bronchi and arteries are very richly supplied with lymphatics.

Throughout the whole lymphatic system of the lung we meet with collections of lymphoid cells (FRIEDLÄNDER, ARNOLD, KÖLLIKER), which are either round or fusiform. In children these lymphadenoid patches contain large numbers of cells, but in adults they are often more fibrous and pigmented. The pigment is enclosed in round, fusiform, or stellate cells, or it may lie free between them.

References:—Text-books of normal histology such as *Quain's Anatomy II*. London 1882; KLEIN's *Elements of Histology* London 1883; FRIEDLÄNDER, *Virch. Arch.* vol. 68; ARNOLD, *ibid.* vol. 80; KÖLLIKER, *Zur Kenntniss d. Baues d. Lunge* Würzburg 1881; KLEIN, *Anatomy of the lymphatic system* London 1875; FEUERSTÄK, *Ueber d. Verhalten d. Epithels bei d. fibrinösen Pneumonie* Göttingen 1882; KÜTTNER, *Die Kreislaufverhältnisse d. Säugethierlunge*, *Virch. Arch.* vol. 73; COHNHEIM and LITEN, *ibid.* vol. 65; ZUCKERKANDL, *Ueber Verbind. zwischen den art. Gefässen d. menschl. Lunge*, *Wiener Sitzungsberichte* LXXXVII.

The pulmonary artery is distributed almost entirely to the parenchyma of the lung, but it also according to KÜTTNER gives off small branches to the subpleural and interlobular connective tissue and to the bronchial mucous membrane. The pulmonary arterioles are terminal, but by dilatation of the communicating capillaries connections between neighboring arterial territories are readily established and perform the function of anastomoses.

The branches of the bronchial arteries subdivide with the bronchi and supply these and their nerves and lymphatic trunks. Their capillaries are connected with those of the pulmonary artery. The vessels which reach the lung from the mediastinal pleura supply the subpleural and interlobular lymphatics, but they also communicate with the pulmonary and bronchial arterial systems.

585. The **morbid affections** of the lung originate in the vascular system or in the bronchi, or are extensions by contiguity from neighboring parts.

The affections starting in the vascular system, that is to say depending on disturbance of the circulation or disorder of the blood, make their first appearance in small patches corresponding to the territory of

an arteriole, or they at once extend over a whole lobe, or over one or both lungs. In each case the extent and distribution of the local change is independent of the disposition and configuration of the smaller air-tubes.

With regard to affections of bronchial origin it must be noted that mere disturbance of the influx or efflux of respired air may give rise to grave changes in the pulmonary parenchyma. Impurity of the respired air is a still more potent cause of disease, as it leads not merely to morbid deposits in the lung but also, and very frequently, to inflammatory change. This latter is always at first localized, and often over areas corresponding precisely to the distribution of the bronchioles.

Disease of parts contiguous to the lung, and especially of the pleura, often give rise to pulmonary injury by the hindrance or obstruction of the respiration which they cause. In other cases the morbid process itself extends from the surrounding tissues to the lung, and usually spreads along the course of the lymphatic channels.

Malformations of the lung are on the whole not common. Absence of one or both lungs only occurs in cases where there are other grave defects of development. Absence of parts, abnormal smallness, etc., are met with in connection with malformation or deformity of the thorax. A small accessory lung unconnected with the trachea has once or twice been observed.

The commonest anomaly, and one which has no functional significance, is multiplication of the lobes.

In some of the lobes or in parts of them the air-tubes are occasionally absent or ill-developed, and then the corresponding part of the parenchyma consists simply of continuous cellular and highly vascular fibrous tissue. The bronchi leading to the airless tissue may be more or less dilated (Art. 582).

On the other hand we sometimes find in one or more parts of the lung large vesicular cavities resembling excessively distended alveoli.

On congenital malformations of the lungs see FÜRST (*Gerhardt's Handb. d. Kinderkrankheit*, III.), ROKITANSKY (*Path. Anat.* IV. (Syd. Soc.) London 1852), MAYLARD and L. HUMPHRY (*Journ. of Anat. and Physiol.* 1885), EDWARDS (*Amer. Jour. med. sci.* 1885).

CHAPTER LXXXII.

DISORDERS OF CIRCULATION IN THE LUNG.

586. **Congestive hyperæmia** may be due to diminution of the normal resistances to the arterial current within the lung, and may be induced by direct stimuli reaching the lung through the respired air, as when irritating or irrespirable gases are breathed or when the air is excessively hot or excessively cold. It is also the first step to inflammation. Partial or collateral congestion of one part of the lung sometimes results from obstruction of an important arterial branch in another part.

Congestion of the lung, when it is not collateral or due to local textural or vascular change (as in inflammation), extends uniformly over the whole organ. It is usually transient, and is very seldom fatal. In the fatal form of congestion called vascular **pulmonary apoplexy**, the lung appears swollen and abnormally firm, of a uniform dark-red color on section, and containing but little air; the capillaries are everywhere distended with blood and encroach on the alveolar cavities. There are usually some scattered extravasations of blood.

Engorgement or passive hyperæmia results from hindrance or obstruction to the outflow of blood through the pulmonary veins, or from causes tending to weaken the propelling forces. The latter appear when the activity of the right heart is impaired, when the pulmonary artery or its branches are obstructed, or when the respiration is interfered with. Thus when (as in suffocation) the inspiratory muscles dilate the thorax while air is prevented from entering the lungs, blood is as it were pumped from the extra-thoracic vessels into the intra-thoracic, and the blood collects and stagnates as it does under a cupping-glass.

Obstruction to the outflow of blood from the lung is most frequently caused by valvular lesions of the left heart; but the same effect is also indirectly produced by obstructive increase of pressure within the aorta which the heart is at length unable to overcome, and by relaxation or degeneration of the wall of the left ventricle.

Failure of the propulsive power of the heart causes engorgement chiefly of the dependent parts of the lung (**hypostatic engorgement**): arterial obstruction causes hyperæmia of the region supplied by the artery (Art. 589), and interference with respiration causes hyperæmia of

the lobules which are prevented from acting (Art. 591). When the engorgement is great the affected parts become purple or livid in color.

Passive hyperæmia may give rise to various secondary changes, such as hæmorrhage, œdema, dilatation of vessels, and loss of epithelium.

Anæmia of the lung may be due to general anæmia. When it is partial it is usually dependent on compression or excessive inflation of the part. After death the blood generally flows from the anterior portions of the lung to the deeper and posterior portions.

587. When in consequence of endocarditis and valvular thrombosis the mitral orifice is rapidly obstructed and the valve rendered incompetent, the backward pressure and consequent engorgement in the pulmonary veins is apt to be very great, and œdema, hæmorrhage, and epithelial desquamation ensue.

The **œdema** is marked by the escape of serous liquid into the alveoli (Art. 588), but in this variety the quantity of liquid is seldom great. The extravasation of blood also is not usually considerable, though there are here and there small hæmorrhages recognizable even with the unaided eye: the extravasated blood may fill the alveoli to the exclusion of air.

The epithelial desquamation is sometimes slight, but in other cases it is so abundant that the alveoli are all but filled with granular or homogeneous epithelial plates. The lung then looks grayish-red, and is abnormally firm to the touch: it contains little air, and in places may be entirely airless. The desquamation of epithelium is due to the transudation of lymph from the capillaries.

Mitral disease of long standing, when accompanied by hypertrophy of the right ventricle and permanent increase of pressure within the pulmonary vessels, leads to the condition known as **brown induration** of the lung. The organ is larger and firmer than usual, it contains less air, and its tissue is brownish-red and dry, or rarely œdematous. It often contains scattered hæmorrhagic patches and spots of brown.

The principal changes are dilatation of the vessels and pigmentation of the tissues. The dilatation is most marked in the capillaries, which protrude into and encroach on the alveolar spaces.

The **pigmentation** of the lung is due to the presence of yellow and brown granules deposited chiefly along the course of the lymphatics in the peribronchial, circumvascular, and interlobular tissues, and also to some extent in the alveolar walls. The granules are enclosed in stellate, fusiform, or rounded cells or lie free in the tissues. The alveolar epithelium is here and there pigmented.

The pigment is derived from the blood. When blood escapes from the vessels the alveoli are at first more or less filled with it. Part of it passes directly into the lymphatics which communicate with the lumen of the alveoli. Another portion disintegrates within the alveoli, and at the same time white blood-cells migrate from the capillaries and take up the disintegrated matters, becoming thus transformed into corpuscle-

carrying and pigment-granule cells. These lie at first within the alveoli and are sometimes met with in great numbers. Thence they may pass into the bronchi and are coughed up, but the greater number pass into the lymphatics and so reach the lymphatic glands, or remain lodged in the tissues of the lung, especially in the patches of lymphadenoid tissue. The detritus of the blood which passes directly into the lymphatics lodges in the same parts; the ultimate form which it takes being in all cases that of brown or even black pigment.

When the engorgement and excessive pressure persist for a long time the walls of the pulmonary vessels become hypertrophied, and the connective tissue is also somewhat increased. According to RINDFLEISCH and others the muscular fibres of the bronchi and alveolar ducts are also hypertrophied.

References:—DITTRICH, *Beitr. z. path. Anat. d. Lungenkrankheiten* Erlangen 1850; VIRCHOW, *Virch. Arch.* vol. 1; ZENKER, *Beitr. z. norm. u. path. Anat. d. Lungen* Dresden 1862; BUHL, *Virch. Arch.* vol. 16; RINDFLEISCH, *Path. Hist.* II. London 1873; HERTZ, *Ziemssen's Cyclop.* v.; ORTH, *Virch. Arch.* vol. 58; EBERTH, *ibid.* vol. 72.

588. **Œdema** of the lung is a condition in which the alveoli and bronchioles, and often the bronchi also, are filled with serous liquid more or less mingled with air. The condition may extend over the whole lung, or only over a lobe or part of a lobe. The pulmonary tissue may be either anæmic or hyperæmic.

Pulmonary œdema arises in various ways. It generally appears *in articulo mortis* as a result of the gradual failure of the heart. According to COHNHEIM it occurs when the outflow through the pulmonary veins is opposed by an obstruction that the right ventricle cannot overcome. This is the case when from weakness or excessive aortic resistance the left ventricle fails to empty itself in systole. COHNHEIM'S explanation is based on experiment and no doubt applies to many cases of ante-mortem œdema, but not to all.

Not infrequently the signs of previous engorgement are entirely absent, and the distribution of the œdema is so irregular that we cannot refer it to a condition (like engorgement) extending over the whole lung. In such cases we must assume that we have to do with some alteration of the vessel-walls that causes them to be abnormally permeable, and is referable to the disease from which the patient has suffered. The like explanation will apply to the œdema which occasionally results from the breathing of irrespirable gases.

Another variety is the inflammatory œdema which generally accompanies certain inflammatory processes, such as croupous or suppurative inflammation. Lastly, multiple fat-embolism of the pulmonary arterioles may give rise to œdema from obstruction of the capillary circulation.

The liquid of pulmonary œdema is always albuminous, and usually poor in cellular elements derived from the blood. The œdema of engorgement not rarely is due to liquid which contains red blood-cells, often in such abundance as to give it a hæmorrhagic appearance.

Epithelial cells are sometimes abundant in the liquid, sometimes scanty: they are more or less swollen up. If catarrh is present at the same time, numbers of white blood-cells mingle with the liquid. Where pigmentation of the lung is in process some of these cells contain pigment-granules.

References:—COHNHEIM, *Allg. Path.* i. Berlin 1882; WELCH, *Virch. Arch.* vol. 72; POSNER, *ibid.* vol. 79; FALK, *ibid.* vol. 91; S. MAYER, *Wiener Sitzungsber.* LXXVII. 1878. *Prager med. Woch.* 14, 1880; LITTEN, *Berl. klin. Woch.* 1882.

589. **Hæmorrhage** from the pulmonary vessels is of very common occurrence and arises from a great variety of causes.

In the first place hæmorrhage is very frequently a result of engorgement, especially that due to violent inspiratory efforts with obstructed access of air (inspiratory dyspnoea). The quantity of blood which escapes is not usually so great as to cause firm hæmorrhagic infarction, but it may lead to the formation of rather large dark-brown patches of infiltrated and airless tissue.

When a large quantity of serous liquid transudes with the red blood-cells we have what is called hæmorrhagic œdema of the lung.

When the air is entirely displaced from the lung-tissue, so that it becomes dark-red and not unlike a soft and very vascular spleen, the condition has been termed **splenization** of the lung. It is most commonly a result of gradual cardiac paralysis before death: the blood no longer efficiently propelled accumulates in the deeper parts of the lung and so gives rise to what we might describe as hypostatic hæmorrhagic œdema. If as often happens inflammation begins in the engorged region the process is termed **hypostatic pneumonia**.

Extravasation of blood is an exceedingly common accompaniment of pneumonic and bronchopneumonic affections (Arts. 602, 613).

In acute inflammations the red blood-cells escape from the vessels with the inflammatory exudation, of which indeed they form a component part. In the later stages of the inflammation, when the pulmonary tissue breaks down, hæmorrhage is usually due to the rupture of small or large blood-vessels whose walls have been softened or ulcerated through.

In the case of the larger arterial branches the wall usually yields and becomes dilated into a small **aneurysm** before actual rupture. These aneurysms are most frequently observed on vessels which traverse or lie in the wall of ulcerating cavities. When they rupture more or less copious hæmorrhage ensues, and the cavities together with the bronchi which open into them are flooded with blood.

Mechanical injury, like that caused by a bullet or a broken rib, gives rise to bleeding whose amount depends of course on the nature and extent of the wound.

In somewhat rare cases pulmonary hæmorrhage is referable to a congenital or acquired hæmorrhagic diathesis, as in hæmophilia, in purpura, or in scurvy; or to infective diseases like scarlatina, typhoid, and small-pox; or lastly to cerebral disease, especially such as causes disturbance of the respiratory function. In the latter case the bleeding may be very considerable, whole segments of the lung becoming infiltrated and airless.

The most marked form of **hæmorrhagic infiltration** or **infarction** is that which follows thrombosis or embolism of a branch of the pulmonary artery. The infarct is usually subpleural, of a sharply defined conical form, and in the recent state dark brownish-red in color and firm in consistence. When the blood is somewhat leukæmic the infarct may be grayish-red or grayish-white in color. The emboli come from the right side of the heart or from the systemic veins and usually lodge at the bifurcation of the arterial branches. The characteristic extravasation takes place when the blood reaching the embolized region from the neighboring capillaries is insufficient to maintain the circulation.

Pulmonary infarcts vary in size from that of a cherry-stone to that of a hen's egg, though occasionally they are much larger. The pleura over a recent infarct is smooth and glistening, but afterwards it becomes turbid and covered with a thin fibrinous film.

Embolism of a pulmonary arteriole is not always followed by hæmorrhagic infarction, though the arteries are *terminal* in COHNHEIM'S sense of the word (Art. 30). Sometimes of course death ensues before there is time for the formation of an infarct, but apart from this the circulation may be maintained by the free influx of blood from the neighboring capillaries.

References on hæmorrhagic infarction of the lung:—VIRCHOW, *Gesammelte Abhandl.* Frankfort 1856; COHNHEIM, *Allg. Path.* I. Berlin 1882; PANUM, *Virch. Arch.* vol. 25; WILLIGK, *Prager Vierteljahrsschrift* L.; GERHARDT, *Sammlung klinischer Vorträge* 91, *Gerhardt's Handb. d. Kinderkrankh.* III.; HAMILTON, *Liverpool med. chir. Journ.* 5, 1833; LITTEN, *Berl. klin. Woch.* 1882.

References on pulmonary hæmorrhage in cerebral disease:—PINEL, *De l'hémorrhagie pulmonaire en rapport avec les lésions du cerveau* Thèse de Paris 1876; NOTHNAGEL, *Cent. f. d. med. Wiss.* 1874; JEHN, *ibid.*; BROWN SÉQUARD, *Lancet* 1, 1871; CHARCOT, *Leçons sur les maladies du syst. nerv.* Paris 1875; CARRÉ, *Archives générales* 1877.

590. Blood extravasated into the tissue of the lung is re-absorbed provided the tissue remains otherwise uninjured (Art. 587). The corpuscles dissolve and are taken up in solution, or they break up and pass, either free or enclosed in cells, into the lymphatics. Thence they are carried to the lymphatic glands, or are deposited in the walls of the lymphatic vessels, and give rise to black or brown pigmentation. Some of the cells containing disintegrated blood are removed with the sputum.

During the stage at which the lymphatics and the alveoli contain a large amount of disintegrated blood the pulmonary tissue has a dirty orange or rusty tint.

In more copious hæmorrhage, such as follows the rupture of an artery, blood passes into the bronchi and is coughed up (**hæmoptysis** or hæmoptœ). Some of the blood may be aspirated from the bronchi into neighboring branches and into their alveoli. In this way hæmorrhagic patches exactly resembling primary hæmorrhages are formed; usually however their number and distribution, and the circumstances in which they occur, enable us to discern their nature.

The firm hæmorrhagic infarct becomes rapidly decolorized, assuming a reddish-brown or rusty tint. Then a reactive inflammatory immigration of leucocytes sets in from the vessels of the contiguous parts, and accelerates the re-absorption of the blood. In the course of time such infarcts often disappear entirely, leaving no permanent structural change behind. In other cases the affected region is indicated by a more or less marked but seldom very definite condensation of the pulmonary tissue, with some cicatricial contraction; the pleural surface of the region is slightly drawn in, and shows a certain amount of fibroid thickening with white radiating bands extending from it. The condensed tissue is sometimes brown or slate-colored, sometimes undistinguishable in color from the surrounding tissue. The condensation is due partly to collapse of the infiltrated alveoli, partly to new-formation of fibrous tissue in the alveolar septa by which they are thickened and bound together into a compacter mass.

The embolus is meanwhile absorbed in like manner, its place being indicated by slight corrugations of the wall or filaments traversing the lumen of the artery.

When the infarct is large or the re-absorption of the extravasated blood and the re-establishment of the circulation delayed, part of the infiltrated tissue may perish and break down into an inodorous brownish-red pulp: this either makes its way into a bronchus and is so removed, or is re-absorbed. The loss of substance is repaired by the development of cicatricial tissue, provided no septic change is set up within the cavity.

In rare instances the re-absorption of blood and disintegrated lung-tissue is incomplete, and the detritus remaining passive for a time becomes thickened and caseous, and at length calcified, the whole being enclosed in a capsule of new-formed fibrous tissue.

When the embolus causing the infarction contains at the same time infective matters capable of setting up decomposition or suppuration, or when these reach the injured tissue with the inspired air, we may have gangrene or suppuration of the lung (Art. 605).

CHAPTER LXXXIII.

ATELECTASIS, COLLAPSE, AND EMPHYSEMA OF THE LUNG.

591. In the unborn child the lung is a compact structure, the alveoli exist potentially, but they are everywhere collapsed and airless. When respiration commences the alveoli become distended with air into hollow vesicles and the epithelial lining of their walls becomes expanded and flattened.

If the respiration is imperfect owing to the occlusion of a bronchus or the compression of some part of the lung, some of the lobules remain unexpanded and retain the dense fleshy consistence and livid tint of the foetal organ. This condition is known as **foetal atelectasis** or **apneumotosis**.

When a part of the lung which has once acted becomes from any cause airless it is said to be **collapsed** or atelectatic. The condition may be due to compression, or to obstruction of a bronchus. Compression of the lung is most commonly brought about by the collection of air or liquid in the pleural cavity, or by excessive elevation of the diaphragm: it may also be due to aortic aneurysm, spinal curvature, thickening and contraction of the pleura, distention of the pericardium, etc. The compression may be partial or total, and the collapse may be more or less complete.

When the collapse affects the whole lung and is complete, the organ is usually squeezed up against the spine, and its tissue is dense, tough, and airless: its color is generally pale pink or gray. Collapsed segments of the lung have a similar appearance, but there is often more blood in the part and so it has a redder color.

When a bronchus or bronchiole is occluded by secretion or other cause, the corresponding segment always becomes airless after a time. LICHTHEIM states that the oxygen of the enclosed air is first absorbed by the blood, then the carbonic acid, and ultimately the nitrogen; the lung shrinking to its foetal condition.

As the collapsed part no longer expands or contracts with respiration, and its capillaries are much folded and contorted, a certain amount of engorgement takes place. The unexpanded tissue thus looks somewhat livid in tint, and is retracted or sunken in comparison with the normal tissue.

Obstructive collapse is extremely common and is indeed a usual accom-

paniment of inflammation of the smaller bronchi. *Post mortem* the lung looks mottled with livid retracted patches alternating with pink or reddish-white air-containing regions.

References:—WEBER, *Beiträge z. path. Anat. d. Neugeborenen* Kiel 1852; BARTELS, *Virch. Arch.* vol. 21; HERTZ, *Ziemssen's Cyclop.* v.; GERHARDT, *Virch. Arch.* vol. 11, and *Gerhardt's Handb. d. Kinderkrankh.* iii.; LICHTHEIM, *Arch. f. exp. Path.* x.; TRAUBE, *Gesamm. Beiträge z. Physiol. u. Path.* Berlin 1871; BALZER, *Gaz. méd. de Paris* 1878; ROMELAERE, *De l'atélectasie pulmonaire* Brussels 1881; SCHUCHART, *Virch. Arch.* vol. 101.

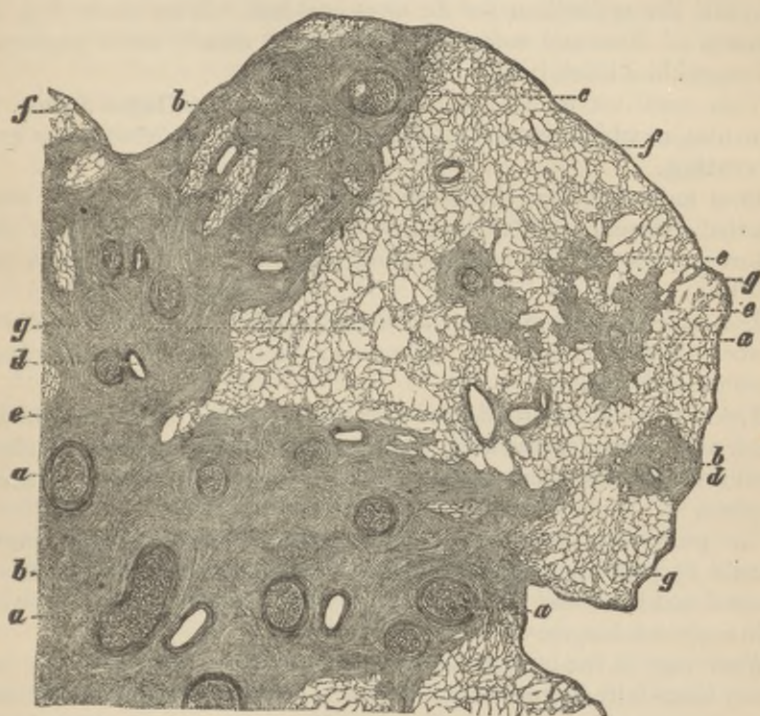


FIG. 221. CIRRHOSIS FROM COLLAPSE OF THE PULMONARY TISSUE.

(Horizontal section through the apex of the lung, stained with picrocarmine and mounted in Canada balsam: $\times 5$.)

a, bronchi plugged with secretion

b, obliterated bronchioles

c, small bronchus distended with secretion

d, pulmonary arterioles

e, collapsed indurated pulmonary tissue

f, normal, g, emphysematous pulmonary tissue

592. **Results of collapse.** When a part of the lung remains collapsed for some time certain changes in its tissues usually make their appearance. Small hæmorrhages take place from the engorged vessels, by which the tissue becomes permeated by blood-cells and to some extent pigmented: it is however beyond doubt that much of the black pigment

which is ultimately deposited in the collapsed tissue is simply dust and carbonaceous matter inhaled before the bronchi became occluded. Presently the alveolar septa cohere and coalesce, and the tissue is transformed into a more or less compact and continuous mass (**carnification**).

The cohesion of the alveolar walls and the consequent condensation and induration of the tissue probably never take place without some slight inflammation, which is either conducted from the inflamed bronchi or set up by the extravasated blood. After a time but few remnants of pulmonary structure can be made out in the collapsed region, and in them the septa are thickened, the few shrunken alveoli are filled with cells, and the epithelium for the most part lost. Other parts (Fig. 221 *e*) consist of dense and compact fibrous tissue, usually much pigmented and resembling black india-rubber.

This condition we may call the **cirrhosis of collapse**: from the pigmentation which is always present it is often referred to as **gray induration**.

It is most common about the apex of the lung (Fig. 221), where catarrhal obstruction of the bronchi (*a*) frequently takes place and leads to the collapse of the corresponding alveoli with the changes just described.

The occluded bronchi are often hypertrophied (*a*) and distended with the accumulated secretion (*c*). The small respiratory bronchioles (*b*) are nearly all obliterated.

The surface of the condensed portion is always shrunken and distorted, and there are generally adhesions between the pleural surfaces which show that at some time or other inflammation has existed about the parts.

The pulmonary tissue lying between the collapsed regions is partly normal (*f*), partly emphysematous (*g*); it often includes small islands of collapsed and indurated tissue (*e*). The bronchi which are still pervious to air are not infrequently dilated (Art. 582).

When part of the lung persists in a state of foetal atelectasis, the pulmonary tissue is by degrees transformed into compact unpigmented fibrous tissue, sometimes interspersed (HELLER, FEUSTEL) with bits of cartilage and adipose tissue, the obliterated alveoli being represented by a few clusters of epithelial cells. The corresponding bronchi are in general somewhat dilated, so that the unpigmented tissue is traversed by smooth-walled channels and cavities of various sizes: in particular instances these may be as large as a hen's egg. The cavities are lined with cylindrical epithelium, and like other bronchiectases may be the seat of inflammatory change.

HELLER (*Naturforscherversammlung in Freiburg* 1883, *D. Arch. f. klin. Med.* XXXVI. 1885) and FEUSTEL (*Ueber die späteren Schicksale der Atelektase* In. Diss. Kiel 1883) have recently directed attention to the bronchiectasis which may follow upon foetal atelectasis. ZIEGLER has met with a typical example in the case of a

man of 35, in whom about a quarter of the upper lobe of the left lung was transformed into dense white fibrous tissue, excavated in all directions by smooth-walled cavities lined with cylindrical epithelium and communicating with bronchi. The largest cavity was about as large as a hen's egg. There were no signs whatever of any previous inflammation.

593. When the thorax is over-distended by forced inspiration, or when one part of the lung is pervious to air while another part is shut off, the pervious parts become excessively inflated and a condition which we may describe as **acute vesicular emphysema** is induced. The alveoli are not altered in structure but are simply over-distended. This condition is very commonly the result of bronchopneumonia. The distended lobules are pale and anæmic, and those that lie immediately beneath the pleura project like little blebs above the level of the normal or atelectatic parts.

When the pressure within an alveolus exceeds a certain amount its wall gives way, and air enters the interalveolar tissue and especially the lymphatic channels. This condition is called **intervesicular emphysema**. It is generally a result of bronchitis or bronchopneumonia accompanied by violent coughing, and is met with in children who have died of asphyxia during the course of these affections. It has also occurred from over-energetic attempts to insufflate the lungs of stillborn infants.

The alveoli of the anterior border of the upper lobe are the most apt to give way. The inflated vesicles are usually subpleural and may be as large as a pea. Sometimes air passes from them under the pleura towards the root of the lung and into the mediastinal adipose tissue, sometimes even inflating the subcutaneous structures of the neck and thorax (**subcutaneous emphysema**).

594. When the alveoli are subjected to persistent or often-repeated distention, partial atrophy and yielding of their walls ensue, and two or more alveoli being thus converted into one the pulmonary tissue is to that extent 'rarefied.' This state is called **chronic vesicular emphysema** or simply emphysema. Its production may be facilitated by disorders of nutrition, such for example as accompany local inflammation or senile decay. The lungs of many persons seem also normally to possess but little power of resistance to over-distention.

The atrophy of the septa begins at the point where they are thinnest, and first appears in the widening of the intercapillary spaces (Fig. 222 *a*) and the yielding or disappearance (*b*) of the elastic fibres. Holes and gaps next appear between the capillaries in the septa; they are at first very small (*b*), but soon enlarge (*d*). The over-stretched capillaries become impervious (*c*) and ultimately give way (*d*).

By the gradual extension of this process many of the septa and their capillaries at length disappear, the thicker fibrous bundles which surround the alveolar ducts being the last to go.

The epithelium is passive throughout and often shows signs of degenerative (especially fatty) change. Sometimes the tissue is inflamed and infiltrated, but this has nothing to do with the emphysema as such; it is simply a concomitant of the catarrh which so frequently affects patients suffering from emphysema.

Chronic emphysema may be due, like the acute variety, to persistent inspiratory over-distention of the lung-tissue. This occurs chiefly in cases where parts of the lung are collapsed and functionless (Art. 592), and the neighboring parts (Fig. 221 *g*) are accordingly over-distended. We might describe this as vicarious or compensatory emphysema. It is

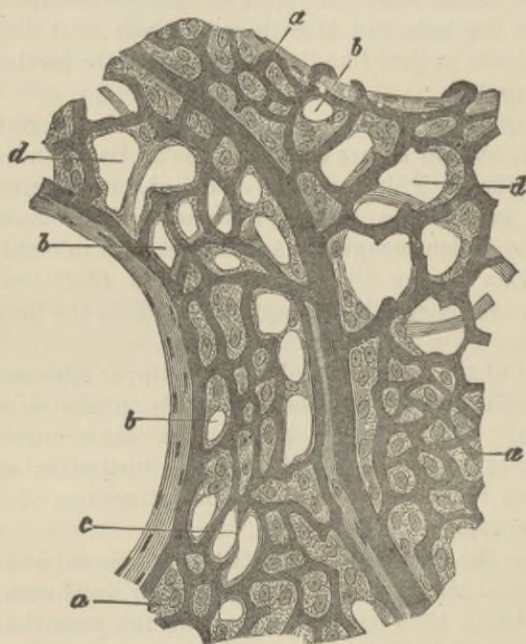


FIG. 222. CHRONIC VESICULAR EMPHYSEMA.

(Injected preparation, stained with carmine and mounted in Canada balsam: $\times 200$.)

- | | |
|--|---|
| <p>a, dilated intercapillary spaces with epithelial cells</p> <p>b, gaps in the alveolar septa (EPPINGER'S primary dehiscence)</p> | <p>c, capillary in process of obliteration</p> <p>d, larger gaps in the alveolar septa and in the capillary network (EPPINGER'S secondary dehiscence)</p> |
|--|---|

sometimes lobular, sometimes lobar in its extension. The emphysematous lobules are inflated and the alveoli abnormally large.

On the other hand emphysema also results from persistent and violent expiratory efforts, in conditions which interfere with the egress of air from the alveoli, ingress being unimpeded. This is the case in the important variety described as chronic idiopathic diffuse emphysema or simply **general emphysema**, an affection which is very common in persons subject to chronic bronchial catarrh or to frequently-recurring

expiratory dyspnoea, or obliged to make violent expiratory efforts in connection with their employment.

This form of emphysema extends over the whole lung, though it is usually most marked at the edges and apices of the lobes, and at the base. When the lung is removed from the thorax it appears abnormally large, its edges obtuse and rounded, and the base frequently studded with hemispherical bladder-like prominences. The air-vesicles are everywhere enlarged by the disappearance of interalveolar septa, sometimes so much so that they look like bullæ and range in size from that of a pea to that of a hen's egg. The latter is chiefly the case at the

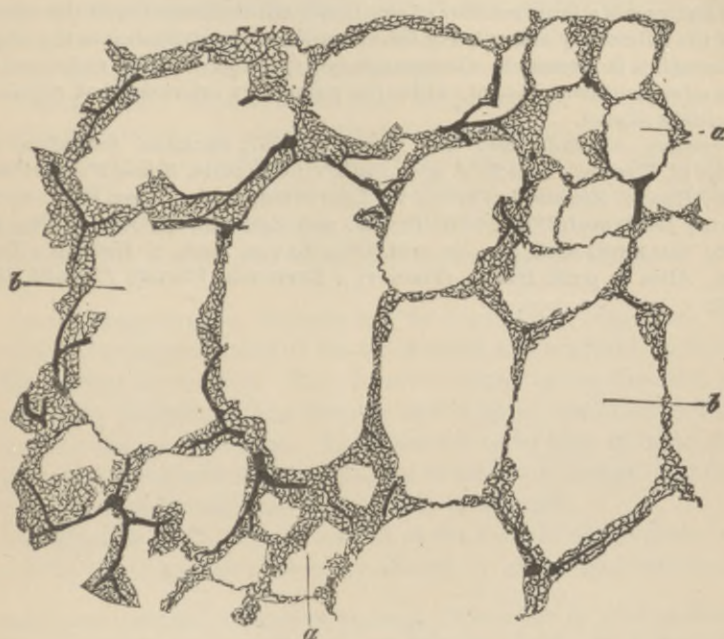


FIG. 223. RAREFIED PULMONARY TISSUE IN EMPHYSEMA.

(Injected preparation: $\times 20$.)

a, infundibular vesicles produced by disappearance of interalveolar septa
b, larger vesicles produced by coalescence of infundibular vesicles

edges and base, and there as a rule only in the lung-tissue immediately beneath the pleura. The smaller vesicles (Fig. 223 *a*) are formed by the disappearance of the interalveolar septa belonging to a single infundibulum; the larger vesicles (*b*) to the disappearance of the partitions between adjacent infundibula.

When there is much atrophy of the parenchyma the distended lung feels remarkably soft and downy, and its edges are markedly translucent. If the air is pressed out the lung becomes a mere flaccid inelastic mass with membranous edges.

Chronic idiopathic emphysema is occasionally limited to a part of the lung, usually to the edges. In this case the expiratory obstruction has obviously been also local.

When some of the vesicles in the general or in the local form are of exceptional size we have what is called **bullous emphysema**. The air is usually not easily pressed out of the larger vesicles.

The above account refers the production of emphysema chiefly to mechanical causes, namely to abnormal distention of the alveolar walls; but the atrophy of the latter may be much accelerated by malnutrition or senile decay of the pulmonary tissue. In senile emphysema the latter factor is of essential importance, though the mechanical factors must not be entirely overlooked.

In emphysema a large number of capillaries are obliterated, and the vascular area of the pulmonary artery being thus contracted the resistance to the circulation through it is increased. Compensatory hypertrophy of the right ventricle is thus a frequent concomitant, while the pulmonary arterioles that remain are often visibly dilated.

References :—JENNER, *Med. chir. Trans.* xi. 1857; BIERMER, *Sammlung klin. Vorträge* 12, *Virchow's Handb. d. spec. Path.* v.; KNAUTHE, *Schmidt's Jahrbücher* vol. 163; HERTZ, *Ziemssen's Cyclop.* v.; LICHTHEIM, *Arch. f. exp. Path.* x. 1878; EHEBALD, *Deut. med. Woch.* 1881; RIEGEL and EDINGER, *Zeitschr. f. klin. Med.* 1882-83; VILLEMEN, *Arch. gén. de méd.* 1866; BAYER, *Arch. d. Heilk.* II.; THIERFELDER, *Atlas d. path. Hist.* I. (Plate VI.); EPPINGER, *Viertelj. f. prakt. Heilk.* vol. 182.

CHAPTER LXXXIV.

DEGENERATIONS OF THE LUNG.

595. The **non-inflammatory degenerations** of the pulmonary tissue are of comparatively slight importance, and have no practical interest for the physician. Emphysema and senile atrophy may form nominal exceptions, and they have already been discussed in Art. 594.

Swelling, fatty degeneration, and desquamation of the pulmonary epithelium accompany every copious transudation into the alveoli, inflammatory or non-inflammatory. The inhalation of deleterious substances also leads to manifold injury of epithelium, blood-vessels, and fibrous stroma; but the changes so induced are of altogether secondary importance in comparison with the inflammation which is at once set up.

Among degenerative changes due to disorders of nutrition we may mention fatty degeneration of the epithelium and amyloid degeneration of the fibrous structures. The former occurs in emphysema and in poisoning by phosphorus and arsenic, the latter in conditions which lead to the like change elsewhere. It is however to be kept in mind that the lung is on the whole but rarely the seat of amyloid change, and that the walls of the blood-vessels are most apt to be affected.

Calcification of the fibrous stroma of the lung is rare, except in cases where the tissue has been morbidly altered by antecedent inflammation.

References :—BUHL, *Lungenentzündung, Tuberculose u. Schwindsucht* 1873 (fatty and amyloid change); CORNIL and BRAULT, *Journ. de l'anat. et de la physiol.* XVIII. 1882 (phosphorus and arsenic poisoning); CORNIL, *Arch. de physiol.* 1874 (hyaline degeneration); ZAHN, *Virch. Arch.* vol. 72 (stratified corpora amylacea); VON RECKLINGHAUSEN, *Allgem. Path.* Berlin 1883 (ditto); CHIARI, *Wien. med. Woch.* 1, 1878 (calcification); HLAVA, *Wien. med. Blätter* 36, 1882 (calcification of pulmonary vessels); ORTH, *Lehrb. d. spec. path. Anat.* II. Berlin 1885.

CHAPTER LXXXV.

PULMONARY INFLAMMATIONS IN GENERAL.

596. All **acute inflammations** of the lung of any intensity are marked by exudation into the respiratory air-spaces, the exudation following upon an initial congestive hyperæmia of the lung-tissue.

The exudation either consists of a clear albuminous liquid (as in inflammatory œdema), or contains a large number of leucocytes (as in catharrhal or purulent inflammation) or of red blood-cells (hæmorrhagic exudation).

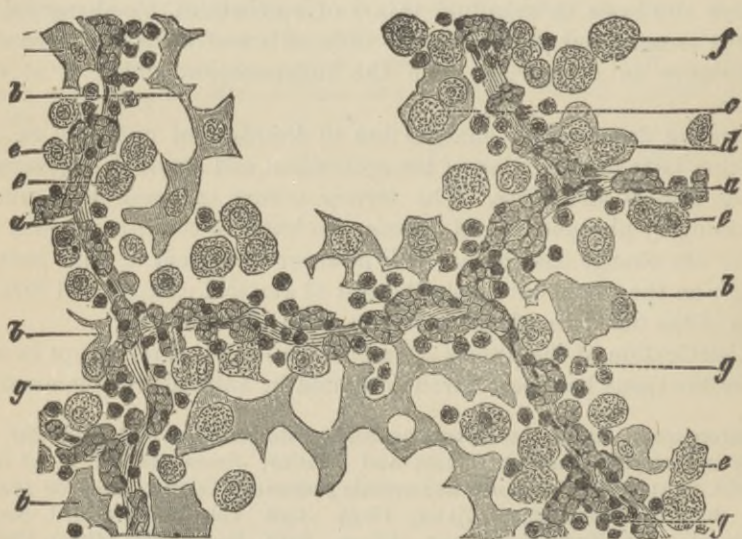


FIG. 224. RECENT BRONCHOPNEUMONIA.

(Section treated with Müller's fluid and picrocarmine, and mounted in glycerine: $\times 300$.)

- | | |
|---|---|
| a, alveolar septa with distended capillaries | e, detached epithelial cells, nucleus little altered |
| b, detached epithelial plates, nucleated and non-nucleated | f, swollen epithelial cells, nucleus obscured by granules |
| c d, epithelial plates containing granules and oil-globules around the nuclei | g, leucocytes |

This exudation is always followed by more or less marked desquamation of the epithelium lining the alveoli, alveolar ducts, and respiratory bronchioles.

The large nucleated and non-nucleated epithelial plates (Fig. 224 b)

are often detached unaltered; when the exudation is sudden and abundant they are often shed in coherent flakes. Oil-globules frequently occur in them (*c*), usually aggregated around the nucleus (*d*).

The small protoplasmic nucleated epithelial cells are also partially detached; many however remain all but unaltered (*e*), appearing only a little swollen or studded with fat-granules (*f*) which to some extent obscure the nucleus.

The blood-vessels are at first distended with blood (*a*), the alveolar septa and walls of the bronchi being saturated with liquid and beset with a moderate number of extravasated leucocytes. The lymphatics also contain some exuded liquid, and the lymphatic glands are swollen. When the onset of the inflammation is less sudden the exudation is at first more scanty, and the epithelial desquamation is accordingly less extensive.

The lung-tissue when recently inflamed is reddened, contains little air or none, and on pressure yields a more or less turbid gray or grayish-red or even blood-stained liquid.

The changes in the pulmonary epithelium and blood-vessels which accompany the beginning of inflammation have frequently been the subject of investigation histological and experimental. Experimenters have set up inflammation in the lung either by cutting the vagus nerve or the recurrent laryngeal nerve, or by injecting irritating liquids such as solution of perchloride of iron or solution (1 per cent) of nitrate of silver. Section of these nerves causes paralysis of the laryngeal muscles, and saliva and other matters get into the air-passages from the mouth. When these are aspirated into the alveoli they set up a local inflammation, which is well-adapted for purposes of investigation.

References:—TRAUBE, *Gesamm. Abhandl.* I. Berlin 1871; COLBERG, *Deut. Arch. f. klin. Med.* II. 1866; FRIEDLÄNDER, *Untersuch. über Lungenentzündung* Berlin 1873, *Virch. Arch.* vol. 68; FREY, *Die path. Lungenveränderungen nach Lähmung d. N. vagi* Leipzig 1877; SOMMERBRODT, *Virch. Arch.* vol. 55; VERAGUTH, *ibid.* vol. 82; WAGNER, *Arch. d. Heilk.* VII., VIII.; CURSCHMANN, *Deut. Arch. f. klin. Med.* XXXII.; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; FELD, *Experiment. Beiträge z. Schluck- und Vaguspneumonie* In. Diss. Bonn 1875; FEUERSTACK, *Ueber d. Verhalten d. Epithels d. Lungenalveolen bei d. fibrinösen Pneumonie* Göttingen 1882; HAMILTON, *Pathology of bronchitis* London 1883.

597. When the exudation has reached its highest point the affected tissue is usually devoid of air, the alveoli being filled with the exuded matters and with desquamated epithelium. We may distinguish certain varieties of pulmonary inflammation by the nature of the accompanying exudation.

In **hæmorrhagic inflammation** the chief contents of the alveoli are red blood-corpuscles, and the inflamed region has a dark-red or brown color.

In **catarrhal inflammation** the contents of the alveoli consist mainly of liquid and small rounded cells with some admixture of larger

squamous cells (Fig. 225). When these larger cells are the more numerous (Fig. 227 *c*) the affection is often spoken of as desquamative catarrh, the assumption being that the large cells are detached alveolar epithelial plates. This is however by no means always the case, for such cells are not infrequently developed from extravasated leucocytes. A portion of lung affected with catarrh looks red, grayish-red, gray, or grayish-yellow according as it contains much or little blood; on pressure it yields a grayish liquid more or less mingled with blood.

Croupous inflammation is characterized by the coagulation of the exudation, fine threads of fibrin appearing between the cells contained in the extravasated liquid (Fig. 226) and making the whole cohere into a compact semi-solid mass.

Coagulated exudations of this kind consist chiefly of liquid mingled with red and white blood-cells and epithelium, coagulation setting in as the white blood-cells dissolve.

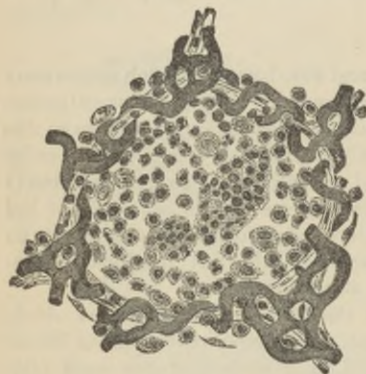


FIG. 225.

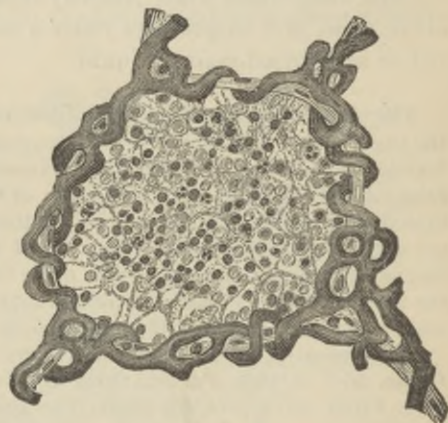


FIG. 226.

FIG. 225. CATARRHAL BRONCHOPNEUMONIA.

(Injected preparation stained with hæmatoxylin : $\times 80$.)

An alveolus filled with liquid and with large and small colorless cells

FIG. 226. CROUPOUS PNEUMONIA (RED HEPATIZATION).

(Injected preparation stained with hæmatoxylin : $\times 80$.)

An alveolus filled with a coagulated exudation containing red and white corpuscles and epithelial cells

Another form of coagulation is observed in exudations containing many large cells (Fig. 227) and tending to become caseous at a later stage. In these the cells break up and dissolve entirely, forming with the exuded liquid a granular and fibrinous mass (*d*): when recent this contains a few nuclei, but soon these too disappear and the mass becomes uniformly fibrinous. The two forms of coagulation are met with in combination.

The coagulated exudation is more or less solid, and the affected

parenchyma accordingly becomes firm and resistant, resembling liver in consistence: the condition is therefore described as **hepatization** of the lung. The surface on section is usually rough and granulated, the coagula projecting somewhat from the cut alveolar walls. The color varies from deep-red (red hepatization) to grayish-red or grayish-yellow (gray hepatization), according to the amount of blood that is present and the composition of the exudation.

In many forms of pulmonary inflammation the changes within the contents of the alveoli are those that are most striking and important, the changes in the parenchyma itself being of secondary significance. These forms have been described as superficial in contradistinction to interstitial inflammations; in the latter marked changes (infiltration, hyperplasia, etc.) are simultaneously set up in the connective tissues

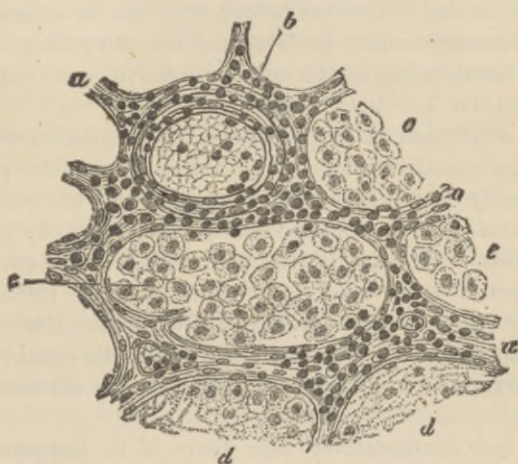


FIG. 227. CASEATING LOBULAR BRONCHOPNEUMONIA.

(Section hardened in alcohol and stained with hæmatoxylin : $\times 130$.)

a, alveolar septa infiltrated with cells

b, venule with infiltrated wall

c, alveoli filled with large epithelioid cells

d, alveolar contents consisting of granular and fibrinous coagula

(Fig. 227 *a b*). The distinction can frequently be made, but it is not exactly one of kind, as the two forms pass the one into the other through a number of transitional stages.

Cellular infiltration of the lung-tissue is never entirely absent in any pulmonary inflammation; but in some varieties it is slight and transient, in others intense and persisting. There is always in like manner a certain amount of exudation into the lymphatic vessels.

The extent of the inflammatory change varies greatly in different cases, and accordingly we have forms described as miliary, nodular, lobular, and lobar.

When the inflamed part of the lung is close to the pleural surface, the pleura in general becomes inflamed at the same time. Hyperæmia is first induced, and a more or less abundant exudation is then poured out on the free surface.

598. **Terminations of pulmonary inflammation.** The most favorable issue is in **resolution**, the exudation being removed and the altered tissue restored. The exudation may be removed by expectoration, but the greater part is re-absorbed.

In many forms of inflammation the pulmonary vessels continue permeable to injections throughout the entire course of the affection (Figs. 225, 226), and the lymphatics in like manner are not permanently obstructed by the inflammatory exudation. Resorption therefore goes on continuously, the exuded matters being carried off directly in a more or less altered condition. Coagulated and cellular exudations must of course become partially liquefied before they can be re-absorbed. This liquefaction is brought about by fatty and mucoid change and by disintegration and breaking up of the cells and fibrin, a turbid pulpy liquid containing granular detritus is thus formed.

While the exudation is in process of disintegration within the pulmonary tissue a certain amount of inflammatory action persists, manifested chiefly by the continued extravasation of leucocytes. The leucocytes play a part in the process of resorption by taking up into their protoplasm fragments of the unliquefied detritus and carrying these with them into the lymphatic channels. At the same time the loss of alveolar epithelium is made good by regenerative multiplication of the intact epithelial cells. When the new cells continue to be shed as they are produced we have the condition known as chronic desquamative catarrh.

A second but comparatively rare issue is in **suppuration**. It is characterized anatomically by an extremely abundant accumulation of leucocytes within the alveoli and in their walls, together with progressive disintegration and liquefaction of the latter. This destructive process is set up by the presence of some intensely irritant agent, giving rise to ferments which dissolve the pulmonary tissue.

A third issue, also not very common, is in **gangrene**. The conditions for its appearance are—first, extreme disturbance and in parts suppression of the circulation, and secondly, the presence in the affected part of putrefactive micro-organisms. The gangrenous tissue is transformed into a dark-brown dirty mass, changing presently into a greenish-black foul-smelling sanious pulp or pus: this at first contains shreds and fragments of pulmonary tissue, but these too at length dissolve and disappear. The gangrenous pus contains various chemical products of disintegration of albumen and fat, such as leucin, tyrosin, margarin, volatile fatty acids, especially butyric, sulphuretted hydrogen, ammonia, etc. The more solid contents include granular detritus, pus-corpuses,

pigment, shreds of lung-tissue, oil-globules, margaric-acid, crystals of triple-phosphate, and various micro-organisms. The latter are the prime cause of the chemical decomposition and of the disintegration of the pulmonary tissue. According to FILEHNE a certain ferment is formed by them which acts like trypsin, and in alkaline solutions quickly dissolves elastic tissue.

Caseation most frequently occurs as a sequel of tuberculous inflammation, though it is also not entirely absent in the other forms. It would thus appear to depend upon some peculiar property of the exciting cause of the inflammation, though under special conditions it may occur in connection with inflammations which usually terminate in a more favorable way. So far as mere morbid anatomy is concerned we may say that caseation takes place most frequently in inflammations which are characterized by dense cellular infiltration of the parenchyma of the lung and accompanied by extensive alteration of the walls of the lymphatics and blood-vessels. The latter feature is most marked in tuberculous inflammation, and thus the anatomical and the ætiological characters are in this regard largely co-extensive.

In caseous degeneration the exudation within the aveoli necroses, and is in the first instance transformed into a fibrinous and granular mass (Fig. 227). In other cases it appears homogeneous, or the extravasated cells lose their nuclei and break down into fatty granular detritus. As a rule the alveolar walls also become speedily necrotic and caseous. The vessels are blocked up, the nuclei of the tissue-cells disappear, the contours of the tissue-fibres become indistinct, and at length the pulmonary tissue becomes granular or homogeneous and structureless, almost or altogether indistinguishable from the caseous exudation proper. When the walls of the larger vessels have been much infiltrated they too become caseous in like manner.

The last and not uncommon termination of a pulmonary inflammation is in the formation of new fibrous tissue and **cirrhosis**.

New fibrous tissue is developed when the cellular infiltration of the parenchyma of the lung is long-continued, the circulation at the same time remaining ample for the nutrition of the part. In such conditions large formative or fibroblastic cells make their appearance first in the alveolar walls (Fig. 228 *a*) and in the circumvascular, peribronchial, and interlobular connective tissue, and at length in the pleura also. These cells develop into fibrous tissue in the usual way (Art. 108), and so give rise to thickening of the affected parts and consequently to diminution of the respiratory spaces. As collapse very commonly accompanies this fibroid change the thickened alveolar walls speedily come into contact and cohere, and the corresponding aveolar cavities are obliterated. Some of the aveoli however may remain open, and these become lined with short cylindrical epithelial cells, so that on section they somewhat resemble the acini of a gland.

Not infrequently the fibrous hyperplasia in the alveolar walls is accompanied by a like development within the alveoli: large epithelioid formative cells (Fig. 228 *d*) make their appearance in the alveolar contents, and growing out as bands or strings of cells (*e*) or as bud-like processes from the alveolar wall traverse the exudation in various directions. At the same time buds and outgrowths spring from the capillaries of the alveolar wall (*g*); these push their way into the new tissue and being transformed into blood-vessels provide for its nutrition. The whole process corresponds closely with that by which a thrombus is organized (Art. 255).

Pulmonary tissue thus thickened by fibroid induration is firm and tough and usually devoid of air. Its color varies from white to slaty-gray or even black, according to the amount of pigment present.

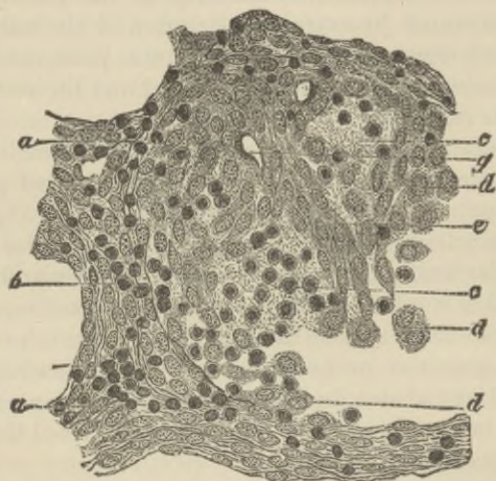


FIG. 228. GROWTH OF FIBROUS TISSUE IN THE WALLS AND IN THE CONTENTS OF AN ALVEOLUS.

(*Hæmatoxylin staining: × 150.*)

a, alveolar wall thickened and fibroid
b, small leucocytes
c, fibrinous and cellular exudation

d, intra-alveolar formative cells
e, string of fusiform fibroblasts
g, new-formed blood-vessels

Caseation and fibroid induration are very frequently met with in combination, the caseous foci being surrounded and enclosed by new and cellular fibrous tissue.

599. **Causes of pulmonary inflammation.** The inflammations of the lung are set up by irritants reaching it by way of the blood-vessels or of the bronchi, or by extension from the pleura or mediastinum. We may therefore conveniently consider these inflammations according to their various modes of origin.

As regards the pulmonary inflammations whose exciting cause is referable to the blood it must be observed that the lung is not on the whole so liable as other organs to be the seat of contaminating deposit

from the blood. Thus pigment-granules and micro-organisms may circulate freely through the capillaries of the lung without being arrested; this is doubtless due to the fact that the capillaries are comparatively wide and the blood-stream rapid. Deposits from the blood do however occur, and thus we meet with forms of hæmatogenous infiltration and hæmatogenous (bacterial) infection.

When the blood contains an excessive proportion of white corpuscles, these may accumulate in great numbers in the capillaries of the lung, and by extravasation in the tissues also, and give rise to **leukæmic infiltration**. Fat and oil-globules circulating in the blood (as in lipæmia) are apt to collect in the pulmonary vessels causing fatty embolism; and in anthrax the specific bacilli frequently crowd the capillaries so as to look like an artificial injection of them.

Four kinds of hæmatogenous infective inflammation are described; they may be described as **pneumonias** in a restricted sense of the term. They are—true croupous pneumonia, embolic septic (suppurative or gangrenous) pneumonia, embolic tuberculosis, and embolic syphilis. They are probably all due to bacterial infection, and we must assume that the bacteria are conveyed by the blood.

What we may term the **pleurogenous pneumonias** are closely allied to those just referred to. The inflammatory process extends from the pleura to the lung-tissue chiefly along the interlobular lymphatic channels, though here and there it passes thence directly to the peribronchial tissue and to the pulmonary parenchyma. The antecedent pleuritic affection is generally itself hæmatogenous. Traumatic pneumonia may be considered as a special pleurogenous variety, pleura and lung being generally injured simultaneously.

An inflammation of the lung induced by an irritant conveyed to the parenchyma by the bronchi is described as a **broncho-pneumonia**. It is immaterial whether the bronchi themselves are previously or simultaneously inflamed or not.

600. **Inhaled impurities.** The lungs are by reason of their function exposed to the access of numerous impurities. We all inhale a certain amount of dust with the air of the street or of the house, while in certain occupations the amount of dust necessarily inhaled is very considerable. Workers in stone of all kinds, masons, bricklayers, potters, inhale mineral and earthy dust; workers in metal such as grinders, gilders, braziers, typefounders, and so on, inhale metallic particles; millers, colliers, coal-heavers, chimney-sweeps, bakers, cabinet-makers, rope-makers, cigar-makers, and workers in spinning and weaving mills, live in an atmosphere charged with dust of vegetable origin. Brush-makers, upholsterers, barbers, cloth-dressers, and hat-makers breathe air containing animal dust; and glass-workers, street-sweepers, etc. dust of various other kinds.

A large proportion of the dust thus inhaled is caught in the air-

passages, but some of it especially in deep inspiration is carried into the parenchyma of the lung. Many of the particles adhere to the walls of the alveoli; others are promptly conveyed into the lymphatic channels communicating with the alveoli, and thence are carried by the peribronchial and interlobular lymphatics into the lymphatic glands at the root of the lung.

When a considerable number of dust-particles reach the parenchyma of the lung they set up a slight inflammation manifested by emigration of white blood-cells from the vessels and the desquamation of some of the alveolar epithelial cells.

The extravasated cells take up the foreign particles, sometimes in such abundance that they have been fitly termed **dust-cells** (LANGHANS, VON INS). They may be carried into the bronchioles and bronchi and are then ejected with the sputa. Much the larger number of them are however carried into the lymphatics.

Within the lymphatics certain kinds of dust, such as chalk-particles, are dissolved. Insoluble dusts are either carried into the bronchial glands or are deposited in the walls of the lymphatic vessels. This deposit takes place wherever lymphatics occur, that is in the interalveolar, interlobular, subpleural, pleural, circumvascular, and peribronchial fibrous tissues, especially in those parts where aggregations of lymphoid elements are normally met with. The particles lie either free in the tissues or enclosed in rounded, fusiform, or stellate cells.

Colored dust gives rise to pigmentation of the lung, while the larger grains appear as sandy or gritty deposits. Some forms of dust-deposit, in particular those which give rise to marked change in the lung, have received special names. The most frequent as well as the best-known form is that due to the inhalation of soot or coal-dust, by which the lung becomes dark-gray or black; it is variously described as **anthracosis** or *pneumoconiosis anthracotica* (*μονις* dust, *ανθραξ* coal), and the lung as **collier's** or **miner's lung**. This form of pigmentation is very common, and is seldom entirely absent in adult lungs. It must however be remembered that all black pigmentations of the lung are not anthracotic, for black pigment is frequently a derivative of the coloring-matter of the blood (Arts. 68, 268). A second form is the so-called **siderosis** (compare Art. 268) or *pneumoconiosis siderotica* (*σιδηρος* iron) of ZENKER, due to the inhalation of metallic dust; in the lung it appears as oxide or sesquioxide or phosphate of iron. Oxide of iron (rouge) is used as a pigment and as a polishing-material; it gives rise to a brick-red pigmentation of the lung, the other iron-compounds tending rather to blacken it. The deposit of stone-dust, especially of quartz, flint, and glass, has been called **chalicosis** (*χαλιξ* grit); dust from clay as inhaled by porcelain-workers and makers of artificial ultramarine gives rise to **aluminosis**. Grinders inhale mixtures of steel-dust and

grit which cause the affection known as **grinder's asthma** or grinder's rot.

PEARSON, THOMSON, ROBIN and others surmised that part at least of the black pigmentation so frequently found in the lung was derived from inhaled soot and coal-dust: TRAUBE verified this by actually demonstrating the presence of microscopic particles of coal in the lung and sputum. COHNHEIM thinks that the black pigment of the lung is entirely of this nature; but VIRCHOW is no doubt right in referring some of it to altered blood-pigment. ZIEGLER has found that in a very large number of cases the lung-tissue and the bronchial glands contain broken-down red corpuscles, corpuscle-carrying cells, yellow and brown flakes, and granules of pigment. This is especially the case in parts that have been altered in any way by inflammation.

ZENKER's researches were the first to give us precise information on siderosis.

KUSSMAUL, SCHMIDT, and MEINEL have examined the mineral residue (ash) of lung-tissue, and have shown that in chalicosis the amount of silica present is remarkably increased. LEWIN, VILLARET, CROCO, VON INS, RUPPERT, SCHOTTELIUS, and others have experimented on dust-inhalation.

References:—PEARSON, *Phil. Trans.* 1813; THOMSON, *Med. chir. Trans.* xx., xxi. (1837); ROBIN, *Traité de chimie anatomique* III. (1853); TRAUBE, *Deutsche Klinik* 1860; ZENKER, *Deut. Arch. f. klin. Med.* xiii.; KUSSMAUL, *ibid.* II.; GREENHOW, *Lancet* 1, 1869, *Trans. Path. Soc.* xvi. et seq., *Report of Med. Off. to Privy Council* 1861; MEINEL, *Deut. Viertelj. f. öffentl. Gesundh.* 1876; VIRCHOW, *Virch. Arch.* vols. 1, 35, *Edin. Med. Journ.* 1858; LEWIN, *Beiträge z. Inhalationstherapie* Berlin 1863; VILLARET and CROCO, *Schmid's Jahrb.* 116, 126; VON INS, *Arch. f. exp. Path.* v.; KNAUFF, *Virch. Arch.* vol. 39; SLAVJANSKY *ibid.* vol. 48; RUPPERT, *ibid.* vol. 72; SOYKA, *Prag. med. Woch.* 1878; MERKEL, *Ziemssen's Cyclop.* I.; HIRT, *Staubinhalationskrankheiten* Breslau 1871; SMITH, *Med. Times* 1, 1881; HESSE, *Viertelj. f. gerichtl. Med.* xxxvi. (1882); SELIGSOHN, *Eulenburg's Realencyclopädie* Article *Staubkrankheiten*; WEICHELBAUM, *Cent. f. med. Wiss.* 1882, *Wiener med. Jahrb.* 1883; BUHL, *Naturforscherversammlung in München* 1877; HARRIS, *Journ. of Anat. and Physiol.* xv. 1881; ARNOLD, *Staubinhalation* Leipzig, 1885.

601. The kinds of dust described in the last article, when in small quantities, give rise to no serious change in the lung, other than pigmentation. This is especially true of coal-dust of which very considerable quantities may be inhaled without injury. Metal-dust and grit are more dangerous, for in any but small amounts they set up inflammations which in some cases are not slight or transient but give rise to very marked alteration in the lungs. Dust-inhalation is thus the exciting cause of a group of bronchopneumonic affections ending in chronic pulmonary change.

If insoluble dust is capable of acting in this way, much more will dust containing soluble chemically-active substances, and organized or microparasitic irritants.

The air we breathe, especially in thickly-populated places, very frequently contains such matters, and some of them must reach the lung and be deposited on the alveolar walls or enter its tissue or the lymphatics. Many of them do no noticeable harm, others and especially the

micro-organisms pass from the lung into other parts of the body, and act as the specific causes of infective disease. Others again give rise to local inflammatory change in the lung itself at the places where they settle. The bacillus of tuberculosis (or its spores) is probably the most striking example, and there is no doubt that other disease-producing agents reach and act on the lung in a similar way.

In addition to these irritants inhaled with the air from the atmosphere without, we may have disease set up by inhalation of matters derived from the body itself, and carried into the alveoli of the lung from the mouth, nose, pharynx, larynx, or air-tubes. Saliva and particles of food may be aspirated instead of swallowed, and pus from the larynx or bronchi may be carried into the respiratory parenchyma instead of being coughed up. The former occurs in very young or comatose patients, and the latter in those suffering from laryngitis or bronchitis.

These substances when thus aspirated usually set up more or less intense inflammation, especially when they are putrescent or contain putrefactive organisms, or specifically virulent agents such as the bacilli of tuberculosis or of glanders.

Very various forms of bronchopneumonia, specific and non-specific, are thus induced, their course and character depending on the nature of the exciting cause. Tubercle-bacilli give rise to inflammatory processes tending to caseation; the products of catarrhal bronchitis as a rule set up a similar catarrhal bronchopneumonia, slight and usually transient in character; pus from a perichondritic laryngeal abscess tends to cause violent suppurative inflammation of the lung, and putrescent particles of food may lead to gangrene.

Many experiments have been made on the action of saliva, decomposing organic substances, and bacteria, when aspirated into the lung. The numerous experiments on so-called *vagus-pneumonia* are of this nature. This form of inflammation is observed when the vagus and recurrent laryngeal nerve are cut, and is due to the fact that the paralyzed larynx permits saliva and foreign matters from the mouth to be drawn into the lung. Other investigators have conveyed into the bronchi liquids or pulverulent matters (dry or suspended in water), others again have caused animals to breathe various substances suspended in the air by means of spray. LIPPL, TAPPEINER, SCHWENINGER, SCHOTTELUS, WEICHELBAUM, VERAGUTH, and others have in this way tested the infectiveness of phthisical sputum.

The result of such inhalation-experiments depends on the nature of the matters inhaled and on the mode of experimentation. When finely-divided irritant substances, such as spray of phthisical sputum or of putrid liquids, are inhaled, small miliary bronchopneumonic foci are produced. When the inhaled matters are coarser or of larger volume, and of an irritant nature, we have large usually lobular patches of inflammation with hæmorrhage, suppuration, or gangrene, as the case may be. When the foreign matters are bulky enough to occlude one or more of the bronchioles the first effect is partial collapse or atelectasis. Large quantities of liquid quickly introduced into the lung may lead, as in drowning, to death by asphyxia. The liquid is carried with the inspired air into the alveoli, and fills them with a mass of froth.

References:—Art. 596; TRAUBE, *Beiträge z. Path. u. Phys.* i. Berlin 1871; BODDAERT *Lésions pulmon. conséc. à la section d. nerfs pneumogastriques* Brussels 1862; FRIEDLÄNDER, *Untersuch. üb. Lungenentzündung* Berlin 1873, *Virch. Arch.* vol. 68; FREY, *Die path. Lungenveränderungen nach Lähmung d. Nervi vagi* Leipzig 1877; SCHOTTELIUS, *Virch. Arch.* vol. 73; BUHL, TAPPEINER, LIPPL, SCHWENINGER, *Naturforscherversammlung in München* 1877; TAPPEINER, *Virch. Arch.* vols. 73, 82; HEIDENHAIN, *ibid.* vol. 70 (inhalation of hot steam).

CHAPTER LXXXVI.

FORMS OF PNEUMONIA.

602. **Croupous pneumonia** is an inflammation of one or more lobes of the lung, and is the characteristic symptom of a certain specific infective disease. The disease is acute, and the anatomical change which accompanies it is the appearance of a firm or solid exudation within the pulmonary alveoli.

The exudation may be limited to a portion of one lobe or appear in several isolated patches; but more usually it extends over the greater part or the whole of one lobe, or over the entire lung. Occasionally indeed both lungs are affected. The exudation either reaches its full extent suddenly and rapidly, or advances by successive stages.

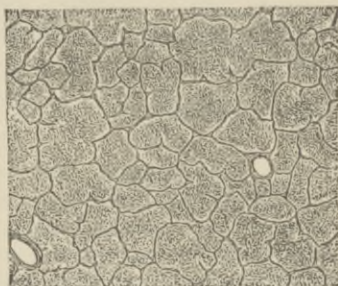


FIG. 220. CROUPOUS HEPATIZATION OF THE LUNG.

(Hardened in Müller's fluid and stained with alum-carminé: $\times 20$.)

The process begins with intense congestive hyperæmia, by reason of which the lung appears of a deep red color. This is the stage of **congestion** (*engouement*). The hyperæmia is accompanied by exudation from the vessels, by which in a short time the air is driven out of the alveoli, alveolar ducts, and respiratory bronchioles. At the same time the protoplasmic epithelial cells, and the homogeneous plates lining these spaces, are at least in part detached or shed (Fig. 224, Art. 596).

The alveolar contents thus consist (Fig. 226, Art. 597) of albuminous liquid, red and white blood-cells, and desquamated pulmonary epithelium. After a time coagulation takes place, granules and filaments appearing between and uniting the cellular elements into a solid mass adhering to the internal surface of the alveolus.

The coagulation of the exudation marks the beginning of the stage of **red hepatization** (Fig. 229). The lung is bulky, heavy, firm, and airless. The cut surface is red or grayish-red and granulated, the plugs which distend the alveoli protruding somewhat beyond their walls. The pleura over the affected region is turbid and covered with a thin film of fibrin: the costal surface is often marked by shallow impressions of the ribs. In the neighborhood of the infiltrated region the lung-tissue is frequently œdematous or filled with a turbid grayish exudation containing numerous leucocytes.

During the stage of red hepatization the lung is still highly vascular and filled with blood, the red tint being due not only to the extravasated red corpuscles but also to the blood which distends the capillaries. When the red corpuscles are extravasated in very large numbers the exudation assumes a dark-red tint like that of hæmorrhagic infiltration.

The stage of red hepatization passes gradually into that of **gray hepatization**. The change of tint is mainly due to the decolorization of the exudation and the accompanying anæmia of the lung-tissue. It must be remembered that in ordinary cases the pulmonary vessels remain throughout permeable by injections, while the normal structure of the lung continues quite distinct (Fig. 229). As the exudation loses color the cells it contains break down by fatty change and disintegration into granules and flakes, and they with the fibrin begin to dissolve. Leucocytes now migrate freely from the vessels, some of which remain clinging to the vessel-walls while others mingle with the liquefying exudation.

These changes result in the **colliquation** of the firm coagula, and when the lung is cut and scraped an abundant turbid whitish or grayish juice comes away, and the plugs that still fill the alveoli are loose and easily removed. The **resolution** of the pneumonia has set in.

The bronchi of the affected part are throughout the changes just described the seat of inflammatory change, and contain a mucous or sero-mucous secretion stained brown or red ('prune-juice' or 'rusty' sputum) with blood pigment. In the later stages the secretion is mingled with liquefied exudation from the bronchioles and alveolar ducts. Sometimes croupous casts of the smaller bronchi are formed.

We alluded in Art. 204 to the fact that KLEBS, KOCH, and FRIEDLÄNDER had observed the presence of micrococci in true croupous pneumonia. More recent investigations by FRIEDLÄNDER, FROBENIUS, and others make it not improbable that these micro-organisms (round or oval diplococci surrounded by a gelatinous capsule) are in causal relation to the disease. If this be established the view long maintained by JÜRGENSEN—that croupous pneumonia is the symptom of a specific infective disease—will be confirmed. The clinical course, the definite duration of the accompanying fever, and the occasional epidemic character of the disease—all point in this direction.

In addition to this idiopathic form croupous pneumonias sometimes appear in the course of various infective diseases such as malarial fever, erysipelas, and

typhoid, and in acute rheumatism. According to E. WAGNER these forms have probably no ætiological connection with the first, but are due to the action of the specific poisons of the respective primary affections.

References:—Art. 204; EBERTH, *Deut. Arch. f. klin. Med.* XXVIII.; FRIEDLÄNDER, *Fortschritte d. Med.* 1883, *Virch. Arch.* vol. 87; JÜRGENSEN, *Ziemssen's Cyclop.* v., and *Die croupöse Pneumonie* Tübingen 1884; E. WAGNER, *Deut. Arch. f. klin. Med.* XXXIII.; SALVIOLI and ZÄSLEIN, *Cent. f. med. Wiss.* 1883; HEITSCH, *Ueb. infect. Pneumonie* In. Diss. Leipzig 1883; MENDELSON, *Die infect. Natur d. Pneumonie*, *Zeitschr. f. klin. Med.* VII.; ZIEHL, *Cent. f. med. Wiss.* 1883; GÜNTHER, *Zeitschr. f. klin. Med.* 1883 (micrococci in living patient); Discussion, *Congress f. innere Med.* Wiesbaden 1884; *Collective Investigation Record* II. London 1884; DRESCHFELD, *Brit. Med. Journ.* 1, 1884, *Fortschritte d. Med.* III. 1885; KLEIN, *Micro-organisms and Disease* London 1884; EMMERICH, *Fortschritte d. Med.* 1884; PURJESZ, *D. Arch. f. klin. Med.* XXXV.; SENGER, *Arch. f. exp. Path.* XX.; CORNIL and BABES, *Les bactéries* Paris 1885; STERNBERG, *Amer. Journ. med. sci.* 1885; Discussion, *Brit. Med. Journ.* 2, 1886.

The composition of the exudation varies much in different cases. We have already remarked that the number of extravasated red corpuscles is by no means constant; the white cells and the amount of fibrin formed is also variable. In the pneumonia of aged patients the fibrin is often scanty, so that the exudation has rather the character of inflammatory œdema, and only in isolated spots is firmly solidified. The like happens now and then in younger persons, and is indicated by the rapidity with which the affected regions recover and again contain air. It appears also that in certain cases the process may stop short at the stage of congestion, the commencing exudation being rapidly re-absorbed. The time at which hepatization is complete is also to some extent variable, so that no definite statement can be made as to the precise duration of each stage. All we can say is that during the first two days the hepatized lung is red in tint, after that it becomes pale. Sometimes the transition takes place irregularly, the lung showing patches of grayish-red, grayish-white, and yellow simultaneously.

603. As the coagulated exudation liquefies its removal becomes possible. This takes place chiefly by re-absorption, in part also by expectoration. During this process the lung appears as if saturated with moisture; it is beset with leucocytes but not in excessive number, and its tissue is easily torn.

In the great majority of cases complete recovery takes place, so that after re-absorption is complete nothing remains of the affection. The time required to bring this about varies much in different cases. Not infrequently there is for weeks some dulness to percussion over the affected region.

In few cases does any permanent textural change remain, but it is possible for the pneumonic exudation to issue in gangrene, suppuration, or cirrhosis of the lung.

Gangrene of the lung occurs when the pulmonary vessels are so gravely injured that the circulation comes to a stand-still, while putrefactive organisms gain access to the affected parts. The former condition is most frequently met with in drunkards and ill-nourished persons, in whom the pneumonic exudation often has a hæmorrhagic character. The latter condition is most likely to arise in cases where before the

attack of pneumonia bronchiectases or other cavities containing decomposing secretion exist in the lung.

The destruction of the lung may take place in isolated patches or continuously. The tissue is transformed into a tindery or pulpy mass with a characteristic intensely fœtid odor. When a gangrenous patch lies immediately beneath the pleura the latter may be raised up in bullæ or blisters, or the softened mass may break through into the pleural cavity.

The tissue surrounding the gangrenous part is inflamed and infiltrated, often hæmorrhagic. Death usually ensues either from intense pleurisy or from putrid poisoning. If recovery takes place, the gangrenous portion is separated off from the healthy by a zone of granulations, and gradually removed: in most cases a cavity remains which may be the starting-point for fresh inflammatory mischief.

Another and comparatively uncommon issue is in **suppuration**, due to excessive extravasation of leucocytes in the later stages of the pneumonia. Sometimes patches of necrosis are the starting-point of the suppuration. The accumulation of leucocytes appears partly in the alveoli, partly in the substance of the lung-tissue, and may be disseminated or diffuse. The tissue becomes yellow and very brittle; here and there it may break up and dissolve outright. Large abscesses are however very rare indeed, and are probably formed only where some previous morbid alteration has already existed.

The pus thus formed may find an exit in various directions. Most frequently it is evacuated through the bronchi. Death is a common termination; though the suppurative process may come to an end and granulations spring up, by which cicatrization is effected, or a cavity bounded by new-formed connective tissue remains.

The frequency of gangrene, suppuration, and caseation as terminations of pneumonia is still matter of discussion. LEYDEN doubts whether a lung previously healthy ever becomes gangrenous or suppurates after pneumonia. It is however by no means always possible to demonstrate *post mortem* the presence of previous morbid change. It is to be doubted whether croupous pneumonia ever issues in caseation.

References:—JÜRGENSEN, *loc. cit.*; LEYDEN, *Sammlung klin. Vorträge* 114, 115, *Deut. Zeitschr. f. klin. Med.* II.; BUHL, *Lungenentzündung, Tuberculose und Schwindsucht* 1872, *Arbeiten a. d. path. Inst. zu München* 1878; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* III.

604. Another termination of croupous pneumonia, not very common it is true but by no means rare, is in collapse and induration of the lung, a condition which is best described as **simple cirrhosis**.

In some cases this comes about by the lung failing to expand after the resolution and absorption of the exudation. This may be due to persistent obstruction of the bronchi (Art. 592, Fig. 221) or to compres-

sion from without. The walls of the unexpanded alveoli soon become coherent and undergo a certain amount of thickening.

In other cases the absorption of the exudation is incomplete: weeks and months elapse and the consolidation does not disappear. The inflammatory condition is maintained, repeated extravasations of cells from the blood-vessels into the alveoli take place, and the lung-tissue itself is the seat of inflammatory infiltration. In process of time new fibrous tissue is formed both within the alveoli and in the interalveolar septa (Art. 598, Fig. 228). In this way more or less extensive fibroid induration of the lung takes place: in many places it is transformed into a dense airless mass of fibrous tissue, usually containing pigment (Fig. 230); in other parts the alveolar walls are thickened (*b*) or infiltrated

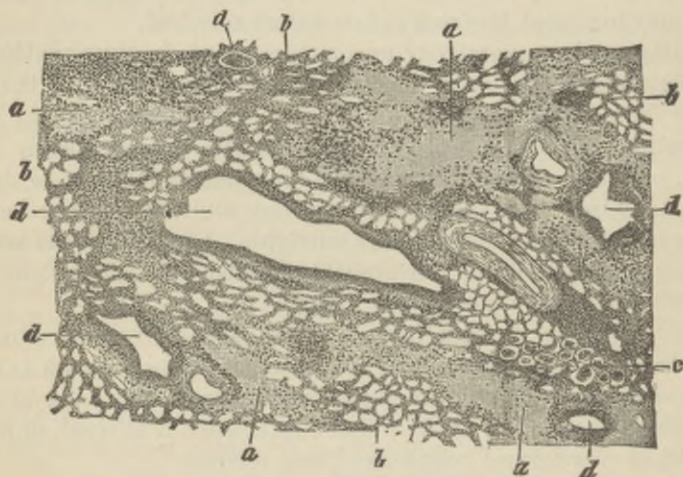


FIG. 230. SIMPLE CIRRHOSIS OF THE LUNG.

(Hardened in alcohol and stained with carmine: $\times 15$.)

- | | |
|---|---|
| a, dense pigmented fibrous tissue | c, alveoli filled with cells |
| b, alveoli with thickened and infiltrated septa | d, dilated bronchi with infiltrated walls |

with cells, or the alveoli are filled with leucocytes or new-formed cellular tissue (*c*).

The cirrhotic patches have in the earlier stages a gray or grayish-red or grayish-yellow tint, and a small quantity of turbid exudation can here and there be squeezed from them. But where the development of fibrous tissue in the alveoli or their walls has begun, the lung is dense, firm, airless, and fleshy, having something of the appearance of freshly hepatized lung. The condition is well described as **carnification**. When the fibroid transformation is complete the tissue is firm and continuous, and white or slaty-gray in color.

The extent of the induration left by an antecedent pneumonia varies very greatly. It may be limited to the stratum immediately beneath the

pleura, or extend over the greater part of a lobe. It may be continuous, that is uninterrupted by islands of air-containing tissue, or it may take the form of fibrous bands traversing the parenchyma in various directions and not very sharply marked off from it. This variety of cirrhosis is indeed always characterized by the peculiarity—that it occurs not in well-defined nodes or groups of nodes, but in bands and patches which pass gradually into the air-containing tissue. This character is obscured only when secondary bronchopneumonia or peribronchial inflammation sets in.

The pleura overlying the cirrhotic patches is usually thickened and adherent to the costal pleura. The patches are usually shrunken and contracted, and the intervening alveoli emphysematous. After a time, if the induration and contraction are at all extensive, the corresponding bronchi are distorted and more or less dilated (Fig. 230 *d*); sometimes they are also ulcerated. For months and it may be years a chronic inflammation of the bronchi and of the pulmonary parenchyma is kept up, its existence being indicated by the patches of cellular infiltration that lie scattered throughout the affected region.

The occurrence of indurative contraction of the lung as a sequel of croupous pneumonia is regarded by most authorities as indisputable. BUHL however maintains that the form of pneumonia which leads to contraction is *ab initio* distinct. According to him it begins with cellular infiltration of the parenchyma of the lung, and the filling of the alveoli with desquamated epithelium, and issues in cirrhosis and caseation. He names it 'desquamative pneumonia' and considers it as a local manifestation of a general disease. This desquamative pneumonia is not however a pathological entity: BUHL's cases were partly cases of croupous pneumonia, partly of tuberculous, lobular, and confluent bronchopneumonia (Arts. 606, 617).

Within the last ten or twelve years ZIEGLER has had the opportunity of examining a large number of cases of post-pneumonic cirrhosis in various stages of development, and the account in the text is drawn up from actual observation. MARCHAND's account agrees in the main with the above, though he has laid somewhat exclusive stress on the intra-alveolar formation of fibrous tissue.

References:—LAENNEC, *Traité de l'auscultation médiate* Paris 1819; ROKITANSKY, *Path. Anat.* III.; FÖRSTER, *Path. Anat.*; HESCHL, *Prag. Vierteljahresschr.* vol. 51; EPPINGER, *ibid.* vol. 125; MARCHAND, *Virch. Arch.* vol. 82; BIERMER, *Virchow's Handb. d. spec. Path.* v.; BUHL, *loc. cit.*; JÜRGENSEN, *Die croupöse Pneumonie* Tübingen 1883; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* III.; LÉPINE, *Nouveau Dictionnaire* XXVIII. Paris 1880; LEYDEN, *Berl. klin. Woch.* 1879; E. WAGNER, *Deut. Arch. f. klin. Med.* XXXIII.; NOTHNAGEL, *Sammlung klin. Vorträge* 66; AMBURGER, *Deut. Arch. f. klin. Med.* XXXIII.; BASTIAN, *Reynolds' Syst. of med.* II. London 1876; STURGES, *Pneumonia* London 1876; COUPLAND, *Trans. Path. Soc.* XXX. 1879; HEITLER, *Wien. med. Woch.* 1884.

605. **Embolie septique pneumonia** always occurs in isolated patches, whose appearance varies in different cases. When infective matters enter the circulation from a septic wound, some may be arrested in the lung and give rise to embolic infarction. Suppurative inflammation is

set up around the infarcted tissue, by means of which the latter is surrounded by a zone of yellowish infiltration, and presently is loosened and separated from the healthier tissue. It then naturally undergoes necrosis and breaks up under the action of continued suppuration, so that at length there is formed a cavity filled with pus, a **metastatic abscess** of the lung. If the septic embolus contain putrefactive organisms, or if these enter the infarct from the bronchi, the tissue may undergo putrid change or gangrene, and so be transformed into a foul dirty-gray or blackish mass.

When the original irritant reaches the vessels of the lung in the form of fine particles, such as micrococci, which are not arrested till they reach the capillaries and there lodge, the patches of inflammation are usually small and ill-defined. At first the inflammation is as a rule hæmorrhagic in character, but no infarct is formed and the patches speedily become purulent or gangrenous.

In recent cases the tissue appears saturated with blood-corpuscles and pus, the pulmonary epithelium desquamated and partially necrosed. In the gangrenous patches the lung-tissue is disintegrated and dissolved (Art. 598).

When the septic embolism is subpleural, the pleura is always simultaneously inflamed. The exudation is purulent or fibrino-purulent, and may extend over the entire surface of the membrane.

Within the lung the suppuration and gangrene may extend by continuity to the neighboring tissue. The inflammation set up is usually hæmorrhagic and fibrinous in character, and speedily passes into suppuration and gangrene. Sooner or later the process reaches the peribronchial and interlobular lymphatics, and they become filled with serous, fibrinous, and purulent exudations, while the tissue about them becomes infiltrated with cells. This lymphangitis and perilymphangitis may start either from an embolic abscess or from a purulent pleurisy. In the latter case the interlobular tissues are the most affected.

The embolic abscesses may break through either into bronchi or into the pleural cavity, the former being the commoner event. When adhesions unite the lung to the thoracic wall or to the diaphragm, the pus may find its way to the exterior or into the abdomen.

The smaller abscesses may heal up more or less perfectly by absorption of the pus, the larger by rupture and evacuation; granulations are formed round the cavity, and develop into cicatricial tissue. If the absorption of the pus is incomplete it may become inspissated and calcified. Adhesions are invariably the result of the healing of the pleuritic patches.

JÜRGENSEN and SCHÜPPEL have raised the question whether the cattle-disease called **pleuro-pneumonia** does not also occur in man (WIEDERMANN, *Deut. Arch. f. klin. Med.* xxv.; SUSSDORF, *Die Lungenseuche d. Rindes* In. Diss. Tübingen 1879; BRUYLANTS and VERRIERS, *Bull. de l'acad. belge* 1880; PÜTZ, *Seuche-*

und Herdekrankheiten Stuttgart 1882; POELS and NOLEN, *Cent. f. med. Wiss.* 1884; KORÁNYI and BABES, *Pest. med. chir. Presse* 1884; CORNIL and BABES, *Les bactéries* Paris 1885). This is an infective disease of bovine cattle, the main symptom being an affection of the lung characterized by red hepatization with extensive interlobular and pleural inflammation. The lobules appearing red and the swollen and infiltrated interlobular septa yellow, the surface has a typically marbled appearance. The exciting virus is probably a micrococcus.

The septic (suppurative and gangrenous) inflammations of the lung which occur in new-born infants are in general bronchopneumonias due to aspiration of decomposing genital secretions or liquor amnii; sometimes they are due to embolic infection from the unhealed stump of the umbilical cord. The pleura and interlobular septa are usually much inflamed at the same time.

References:—P. MÜLLER, *Gerhardt's Handbuch d. Kinderkr.* II.; ORTH, *Arch. d. Heilk.* XIII.; RUNGE, *Zeitschr. f. Geburtshülfe*, VI. (1881); SILBERMANN, *Deut. Arch. f. klin. Med.* XXXIV., and *Die septische Pneumonie d. Neugeborenen* In. Diss. Breslau 1883.

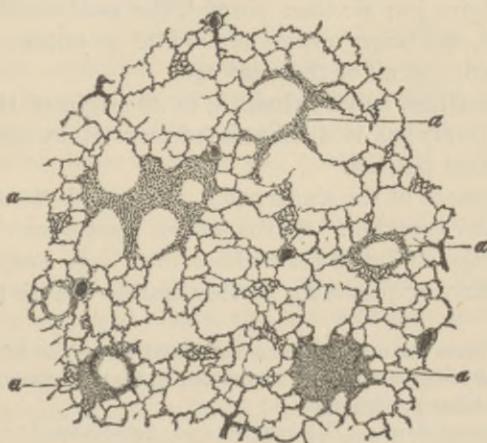


FIG. 231. MILIARY TUBERCULOSIS OF THE LUNG.

(Preparation injected, and stained with carmine: $\times 30$.)

a, a, tubercles.

606. **Embolic tuberculosis** of the lung occurs in two forms. The commonest and best-known is miliary tuberculosis, the rarer is the embolic localized form.

Miliary tuberculosis of the lung is set up when tubercle-bacilli enter the circulation in considerable numbers, and lodge in the pulmonary capillaries. As they settle and multiply they give rise to the formation of miliary nodules or tubercles, which are numerous or scanty according to the number of bacilli introduced. Usually they are distributed pretty uniformly through the parenchyma of the lung and the pleura, though sometimes they are concentrated more closely in one part.

The formation of the tubercles begins with a localized cellular infil-

tration in the alveolar septa (Fig. 231) or other element of the pulmonary tissue where the bacilli have found a nidus.

The recent tubercles have all sorts of irregular shapes—crescentic, annular, stellate, and so on. Later on an accumulation of cells takes place in the neighboring alveoli and ducts and the nodules become more rounded, though even in this stage they frequently have processes and projections corresponding to the thickened alveolar septa. Where a tubercle forms the capillary-system of the part is always destroyed, so that a fully-developed tubercle is non-vascular.

Recent (or 'crude') tubercles are gray and translucent; afterwards they become opaque, yellow and caseous.

The eruption of the tubercles is sometimes accompanied by a catarrhal exudation.

A lung studded with miliary tubercles is generally hyperæmic; it is firmer and contains less air than normal, the smaller nodules are gray and translucent, the larger opaque and white or yellow. The tubercles are thus obviously not all of the same age.

Embolic localized tuberculosis is in its origin of the same nature as the miliary form, but is distinguished from it by occurring only in one or two isolated patches.

The development of the single patch corresponds to that of the disseminated miliary eruption. As the patient usually survives for a longer time, the tubercles as they form coalesce into large nodular formations which are the starting-points for further morbid change (Art. 612).

Many writers have maintained the existence of a form of lobar pneumonia of which the regular termination is in caseation, and which they consequently describe as caseous lobar pneumonia.

BUHL (*Lungenentzündung, Tuberculose und Schwindsucht* Munich 1872) has asserted that this caseous pneumonia is a sequel of what he calls true desquamative pneumonia. This latter begins acutely like croupous pneumonia and terminates in recovery, or after weeks, months, or years, in death. The gravest form ends in caseation and is the local expression of a 'tuberculous constitution.' As we have pointed out in Art. 604, there is no distinct form of pneumonia possessing the characters which BUHL describes, and the same holds true for the so-called 'caseous labor pneumonia.' What has been so frequently described under this head is a confluent caseous lobular bronchopneumonia of tuberculous origin. ZIEGLER has examined a large number of lungs clinically described as the seat of caseous lobar pneumonia, and has always found them to be examples of nodular and lobular bronchopneumonia. NAUWERCK and KOCH have demonstrated the presence of tubercle-bacilli in the diseased foci (NAUWERCK, *Deut. med. Woch.* 18, 1883; KOCH, *Mittheil. a. d. k. Gesundheitsw.* II. 1884). For an account of the various views on the subject of caseous lobar pneumonia see SHEPHERD, *Brit. Med. Journ.* 1876; HAMILTON, *ibid.* 1880; ORTH, *Lehrb. d. spec. Path.* II. Berlin 1885.

607. **Syphilitic pneumonia** occurs most frequently as the result of congenital syphilis, rarely in the acquired disease.

As we have already seen (Art. 128), when the poison of syphilis is

diffused by way of the circulation it sets up inflammations which in some cases differ little from ordinary non-specific forms, in others are characterized as specific by the formation of gummatous foci. Both forms occur in the lung, but are certainly very rare indeed (if we except congenital syphilis), and this specific character is by no means easily established.

Gummatous pneumonia is a syphilitic inflammation of the lung in which caseous granulomatous foci develop within patches of inflamed pulmonary tissue or of new-formed and hyperplastic fibrous tissue. Similar foci are often described as met with in post-mortem examinations, but there is little doubt that in most cases they are not due to syphilis. They are in general merely encapsulated patches of bronchopneumonia, dilated bronchi filled with caseous exudations, caseous detritus lying within dilated and thickened lymphatics and surrounded by new-formed fibrous tissue, and so on.

Gummata are extremely rare in the lungs of adults; they are commoner in new-born syphilitic infants, and may occur in considerable numbers. When recent, they are gray or grayish-white and somewhat translucent; they vary from the size of a pea to that of a hazel-nut. Afterwards the centre becomes white and opaque, and by disintegration may even become excavated.

Another form of syphilitic pneumonia in infants gives rise to diffuse cellular inflammation of the lung, often accompanied by desquamation and fatty degeneration of the pulmonary epithelium. The diseased tissue is abnormally hard and white, and the affection has therefore received the name of **white pneumonia**.

Some writers describe a similar form in adults as the result of acquired syphilis, and it is said occasionally to lead to fibroid induration of the lung. According to PANKRITIUS it usually starts from the hilum and extends radially. Others describe as syphilitic certain indurative inflammations starting from the pleura or the interlobular septa.

Some of these inflammatory indurations in syphilitic subjects are no doubt due to the specific influence of the disease, but it is very difficult to distinguish them with any certainty. We may be sure that many of the indurative changes in the lung set down to syphilis have really no connection with it, but are due to other causes. The like is true of many of the so-called syphilitic cicatrices of the lung, the pleura, and the interlobular septa.

On syphilitic bronchopneumonia see Art. 618.

VIRCHOW has expressly called attention to the fact that the diagnosis of syphilitic changes in the lung is of exceptional difficulty: he thinks however that both gummatous and simple irritative inflammations of the lung due to syphilis do occur. Among the latter are certain forms of fibrous pneumonia, pleurisy, and peribronchitis, and of catarrhal and caseous bronchopneumonia. Although of late years much has been published on the subject of pulmonary syphilis it

cannot be said that our knowledge of its morbid anatomy has much advanced. Most of the cases described leave room for considerable doubt as to their syphilitic nature.

References:—DEPAUL, *Gaz. des hôpitaux* 1851; HECKER, *Virch. Arch.* vol. 17, *Berl. geburtshülfl. Gesellsch.* VIII. (1854); E. WAGNER, *Arch. d. Heilk.* IV. (1863); FÖRSTER, *Würzburg. med. Zeitschr.* IV. (1863); VON BÄRENSPRUNG, *Hereditäre Syphilis* Berlin 1864; VIRCHOW, *Virch. Arch.* vols. 1 and 15, *Krankhafte Geschwülste* II. (1865); HOWITS, *Arch. f. Syphilidologie* III.; ANDREAE, *Anat. Unters. üb. d. Lung. syph. Kinder* In. Diss. Würzburg 1875; SCHÜTZ, *Syphilome d. Lunge, Klebs' Beiträge z. path. Anat.* I. 1878; VIERLING, *Deut. Arch. f. klin. Med.* XXI.; COLOMATTI, *Arch. f. Derm. u. Syph.* V. (1878); PAWLINOFF, *Virch. Arch.* vol. 75; SCHNITZLER, *Die Lungensyphilis* Vienna 1880; GRANDIDIER, *Berl. klin. Woch.* 1875; GERHARDT, *Sitzungsber. der phys.-med. Gesellsch. z. Würzburg* 1881; RAMDOHR, *Arch. d. Heilk.* XIX.; THOMPSON, *Lancet* 1, 1878; SACCHARJIN, *Berl. klin. Woch.* 1878; TIFFANY, *Amer. Journ. med. sciences* 1877; PANKRITIUS, *Ueb. Lungensyphilis* Berlin 1881; GÜNTZ, *Memorabilien* 1882; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; KOPP, *Deut. Arch. f. klin. Med.* XXXII.; HILLER, *Charité-Annalen* 1884 (with critical summary of published cases); BIRCH-HIRSCHFELD, *Lehrb. d. path. Anat.* II. 1884; GOODHART and others, *Trans. Path. Soc.* XXVIII.

608. **Pleurogenous pneumonia.** When the pleura becomes affected with inflammation (pleurisy) the underlying pulmonary tissue may be injured, either mechanically (Art. 591) or by extension of the inflammatory process to the lung. The extension takes place chiefly by way of the lymphatics, which are very abundant in the pleura and communicate directly with those of the interlobular septa. The first sign of the inflammation is exudation into the lymphatic vessels, by which they are distended—often to the dimensions of a middle-sized bronchus.

Interlobular lymphangitis of this kind may result from various types of inflammation, though it is most commonly associated with purulent or fibrino-purulent pleurisy, whether set up by pyæmic (embolic) suppuration in the lung or as a primary local affection. For example, it is not infrequently met with in infants who have died of pyæmia from septic infection of the umbilicus.

The distention of the interlobular lymphatics with purulent or fibrino-purulent exudation causes the lobules to be separated by zones of yellowish-white infiltrated tissue, and if the septa themselves undergo suppuration the lobules may be loosened and isolated from each other. This form of pulmonary inflammation is accordingly spoken of as **dissecting pneumonia** (HUTINEL and PROUST, *Archives générales de méd.* 1882).

From the septa the inflammation may spread to the peribronchial lymphatics and affect them in a similar way. The lobules also may become inflamed, so that the already compressed lung-tissue becomes the seat of inflammatory exudation and infiltration—catarrhal, croupous, hæmorrhagic, or purulent—as the case may be. Accordingly the lobules may look red, grayish-red, or grayish-yellow, and saturated with

a turbid secretion. The appearance of the lung is in fact like that of an ox dead of pleuro-pneumonia (Art. 605).

If the disease is not fatal, recovery takes place by resorption, though in most cases there remains some permanent thickening of the interlobular tissues. Should residues of inspissated pus remain in the thick-

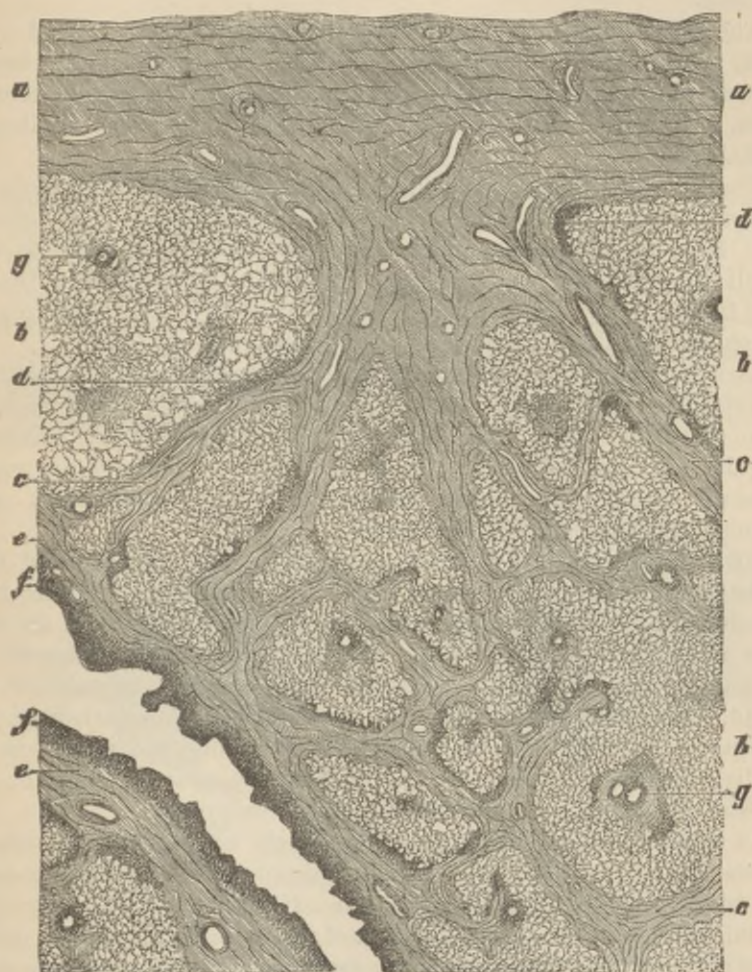


FIG. 232. CHRONIC PLEUROGENOUS INTERLOBULAR PNEUMONIA.

(Hardened in Müller's fluid, stained with picrocarmine: $\times 3.5$.)

- | | |
|---|---|
| a, thickened pleura | e, dilated bronchus with infiltrated mucous membrane f and thickened peribronchial tissue |
| b, pulmonary tissue | g, bronchioles with infiltrated walls |
| c, thickened interlobular septa | |
| d, cellular infiltration at the boundaries of the thickened septa | |

ened septa, nodules having much resemblance to gummata are formed and have occasionally been mistaken for them.

Tuberculosis may in like manner extend from the pleura to the lung, as in cases of tuberculous disease of the ribs or vertebræ; and then tubercles appear along the course of the several lymphatics.

Chronic indurative and plastic inflammations of the pleura may also extend to the alveoli by way of the interlobular and peribronchial channels.

The thickening of the pleura causes the lung to be enclosed in a thick, tough, fibrous casing (Fig. 232 *a*) from which stout fibrous bands (*c*) (corresponding to the interlobular septa) extend into the pulmonary tissue, forming a kind of coarse meshwork with the thickened peribronchial tissue (*e*).

The pulmonary tissue enclosed in the meshes of the septa is more or less compressed, and sometimes becomes entirely collapsed and functionless. Moreover active inflammation may extend from the septa to the alveoli (*d*) and give rise to infiltration and fibrous hyperplasia in them. Very frequently too the morbid process is associated with evidences of bronchopneumonia, either primary, secondary, or antecedent.

The bronchi of the affected region seldom remain entirely healthy. As a rule they are distorted and dilated (*e*), partly owing to the traction of the shrinking fibrous tissue, partly to the pressure of the air which is irregularly distributed among the alveoli. There is usually also some bronchial catarrh, the mucous membrane both of bronchi (*f*) and bronchioles (*g*) being visibly infiltrated.

609. **Inflammation of other contents of the thorax** or of the abdomen sometimes extends to the lungs. The mediastinal organs, the bronchial glands, the œsophagus, the stomach, and the liver, are the parts most commonly concerned. And according to the character of the primary affection the inflammation of the lung may be purulent or putrid, tuberculous, caseous, or indurative. Thus a tuberculous gland may give rise to tuberculosis of the root of the lung, and an abscess of the liver breaking through the diaphragm may cause suppuration of the base of the lung with purulent pleurisy or empyema.

In ulcerative disease of the lung the bronchi may become perforated. A basal abscess, for instance, or a broken down caseous bronchial gland, may rupture into a neighboring bronchus. If the matters thus evacuated are infective or irritating, and if some of them are aspirated into other parts of the parenchyma of the lung, secondary bronchopneumonia may result (Art. 613).

Traumatic lesions of the lung, caused for example by a fractured rib, give rise in the first place to hæmorrhage and perhaps entrance of air into the pleural cavity (pneumothorax). If the wound is not contaminated the rent is healed by thrombosis and subsequent cicatrization. Septic contamination of the wound results in suppuration and gangrene of the lung.

CHAPTER LXXXVII.

FORMS OF BRONCHOPNEUMONIA.

610. **Non-specific bronchopneumonia.** All forms of bronchopneumonia are at first essentially local disorders, whose extent and distribution are determined by the position and relations of the affected bronchioles and alveolar ducts. This local character is most apparent when the irritant substance which induces the bronchopneumonic inflammation is in a minutely divided form and suspended in the inspired air, so that it reaches the terminal air-passages directly. In animals such inflammations can readily be produced by causing them to breathe an atmosphere containing irritant substances in the form of dust

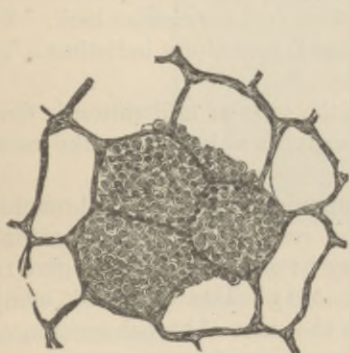


FIG. 233.

FIG. 233. MILIARY BRONCHOPNEUMONIA.

A patch extending over three alveoli.

(From the lung of a dog, after inhalation of an irritating spray: $\times 30$.)

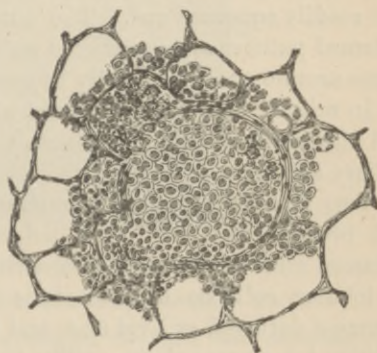


FIG. 234.

FIG. 234. MILIARY BRONCHOPNEUMONIA.

A patch extending over a respiratory bronchiole and the adjacent alveoli: some of the extravasated cells contain particles of dust.

(From the same lung.)

or spray. In man the earlier stages can be observed only in cases where shortly before death a quantity of irritating dust, or very small particles of secretion from the air-passages themselves, have been inhaled.

Wherever these particles lodge an acute reactive inflammation is set up around them, first of all in the wall of the particular air-space, and soon (if the irritation be sufficiently great) in the adjoining tissue also.

In this way are formed minute, or as they are called miliary, patches of inflammation starting from the terminal air-sacs or infundibula (Fig. 233), or from the alveolar ducts and respiratory bronchioles (Fig. 234) with their alveoli, and spreading to the neighboring elements by direct extension.

When the aspirated substances are still more irritating (*e. g.* saliva with remains of food, pus from laryngeal abscesses, etc.), the inflammations induced are more extensive. In this way are produced larger areas of bronchopneumonia extending over a number of contiguous alveoli, alveolar ducts, and bronchioles. When entire lobules are thus attacked we have what is called **lobular bronchopneumonia**. When all or most of the lobules of a lobe are simultaneously affected we have what may be called **lobar bronchopneumonia**.

The appearance of the bronchopneumonic patches naturally varies with the form of the inflammation (Arts. 596, 597) and the stage it has reached. When exudation has followed upon the initial hyperæmia, the spots have a dark-red, grayish-red, gray, or grayish-yellow tint, and yield on pressure a turbid liquid whose tint varies in like manner, according to the proportion of red and white blood-cells it contains. Only in croupous inflammations is the exudation solid or semi-solid and not readily squeezed out. The cut surface has a granular look. The inflamed patches are sometimes well-defined, sometimes indistinct. The tissue around them is usually hyperæmic.

In miliary bronchopneumonia when the cellular infiltration is dense and the patches sharply-defined, they sometimes look very like recent miliary tubercles.

Very frequently indeed bronchopneumonia is preceded by bronchitis and bronchiolitis, and thus before the respiratory tissue is actually inflamed some of the smaller bronchi may be obstructed and so give rise to lobular collapse or atelectasis (Art. 591). The collapsed lobules assume a dark-red or livid tint, and thus the onset of bronchopneumonia in them is not very obvious. The tint alters only after a certain amount of cellular and serous exudation has taken place into the alveoli, and then the characteristic turbid juice can be squeezed from the affected tissue.

611. The **number and distribution** of the bronchopneumonic centres will of course be very different in different cases. In one instance they may be scattered over both lungs, in another confined to a part of a single lobe. When a large number of lobules are collapsed or inflamed, compensatory dilatation of the still active lobules takes place. Subpleural inflammations usually lead to inflammation of the pleura also.

Suppuration and gangrene of the bronchopneumonic patches are comparatively infrequent; they are most commonly due to the aspiration of irritating liquids from the mouth or stomach, or of pus and detritus from abscesses or ulcers in the larynx or trachea, from cavities

in the lung itself, and so on. As in the case of embolic abscesses and necroses, these **bronchopneumonic abscesses** may heal more or less completely by delimiting inflammation and cicatrization. Death however is the more frequent result.

In most cases of bronchopneumonia the exudation is absorbed, and the lung restored to its normal state. It must however be remembered that unabsorbed residues are much more common after bronchopneumonia than after croupous pneumonia. Even in the non-suppurative forms the cellular infiltration of the interlobular and peribronchial fibrous structures is here and there so abundant that complete resorption is impossible: the circulation of the part may indeed be so much interfered with that caseous necrosis takes place. In other cases the inflammation persists for a considerable time, and passing into a chronic condition leads to the formation of new fibrous tissue and thus to induration.

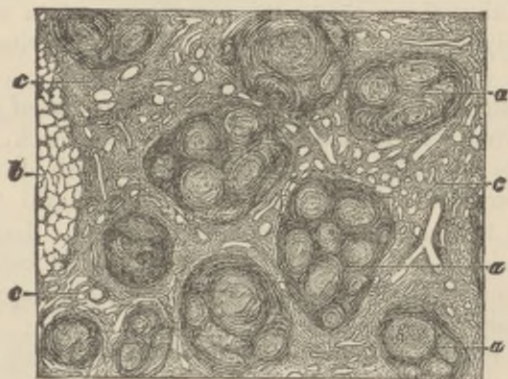


FIG. 235. MASON'S LUNG WITH BRONCHOPNEUMONIC FIBROUS NODULES.

(Section hardened in alcohol, and stained with picrocarmine: $\times 9$.)

a, group of fibrous nodules
b, normal pulmonary tissue

c, thickened pulmonary tissue containing bronchi, vessels, and a few alveoli

Dry caseous necrosis of the pulmonary tissue occurs generally as a sequel of the lobular inflammation, especially in children suffering from bronchitis and bronchopneumonia after measles or whooping-cough. It may however occur in adults and in connection with other forms of bronchopneumonia. While many of the patches of inflammation disappear by resorption, here and there the exudation persists, condenses, and by degrees assumes a dry cheesy consistence, while the surrounding tissue simultaneously undergoes necrosis. In this manner caseous nodules, from the size of a pea to that of a walnut, are produced; after a time they become enclosed in a fibrous capsule, and then may remain for an indefinite time without further change, though frequently they become calcified. These nodules are met with in all parts of the lung,

though the apex is the commonest seat. Occasionally they give rise to obstruction of some of the bronchial tubes (Art. 580).

A more frequent result of bronchopneumonia is induration or **cirrhosis of the lung**. In its least-complicated form this occurs in cases where the continual inhalation of irritating dust keeps up a constantly-renewed inflammation.

Coal-dust is the least irritating, stone-dust and metallic particles are much more injurious. The power of the absorbents is usually insufficient to remove all the dust inhaled, and inflammation being set up around the particles that remain in process of time they are enclosed in capsules of new fibrous tissue (Fig. 235 *a*), and thus give rise to hard fibrous nodules.

In some cases these nodules are few and scattered: in others they are numerous and lie together in groups (Fig. 235). Instances occur in which they are so numerous in particular parts of the lung that scarcely any air-containing tissue exists between them, and in other parts the lung is entirely fibrous. This condition is best described as **nodular cirrhosis**.

The separate nodules are of various sizes from that of a lentil to that of a bean. They are white, slate-colored, or even black, and that even in the absence of coal-dust. The pigment is then derived from the coloring-matter of the blood. When fully developed they consist of coarse fibrous tissue, often concentrically stratified. Larger nodes are formed by the coalescence of smaller nodules, and correspond to the territory of a single bronchiole: the smallest nodules represent terminal alveoli or infundibula.

The tissue round about the nodules is infiltrated with cells, or thickened and fibrous, the indurative inflammation extending radially.

When the bronchopneumonia is lobular, and associated with obstructive collapse, the nodular cirrhosis is accompanied by a more diffuse indurative change, which we may call **lobular cirrhosis**. In this way, as in the cirrhosis of simple collapse (Art. 592, Fig. 221), the lung is beset with patches of compact gray or slate-colored tissue, enclosing scattered nodules which are usually of a paler tint.

Patches of this kind may be formed in any part of the lung, though they are most common at the apex: not infrequently they contain small cheesy nodules.

The pervious bronchi traversing the indurated region generally become dilated, and are the seat of chronic inflammation often of an ulcerative kind and leading to the formation of cavities or **vomicæ**. When such a vomica contains a decomposing or irritant secretion, the latter may gain access to the air-passages and by aspiration pass into the terminal branches of other bronchi. In this way fresh bronchopneumonia is set up, and may lead to miliary or nodular or lobular inflamma-

tion, ending in local recovery, or it may be in suppuration or induration like the first.

The pleura is affected in all bronchopneumonic indurations that are not entirely limited to the deeper parts of the lung; thickening and adhesions are the usual result. So also it is not unusual to find thickening of the peribronchial and the interlobular fibrous tissue.

612. **Tuberculous bronchopneumonia.** Tuberculosis of the lung may begin in one of three ways: namely, as embolic tuberculous pneumonia, as primary tuberculous bronchopneumonia, and as tuberculous lymphangitis.

Embolic tuberculous pneumonia has already been considered (Art. 606). It takes the form either of disseminated miliary tuberculosis and terminates fatally, or of a localized affection leading to the formation of one or more isolated caseous nodes. These nodes may occur either in a part of the lung previously healthy, or in tissue already altered by disease.

Tuberculous lymphangitis (Art. 609) takes the form of a local eruption of tubercles in the neighborhood of a tuberculous focus outside the lung. A caseous bronchial gland or tuberculous disease of the vertebral column is the commonest starting-point of the affection.

Primary tuberculous bronchopneumonia attacks both healthy and diseased lung-tissue.

In the former case tubercle-bacilli, either alone or accompanied by other irritant matters, gain access with the inspired air to the respiratory parenchyma, settle in some ramification of the air-passages, and in the first instance give rise to a nodular patch of inflammation (Fig. 236 *g*). Occasionally the bacilli may at once be taken up by the lymphatics and give rise first in them to the formation of granulomatous nodules.

When the tubercle-bacilli alone enter the lung, these are the only changes induced; but if at the same time other sources of irritation are at work the tuberculous changes are accompanied by more or less extensive bronchitis and bronchopneumonia. As the case goes on the latter affections pass away, often however leaving behind bronchi obstructed with secretion, or collapsed and indurated patches sometimes containing caseous foci; so that the affected part of the lung includes one or more caseous patches (*e*) containing bacilli, caseous masses free from bacilli, obstructed or occluded bronchi, and gray cirrhotic areas. In certain cases patches originally containing bacilli may become free from them, and undergo cicatrization with or without caseous enclosures.

The specific infection frequently reaches a lung already morbidly affected. If the affection is a recent bronchitis with bronchopneumonia, the after-course of the disease will resemble that just described. Exactly how often such a secondary infection takes place it is not at present easy to determine. Most probably we have instances of it in those cases

where chronic tuberculosis appears to be developed from a non-tuberculous bronchopneumonia such as follows measles or whooping-cough.

Secondary tuberculous infection is also favored by the fact that inhaled bacilli may develop more readily in tissue which is altered by antecedent or still persisting chronic inflammatory processes. This possibility is supported by the observation—that certain tissue changes connected with particular inflammatory affections of the lung appear to predispose it to tuberculosis. So far as can be made out by morbid anatomy these are chiefly—caseous necrotic patches, inspissated collections

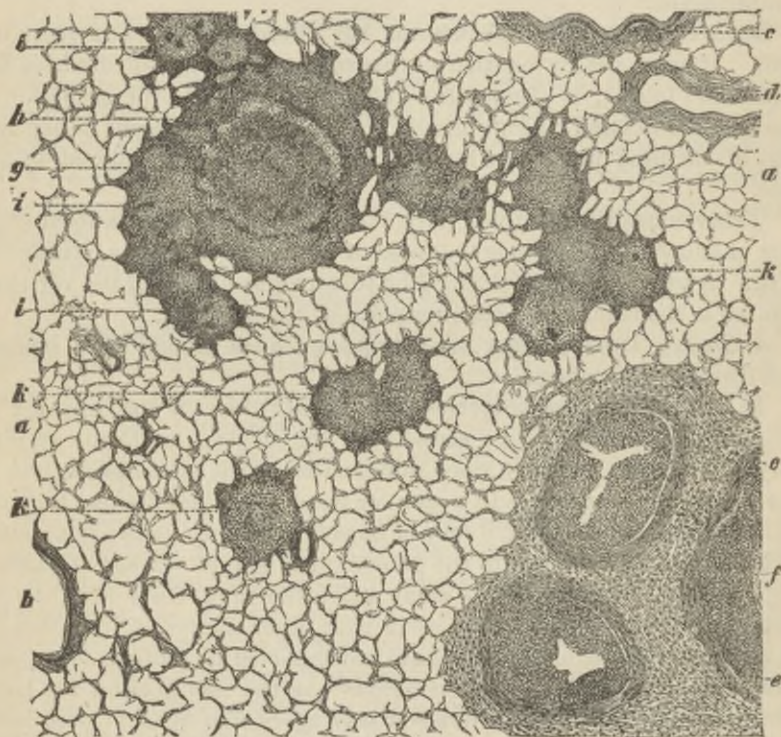


FIG. 236. PRIMARY TUBERCULOUS BRONCHOPNEUMONIA WITH COMMENCING TUBERCULOUS LYMPHANGITIS.

(Section from the left apex of the lung of a woman of 25, which contained a few scattered nodes with central caseation; carmine staining: $\times 15$.)

a, normal lung-tissue

b, normal bronchus

c, bronchus with inflamed wall

d, artery

e, encapsulated caseous bronchopneumonic patches

f, fibroid induration

g, caseous centre and

h, cellular periphery of a tuberculous node

i, k, tubercles in the neighboring lymphatic vessels

of bronchial secretion, and bronchiectatic cavities. The predisposition does not depend on the way in which these morbid changes have been brought about. When the bacilli once gain a settlement the periphery

of the caseous node or the wall of the bronchiectatic cavity becomes the seat of a new inflammation which thenceforth exhibits the character of a tuberculous process.

The author has for a number of years endeavored from the anatomical side to make out the early stages of pulmonary tuberculosis, and the above account represents the outcome of his investigations. In Würzburg and in Zürich he had to make post-mortem examination of a large number of children and young persons, and so had frequently the opportunity of observing tuberculosis in all its stages, even from the very beginning. He has thus convinced himself that in the great majority of cases tuberculosis of the lung begins in the form of solitary nodes or nodular foci. The tuberculous nature of these foci is in general readily determined from the appearance of the parts immediately around them. Recently also NAUWERCK and GLASER have demonstrated the presence of tubercle-bacilli in some of the cases collected by the author.

The occurrence of secondary tuberculous infection in lungs already diseased appears to follow from the frequently-observed fact that recent tuberculous bronchopneumonia is found side by side with old patches of induration that are devoid of any recognizably tuberculous character, while the bronchiectatic cavities they enclose contain tubercle-bacilli. It must however be granted that a tuberculous lung may recover locally, the disease sometimes leaving behind it patches of induration that possess none of the special characters of tuberculosis.

Formerly attempts were made to explain pulmonary phthisis and tuberculosis as the direct result of a special **constitution** or predisposition, which reacted in a peculiar way to ordinary irritations. After the communicability of tuberculosis was established stress was always laid on the fact that certain animals are more susceptible of the disease than others, and accordingly the special predisposition of the individual has always been regarded as a principal factor in the genesis of tuberculosis. Since KOCH'S discovery of the tubercle-bacillus the question of predisposition has fallen somewhat into the background. It appears however unwise to lose sight of what is almost certainly the fact—that many persons are more disposed to become tuberculous than others. This predisposition is either congenital or acquired, and consists either in local alterations of tissue or in the general constitution of the system, that is in peculiarities of the metabolism of the tissues. For instance, diabetic patients are well-known to be very apt to suffer from a fatal form of tuberculous phthisis. Other predisposing conditions are—excessive smallness of the heart in proportion to the lungs and the body generally, poverty of the blood in albuminoids and water such as follows continued lactation, suppuration, cholera, etc., lesions of the heart limiting the blood-supply to the lungs, contracted thorax, and enfeebled inspiration. Scrofula, that is to say the particular anomaly of constitution which is manifested chiefly by a tendency to chronic catarrh of mucous membranes, also favors tuberculous infection. How exactly these conditions act as predisposing causes of tuberculosis we can hardly at present determine, though all clinical experience goes to show that they are of some importance.

In addition to the constitutional predisposition we have to consider the **local predisposition**: and it is reasonable to suppose that in the case of the lung this latter plays a considerable part. Thus lung-tissue that is inflamed or that is altered in a certain way by previous inflammation is more apt to become tuberculous than normal healthy tissue.

Lastly, it appears certain that many persons are predisposed or rather predestined to tuberculosis because they are much more exposed to the chances of

infection than others. This is especially the case with children who grow up in the company of tuberculous parents.

An extremely important, but at present involved, question is—whether tuberculosis can be **inherited**, *i. e.* whether the tubercle-bacillus can be transmitted from the parent to the foetus in fecundation or during gestation. ZIEGLER has pointed out in several of his writings that no anatomical facts are yet to hand in support of the affirmative supposition. There is on record no indubitable instance of intra-uterine foetal tuberculosis, and after birth the affection appears at the earliest in the third week, by which time it is quite possible for infection from without to have taken place. It must however be kept in mind that in some instances the disease had at this time made such progress that the beginning of it might with great probability be referred to the intra-uterine period (DEMME and LICHTHEIM, *Verhandl. d. med. Congresses in Wiesbaden* 1883). ZIEGLER'S view is—that **congenital tuberculosis** is possible but not yet certainly demonstrated, and that it must at any rate be rare. Since KOCH'S discovery a good many authorities have come over to this view. Actual transmission of tuberculosis to the foetus appears conceivable only when at the time of impregnation the male suffers from urogenital tuberculosis, or when during gestation the female genital organs are tuberculous, or tubercle-bacilli gain access to the circulatory system. Future observation alone can determine whether this view is correct or not, and meanwhile we may explain the fact—that the children of tuberculous parents so readily perish from tuberculosis—by observing that they inherit some predisposition to the disease and by their constant intercourse with the parents are in a special way exposed to the risk of infection.

Tuberculosis by **inhalation** was first induced in animals by TAPPEINER, LIPPL, and SCHWENINGER (*Naturforscherversammlung in München* 1882, *Virch. Arch.* vols. 74, 82), afterwards by WEICHSELBAUM (*Cent. f. med. Wiss.* 1882, *Wiener med. Jahrb.* 1883), SCHOTTELIUS (*Virch. Arch.* vol. 73), and others. When animals are made to breathe air containing phthisical sputa pulverized by means of the spray apparatus, small miliary bronchopneumonic patches much resembling tubercles are found in the lungs. TAPPEINER took them for actual tubercles and compared them to the tubercles found in miliary tuberculosis of the lung. This however is a mistake: they are multiple primary tuberculous bronchopneumonic patches of miliary size, caused by the inhalation of tubercle-bacilli (ZIEGLER, *Sammlung klin. Vorträge* 151). VERAGUTH worked at the subject in ZIEGLER'S laboratory during 1881-82, and showed that in the bronchopneumonic patches great masses of bacilli were developed, that in course of time from these patches were formed larger caseous and even ulcerating nodes, and that in goats the process might give rise to tuberculous disease of the lymphatics, lymphatic glands, and serous membranes, all of which contained bacilli. Fourteen days elapse from the time of inhalation before the first visible changes are detected. As the changes set in masses of bacilli are seen in the alveolar epithelial cells, which they presently cause to degenerate, while reactive inflammation is set up in the adjacent tissue.

References:—BAYER, *Études compar. de la phthisie pulmonaire* 1842; SEEGEN, *Der Diabetes mellitus* Berlin 1878; BOUCHARDAT, *De la glycosurie* Paris 1878; LEYDEN, *Ueb. diabet. Lungenphthise*, *Zeitschr. f. klin. Med.* IV.; RÜHLE, *Ziemsens's Cyclop.* V.; JÜRGENSEN, *ibid.*; ZIEGLER, *loc. cit.*; BAUMGARTEN, *Zeitschr. f. klin. Med.* VI., *Sammlung klin. Vorträge* 218, *Berl. klin. Woch.* 1883; *Collective Investigation Record* I. London 1883; KLEBS, *Art. Tuberculose*, *Eulenburg's Encyclopädie* XIII.; VERAGUTH, *Arch. f. exp. Path.* XVII. 1883; KÖSTER, *Sitzungsber. d. niederrhein. Gesellsch.* Bonn Feb. 1876; SENISE, *Movimento med. chir. di Napoli* 4, 1883; JOHNE, *Geschichte d. Tuberculose* Leipzig 1883, and *Die käsige*

Hüttenrauchpneumonie d. Rindes, *Fortschritte d. Med.* i. 1883, III. 1885; BIEDERT and SIGEL, *Virch. Arch.* vol. 93; WARGUNIN, *ibid.* vol. 96; WAHL, *Deut. med. Woch.* 1, 1885; SCHÄFFER, *Die Verbreitung d. Tuberculose in den Lungen* In. Diss. Berlin 1884; BREHMER, *Die Aetiol. d. chron. Lungenschwindsucht* Berlin 1885.

613. **Extension of tuberculosis in the lung.** The manner in which tuberculosis of the lung extends from part to part is always the same, whether the original infection is due to embolism or to inhalation.

The first-formed nodule increases in size by **peripheral extension** of the cellular infiltration. The accumulation of cells in the contiguous alveolar walls and alveoli takes place continuously and uniformly (Fig. 236 *h i*), though here and there we may find typical tubercles with epithelioid cells and giant-cells in the midst of the mass of simple leucocytes.

After a certain time this continuous extension is accompanied by **tuberculous lymphangitis**, manifested by the development of tubercles in the course of the surrounding lymphatics (Fig. 236 *i k*). This eruption may be interalveolar, interlobular, or peribronchial, and often spreads rapidly to the pleura and the bronchial glands.

In many cases this is the only mode of extension, at least for a considerable time. For months together, either steadily or with occasional pauses, fresh nodular foci continue to be formed along the course of the lymphatics, and the intervening tissue becomes chronically inflamed. In this way patches of induration of various sizes are produced, which contain single tubercles and groups of tubercles, usually all enclosing bacilli, and in various stages of growth and decay.

Sooner or later another mode of extension takes place in addition to this ordinary one of lymphangitic induration and caseation.

A primary (or it may be a secondary) caseous node reaches a certain size, softens and disintegrates, and then breaks through into a bronchus. The caseous detritus contains tubercle-bacilli, and consequently a possibility arises that the disease may be spread to other parts of the lung by **aspiration** into the air-passages. As a fact much of the detritus and the bacilli are coughed up as sputum, but some may be aspirated into the smaller tubes and so reach the respiratory parenchyma. This may also happen when the infected contents of a bronchiectasis or of a bronchiectatic vomica are emptied into a bronchus, or when a cheesy tuberculous gland softens and breaks through.

The aspirated matters lodge in various parts of the pulmonary tissue and give rise to a reactive inflammation whose extent and intensity depend partly on the amount and nature of the irritant substances, partly on the relations of the tissue involved, partly on the special predisposition of the patient. As regards the irritant substances it must be kept in mind that they often include not only tubercle-bacilli but also other micro-organisms and chemical products of decomposition from the

diseased cavities, and these may give rise to suppurative, or fibrinous, or even putrid inflammations.

In this way a fresh focus of bronchopneumonic inflammation is lit up. The course of the new inflammation is in general this—there is first an abundant cellular exudation; after some days or weeks this forms a nodular infiltrated patch (Fig. 237 *f g*), which then becomes caseous in the centre (*f*), while the periphery (*g*) consists of living cells. By proper staining-methods bacilli (*h*) can be shown lying singly or in groups both in the caseous and in the cellular parts. The vessels which

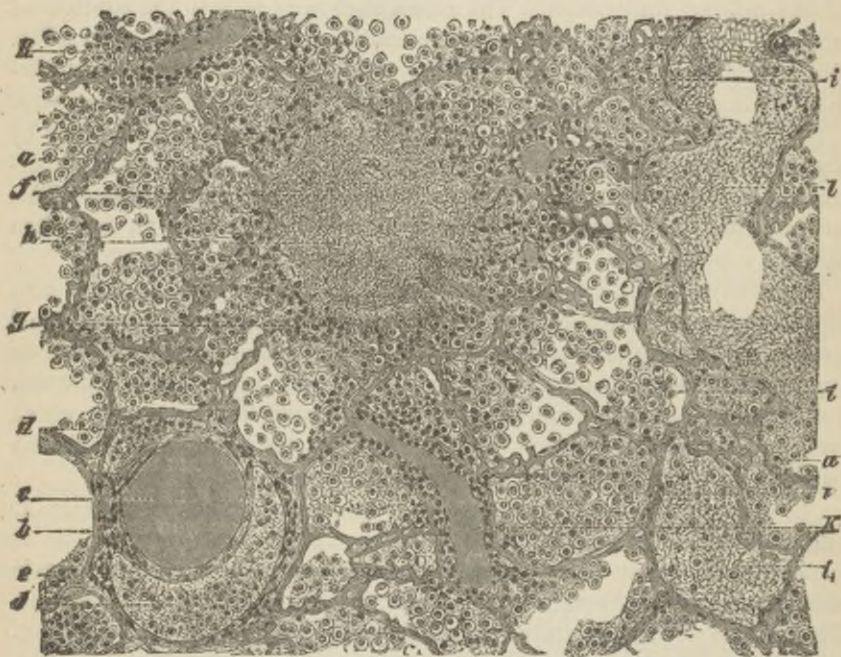


FIG. 237. MILIARY TUBERCULOUS BRONCHOPNEUMONIA.

(This is a secondary patch due to the aspiration of the contents of a small caseous node which ruptured into a bronchus: preparation injected with blue gelatine and stained with alum-carmine: the bacilli drawn from a parallel section stained with fuchsin: $\times 80$.)

- | | |
|--|---|
| a, interalveolar septa with injected capillaries | g, cellular periphery of the bronchopneumonic patch |
| b, respiratory bronchiole | h, tubercle-bacilli ($\times 160$) |
| c, injected artery | i, cellular exudation in the alveoli |
| d, circumvascular lymphatic distended with exudation | i ₁ , chiefly fibrinous exudation |
| e, pigment lying round the lymphatic | k, vein with surrounding cellular infiltration |
| f, caseous centre, and | l, interlobular lymphatic distended with exudation |

traversed the part occupied by a solid nodule of this kind are always destroyed.

The lung-tissue around the nodule is the seat of an exudative in-

flammation, whose intensity differs greatly in different cases. As a rule the neighboring alveoli (*i*) contain extravasated liquid and cells, desquamated epithelium, and often fibrin (*i*). The alveolar walls are infiltrated with leucocytes, especially around the veins (*k*). The lymphatics, peribronchial and periarterial (*d*) as well as interalveolar and interlobular (*l*), are also in some measure affected by the inflammation, being more or less distended by exuded matters (*d l*). When the nodule is subpleural, the pleura is simultaneously inflamed.

When a number of tuberculous bronchopneumonic foci are thus formed by aspiration, each passes through much the same series of changes as were described in the case of the primary focus. Some continually enlarge and lead to progressive tuberculous lymphangitis, others soften and break down and by aspiration of their contents lead possibly to fresh bronchopneumonic infection.

At all stages of the disease there is still another possible mode by which the infective agent may be disseminated. Chronic inflammatory change in the lung always extends in some degree to the blood-vessels. Plastic inflammation leads to fibrous thickening of the walls of arteries and veins, and by endarteritic thickening some of the smaller branches may be obliterated altogether. In tuberculous inflammation of the lung the walls of the capillaries as well as those of the arteries and veins are especially apt to be affected. When an actual tuberculous node or nodule is formed the capillaries perish outright, while in the walls of the larger vessels appear granulomatous growths having all the characters of tubercle, and developing some into fibrous thickenings and some into caseous ulcers. These several morbid changes naturally lead to local disorders of the circulation, and to more or less copious hæmorrhages (**hæmoptysis**), which are most apt to follow when the walls of arteries are diseased and are eroded or give way. But there is also the danger that the caseous growths on the walls of veins may break into the interior of them, and permit the tuberculous detritus and bacilli to enter the circulation and spread the infection to distant organs. This however appears not to happen at all frequently, no doubt because before a tubercle actually breaks through the intima into the vein thrombosis is induced by the diseased state of the wall, and in this way the vein itself is effectually blocked up (compare CORNIL, *Journ. de l'anat.* 1880; MÜGGE, *Virch. Arch.* vol. 76; ARNOLD, *ibid.* vol. 88; WEIGERT, *ibid.* vols. 77, 87, 104).

The tubercle-bacilli may at a very early stage of the disease pass from the peribronchial lymphatics into the bronchial glands, and there set up tuberculous changes. Cases indeed not infrequently occur in which only a few scattered bronchopneumonic nodules are found in the lungs, while some of the bronchial glands are tuberculous throughout or entirely caseous. It has even been noted that only a single small patch

may occur in the lung, or that no patch at all may be discovered, and yet the bronchial glands may be extensively diseased.

After the tuberculous process has spread over a considerable part of the lung and the lymphatics the bronchi also become diseased in like manner. The smaller tubes are first affected, then the larger, and often the trachea and larynx as well. If the sputum be swallowed tuberculosis of the alimentary canal may be set up.

The author in a lecture published in 1878 (*Sammlung klin. Vorträge* 151) explicitly insisted on the fact that the extension of tuberculosis in the lung takes place by way partly of the lymphatics and partly of the bronchial passages, the whole course of the disease suggesting inevitably that the secretion and other contents of tuberculous cavities act infectively upon the sounder parts of the lung. This statement was based chiefly on the results of anatomical examination and on the experiments on inhalation cited in Art. 612. The subsequent discovery of the tubercle-bacillus, and the demonstrated fact that the sputum from the diseased lung contains bacilli, corroborate the statement, and all the author's recent observations in the post-mortem room are in entire accord with it. When a number of tuberculous bronchopneumonic patches are found in a lung, there is always present an older disintegrated focus or a bronchiectasis or a caseous lymphatic gland: in these the bacilli have multiplied and have thence been disseminated along the air-passages.

We are unable to set forth in detail the numerous and various accounts which have been given of tuberculous disease of the lung. An analysis of them could only be of value if accompanied by the arguments which have induced us to set aside those that differ from the account in the text, and this would scarcely be in place in a work like the present. In general terms it may be said that some of the views referred to are erroneous because they rest on mistaken ideas as to the structure of the lung; and further that sufficient attention has not been paid to the distinction between diseases of the respiratory parenchyma of the lung and diseases of the bronchi and peribronchial tissue. Many affections have thus been described as peribronchitic in which the peribronchial tissue is intact, the affection being really one of the respiratory tissue and only properly described as bronchopneumonic. Authors again have in many cases entirely ignored the lymphatics, while a few have exaggerated the part they play.

References on the morbid anatomy of chronic pulmonary tuberculosis:—**LAENNEC**, *Traité de l'auscultation médiate et des maladies des poumons et du cœur* II. Paris 1837; **CARSWELL**, *Pathological Anatomy* London 1838; **RÜHLE**, *Ziemsens's Cyclop.* v.; **RINDFLEISCH**, *Pathological Histology* II. London 1873; **RAYMOND**, *Arch. gén. de méd.* 1893; **ORTH**, *Virch. Arch.* vol. 86, *Berl. klin. Woch.* 1881; **AUFRECHT**, *Path. Mittheil.* I., II.; **KÖSTER**, *Sitzungsber. d. niederrhein. Gesell.* Bonn 1876; **HUGUENIN**, *Corresp. f. Schweizer Aerzte* 1880; **ZIEGLER**, *loc. cit.*; **BUHL**, *loc. cit.*; **VON WYSS**, *Gerhardt's Handb. d. Kinderkr.* III.; **HAMILTON**, *Pathology of bronchitis etc.* London 1883; **CORNIL** and **RANVIER**, *Man. Path. Hist.* II. London 1884; **SORMANI**, *Annal. univers. di med.* 1883; **GERMAIN SÉE**, *Bacillary phthisis* (trans. by **WEDDELL**) London 1885; **ORTH**, *Lehrb. d. spec. Path.* II. Berlin 1885.

References on tubercle-bacilli in sputum etc.:—**KOCH**, *Berl. klin. Woch.* 15, 1882 and 10, 1883; **BAUMGARTEN**, *Cent. f. med. Wiss.* 15, 1882; **LICHTHEIM**, *Fortschritte d. Med.* I. (1883); **DE GIACOMI**, *ibid.*; **BALMER** and **FRAENTZEL**, *Berl. klin. Woch.* 45, 1882 and *Deut. med. Woch.* 17, 1883; **HILLER**, *Deut. med. Woch.* 47, 1882, *Zeitschr. f. klin. Med.* v.; **P. GUTTMANN**, *Berl. klin. Woch.* 52, 1882;

PFEIFFER. *ibid.* 3, 1883; ZIEHL, *Deut. med. Woch.* 5, 1883; MENCHE, *Fortschritte d. Med.* 1.; DRESCHFELD, *Brit. Med. Journ.* 1, 1883; DEMME, *Berl. klin. Woch.* 15, 1883; RIEGEL, *Cent. f. klin. Med.* 13, 1883; MÜLLER, *Verhandl. d. phys.-med. Gesell. zu Würzburg XVIII.* (1883), *London Med. Record* 1885; KOCH, *Mitth. a. d. k. Gesundh.* II. 1884; KLEIN and GIBBES, *Annual Report to Local Government Board* 1883-1884; PERCY KIDD, *Med. chir. Trans.* LXVIII. 1885; HUNTER MACKENZIE, *Treatise on the sputum* Edinburgh 1886; CORNIL and BABES, *Les bactéries* Paris 1885.

614. From what has been said in the last Article it will appear that the extension of localized tuberculosis of the lung is essentially a

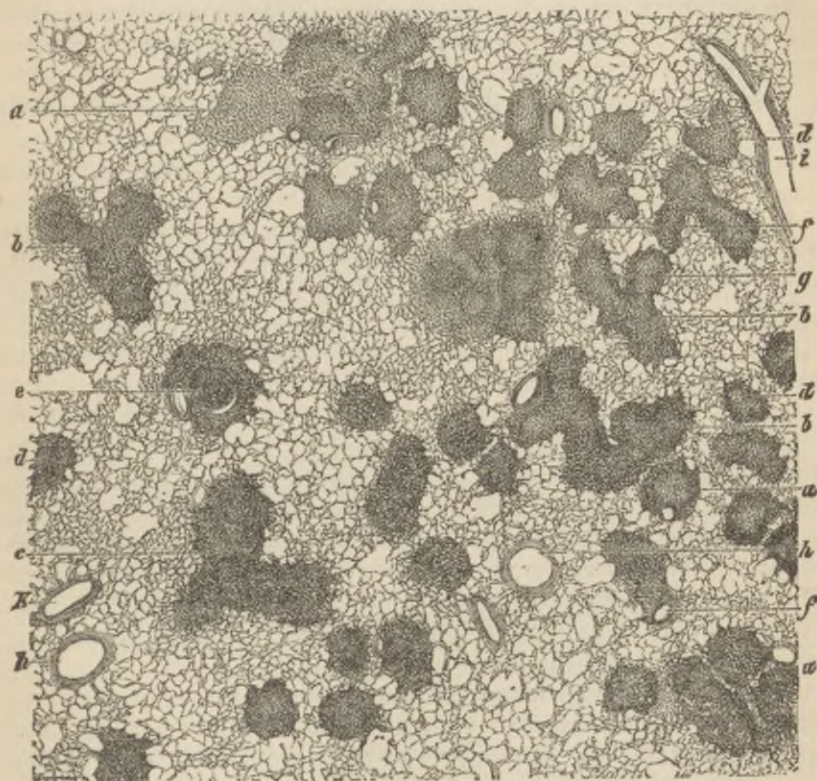


FIG. 238. CHRONIC NODULAR TUBERCULOUS BRONCHOPNEUMONIA.
(Hardened in Müller's fluid, stained with picrocarmine: $\times 6$.)

- | | |
|---|--------------------------------------|
| a, b, c, d, nodules of various forms corresponding to systems of alveolar ducts | f, arteriole |
| e, section through an infiltrated and occluded bronchiole | g, nodules in process of coalescence |
| | h, small bronchus (normal) |
| | k, artery |

bronchopneumonic process, accompanied to a varying extent by lymphangitis, bronchitis, and peribronchitis.

All these inflammatory processes affect in the first instance more or less isolated patches of tissue, which are usually nodular and vary from

the size of a millet-seed to that of a pea. Where the process is still recent we thus find the respiratory tissue studded with small gray translucent nodules, or larger white opaque ones (Fig. 238 *a d*). Most of these are simply respiratory bronchioles and alveolar ducts with their alveoli (*abcd*) which have become transformed by inflammation into compact and continuous masses. On section we can frequently make out in them the form and arrangement (*b c*) of the original parts. It is only when the nodule increases in size by the extension of the inflammation to neighboring alveolar groups and to the lymphatics that this configuration becomes indistinct and disappears.

In the later stages the bronchopneumonic nodules usually give place in a measure to those caused by lymphangitis, bronchitis, and peribronchitis (*e*); but this is by no means always the case.

Cases occur in which the thickening of the bronchi and peribronchial tissue and the occlusion of the smaller air-passages goes on to a very marked extent. In like manner the lymphangitis may spread far and wide.

If we start then with these nodular inflammatory patches it is not hard to gain an understanding of the many diverse forms in which pulmonary tuberculosis presents itself. They are all referable to this primary type, and their differences are due partly to varieties in the original bronchopneumonic patches themselves, partly to variations in the morbid phenomena which accompany their development.

As regards the bronchopneumonic patches, varieties occur chiefly in the character of the inflammatory exudation, to some extent also in the way in which the inflammation terminates—the issue of the inflammation.

In one case we may have a cellular or a fibrous exudation which rapidly becomes caseous or purulent, in another the process tends to fibrous overgrowth with partial caseation: thus we may distinguish caseous, caseo-purulent, caseo-fibroid, and fibroid or indurative varieties of tuberculous bronchopneumonia.

When the development of the nodular patches is accompanied by more extensive inflammation of the adjacent tissue, the nodular patch becomes a lobular one: thus we have a simply nodular and also a lobular form of tuberculous bronchopneumonia.

Both the primary and the secondary tuberculous patches may cease to extend and at length heal. It is very doubtful whether complete recovery of the affected tissue by re-absorption of the exudation is in any case possible, and indeed it can only occur in the very smallest patches whose vessels are not yet obliterated. In larger patches healing can only take place when the inflammatory process issues in fibrous hyperplasia and induration. The indurated portions of the lung are sometimes nodular, sometimes diffuse and extensive: they consist of slaty-gray (*induration ardoise*) or white fibrous tissue. They may contain

caseous residues; but usually some exist scattered through the tissue, and are derived either from bronchopneumonic patches or from altered bronchial secretion. In these nodules and patches it appears likely that bacilli may persist for a considerable time, though we may take it for granted that they ultimately perish. Sooner or later the caseous residues become calcified.

In this way, so long as the affected patches are few, tuberculous disease of the lung may be entirely recovered from, or at least stayed from further advance, so that for years no new portion of the lung is invaded. Of course so long as any bacilli remain in the tissue, we can hardly speak of the recovery as complete. When a large number of tuberculous foci exist in the lung, in some of them absolute or relative recovery may take place, but it is extremely unlikely that this will occur in all simultaneously. So long however as a single patch undergoes disintegration and forms a nidus for the multiplication of the bacilli, the danger and the probability remain that the process may start afresh by extension through the lymphatics, the blood-vessels, or the air-passages.

The term tuberculous bronchopneumonia (including the associated morbid changes) is to a great extent coextensive with the clinical term **pulmonary phthisis**. The two ideas are however not identical. The lung may be destroyed by inflammations which have nothing to do either with tuberculosis or with any other of the infective granulomata. Inasmuch as phthisis primarily connotes simply destruction of tissue, it might very well be taken to include all destructive inflammations of the lung.

It is usual however to limit the term to those destructive inflammations which are progressive, that is to say which advance either steadily or intermittently from bad to worse, and that independently of fresh injury from without. This limitation then excludes those affections of the lung wherein an acute inflammation is followed by a partial destruction of tissue, which however has no tendency to extend or become general.

Even then the terms phthisis and tuberculosis are not equivalent. For as we have seen certain non-specific inflammations may take on a progressive character, and of the specific granulomatous infections glanders, syphilis, and actinomycosis lead to affections of the lung analogous to tuberculous disease.

The varieties observed in the course of tuberculous bronchopneumonia, in other words the diversities in the nature of the individual foci of inflammation, depend partly on differences in the reaction of the pulmonary tissue to irritation in different persons, but chiefly no doubt on the character and quantity of the irritant disseminated through the lung. And though our view at present is that the essential and specific irritant in tuberculous phthisis is the tubercle-bacillus, yet it can hardly be gainsaid that in many cases other injurious agencies cooperate with it.

Many pulmonary cavities or vomices contain not only tubercle-bacilli but also other bacilli and micrococci, and these too may have a destructive action, modifying and perhaps now and then intensifying the action of the specific virus. It is possible that the caseo-purulent form of phthisis may be due to a complex infection of this nature.

With regard to recovery from pulmonary tuberculosis, many cases have been recorded; but until the discovery of the tubercle-bacillus it was impossible to de-

cide with absolute certainty whether when a cicatrix was found in the lung the antecedent affection had or had not been tuberculous. The process of healing referred to in the text undoubtedly occurs: we would refer in support of this not only to cases in which a clinical diagnosis of tuberculosis had been made, and years afterwards the indurative changes above described have been discovered in the lung, but also to a recently-published observation of NAUWERCK'S (*Deut. med. Woch.* 23, 1883). In the body of a man of 45, who five years before his death had for a time shown symptoms of bilateral disease of the apices of the lungs, and who died after a short illness of gastric cancer, NAUWERCK found in the apices cicatricial patches enclosing scattered caseous foci with a few tubercle-bacilli. There was no trace of recent tuberculous bronchopneumonia or lymphangitis. In the indurated fibrous tissue no bacilli were found. It is worth noting that four brothers of the patient had previously died of tuberculosis.

615. The simplest and commonest form of pulmonary tuberculosis is **nodular tuberculous bronchopneumonia**, characterized by the formation of bronchopneumonic nodules and nodes.

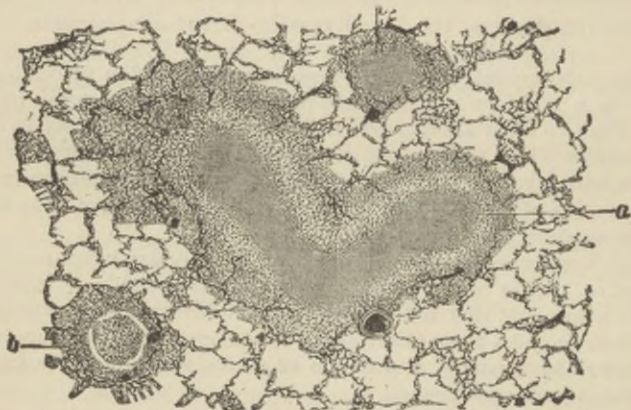


FIG. 239. NODULAR TUBERCULOUS BRONCHOPNEUMONIA.

(Preparation injected with blue, and stained with carmine: $\times 25$.)

- a, v-shaped patch, caseous in the centre and fibro-cellular at the periphery, produced by the infiltration of two contiguous alveolar ducts and their alveoli
 b, respiratory bronchiole with cellular exudation in and around it
 c, alveolar duct, with caseous cellular contents and infiltrated alveoli

To give rise to it there must somewhere exist a mass of softening tubercle, a tuberculous bronchitis, or a bronchiectatic cavity: in other words a focus from which tubercle-bacilli may reach the bronchial passages and thence pass into the terminal bronchioles (Fig. 239 b).

If the dissemination is rapid and extend over the greater part of the lung the patient may sink very speedily, and after death the lung is found studded with miliary gray and white nodules exactly resembling embolic tubercles. This form we might describe as miliary tuberculous bronchopneumonia (Fig 237). The small patches lie partly in the alveolar ducts (Fig. 239 c), partly in the respiratory bronchioles (b): when

recent they are cellular, but afterwards they become caseous or fibrous. The vessels perish as the nodules develop.

When the virus is more gradually disseminated, so that the patient survives for a longer time, the patches become more numerous and increase in size. As a rule they become caseous in the centre (*a*) and fibrous or fibro-cellular at the periphery. The course of the disease is usually chronic, and it might therefore be described as **chronic nodular indurative bronchopneumonia**. The groups of gray or grayish-white nodules are arranged in clusters, and in section appear rounded, oval, bifurcated, or trifoliate. This is of course due to the fact that the solid nodular masses represent the terminal branches of a respiratory bronchiole. In the neighborhood of the nodules there are always a number of obstructed bronchioles with thickened walls, looking on section like encapsuled caseous nodes.

At first the bronchopneumonic patches lie bedded in normal air-containing tissue; but after a time the surrounding tissue is usually condensed, indurated, and gray. This is due in the first place to collapse from occlusion of the bronchioles and small bronchi, and secondly to extension from the nodular patches of the inflammatory infiltration and induration, by which the alveolar walls are thickened and the alveoli are filled up with cells and ultimately fibrous tissue. The pigmentation is referable partly to inhaled dust, partly to the small hæmorrhages which occur from disturbances of circulation in the diseased area or from rupture of the degenerate vessels that run through it.

The rarer form of nodular tuberculosis, **nodular caseous bronchopneumonia**, is characterized by the formation of small cellular foci, gray or yellowish-white, and rapidly becoming caseous or purulent. The caseous non-vascular nodules are always surrounded by a zone within which the alveoli are filled with leucocytes, desquamated epithelium, liquid exudation, and often fibrin, while the lung-tissue itself is infiltrated with small cells. These nodules readily soften and break down, so that little cavities are formed which sooner or later open into the adjacent bronchi.

The caseous, indurative, and caseo-fibroid forms of bronchopneumonia are met with in combination.

616. The processes just described start as a rule in the **apices of the lungs**, and thence extend downwards and backwards. The apex of a lung may thus exhibit terminal stages of the disease while the bases are still in process of invasion. After a time the parts most affected, in the caseo-fibroid or indurative form of bronchopneumonia, become almost absolutely airless, and hard and knotty to the touch. The pulmonary pleura is usually much thickened and adherent to the costal layer (Fig. 240 *a*), the lung-tissue is condensed and studded with caseous nodes (*bc*) surrounded either by translucent gray or white or by slaty-gray pigmented fibrous tissue. These nodules are occluded and indurated alve-

olar ducts with their alveoli (*b*), or bronchioles with caseous contents (*c*) and thickened walls surrounded by condensed tissue. Between the nodules lie white or pigmented fibrous bands (*e*) corresponding to thickened interlobular septa or peribronchial connective tissue, and gray nodules representing recent foci of inflammatory infiltration (*ff*).

The fibrous nodes and bands are coarsely-fibrous with few cells, or mainly cellular. Some of the nodes are caseous in the centre, giant cells being often found in the zone between the caseous matter and the non-necrosed tissue. By appropriate treatment a few scattered bacilli can be demonstrated. Sometimes these indurated patches also contain typical tubercles. The septa of the remaining portions of the lung are frequently infiltrated with cells and more or less thickened.

This morbid change may extend over the greater part of the lung,

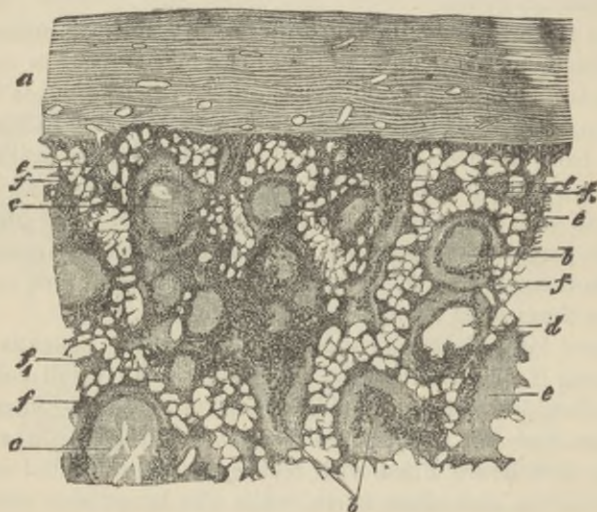


FIG. 240. CHRONIC NODOSE TUBERCULOUS CIRRHOSIS.

(Hardened in alcohol, stained with hæmatoxylin: $\times 20$.)

- | | |
|--|---|
| <i>a</i> , thickened and fibroid pleura | <i>d</i> , small bronchiectatic cavities |
| <i>b</i> , caseo-fibrous bronchopneumonic nodes | <i>e</i> , thickened interlobular septa |
| <i>c</i> , bronchioles with caseous contents and thickened walls | <i>f</i> , recent cellular infiltration surrounding the nodules and (<i>f</i> ₁) the lymphatics. |

The alveolar septa are in parts infiltrated with cells, and the thickened and indurated tissue is pigmented.

and then leads to a form of contraction and induration which we may fitly describe as **nodose tuberculous cirrhosis**. Usually however it is confined to a limited portion of the lung, other changes being set up which lead to a different result.

Even in cases where the cirrhosis is at first the characteristic feature ulceration is never entirely absent. The process may start in the caseous foci within the lung-tissue itself, or in the bronchiectatic cavities

which arise in the shrunken and airless parts. Once the process of disintegration has begun it usually advances steadily and somewhat rapidly to the formation of vomicæ or caverns. Even when these cavities become lined with a layer of granulations the process is seldom thereby brought to a complete standstill, for the bacilli settled in the wall of the cavity give rise to fresh inflammatory change and fresh necrosis.

The usual course of the disease, in indurative tuberculous bronchopneumonia as in other forms, leads to the formation of cavities of considerable size, increasing not only by continuous extension but also by coalescence with others. In the latter case we may have a whole series of intercommunicating cavities, or a single large and very irregular cavern traversed and partially subdivided by bands and fragments of tissue.

The greater part or the whole of the upper lobe and parts of the lower lobe may be thus destroyed, the cavity being in places bounded only by the thickened pleura, while the collapsed and indurated pulmonary tissue is much reduced in bulk. The cavity contains air, and grayish, yellowish, or brownish liquid, mingled with pus-cells and whitish shreds and fragments of necrotic lung-tissue usually beset with bacilli. The disintegration of the lung-tissue takes place much more rapidly in caseous and caseo-purulent bronchopneumonia than in the indurative form. It sometimes happens that in a very short time from the onset of the malady the whole lung is riddled with cavities, whose caseous and infiltrated walls break down into shreds as if they were rotten. When such a cavity lies immediately underneath the pleura there is always (unless previous adhesions limit the process) a certain amount of fibrinous or purulent inflammation of that membrane. Not infrequently the pleura is perforated and **pneumothorax** or **pyopneumothorax** is set up.

The caseo-fibroid, caseous, and caseo-purulent forms of bronchopneumonia occur in various combinations and give rise to a great variety of different morbid appearances in different cases. Sometimes a suppurative form of the inflammation is grafted on a chronic caseo-fibroid form, and leads to a marked acceleration of the destructive process.

The striking fact that tuberculous bronchopneumonia usually begins in the apex of the lung points to the conclusion that the settlement and multiplication of the tubercle-bacilli take place more readily there than in other parts. In the apex the respiratory movement is relatively smaller, and the amount of blood in circulation less. Any bacilli which may reach the apex by aspiration are therefore less readily carried off by the lymphatics and destroyed by the living tissue-cells: in other words the tissue is there less resistant. A fact perhaps still more significant is this—that residues of previous inflammation (Art. 611) linger longer in the apex than elsewhere in the lung, and in this way cause a kind of local weakness or predisposition to bacillary invasion in that part.

starts in miliary or nodose bronchopneumonia. Sometimes in the neighborhood of recent cellular or partially caseous bronchopneumonic foci (Fig. 241 *a*) a lobular inflammation is set up, which is marked by cellular infiltration of the alveolar (*b*) and interlobular (*c*) septa, and distention of the alveoli and lymphatics (*d*) with a fibrinous liquid and cells. The tissue thus infiltrated sooner or later becomes caseous and breaks down, induration seldom occurring to any appreciable extent.

At first the inflamed lobules appear on section airless, grayish-red, smooth, gelatinous, and infiltrated: the condition has been well described as **gelatinous infiltration**. They afterwards become paler, then gray and translucent, and lastly opaque yellowish-white.

The number of the lobules so affected is of course variable. When they are numerous we usually find at the time of death that different

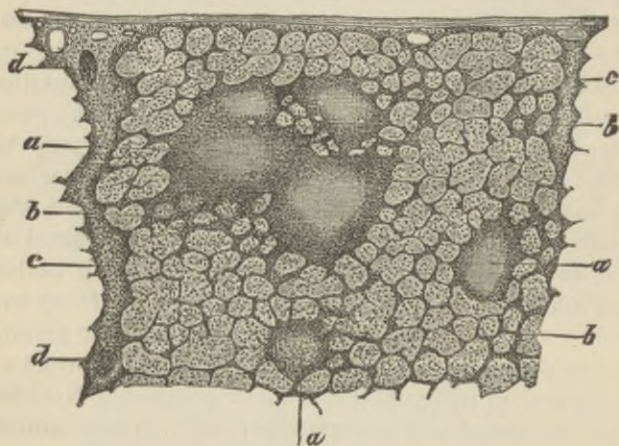


FIG. 241. LOBULAR CASEOUS TUBERCULOUS BRONCHOPNEUMONIA.

(Section through a subpleural lobule; hardened in alcohol, stained with hæmatoxylin: $\times 25$.)

- | | |
|--|---|
| <p><i>a</i>, nodule with caseous centre and cellular periphery</p> <p><i>b</i>, alveoli filled with exudation, the walls infiltrated with leucocytes</p> | <p><i>c</i>, interlobular septa infiltrated with leucocytes</p> <p><i>d</i>, lymphatics filled with exudation</p> |
|--|---|

lobules are in different stages of the process, some being grayish-red, others gray, others yellowish-white. Frequently the latter show signs of softening and excavation, or there are actually cavities of considerable size and communicating with the air by way of the bronchi.

When all the lobules of a lobe are thus affected, the disease assumes the appearance of a lobar affection and is often so described (Art. 606). Microscopical examination however always proves that some of the lobules have been affected long before the others, and so does away with the idea of a 'lobar caseous pneumonia.'

The pleura over the affected lobules is always inflamed, and usually

covered with fibrinous exudation. As the lobules break down the pleura may suppurate and become caseous, and so break down in like manner.

When lobular caseous bronchopneumonia is found in a lung we always find also older morbid changes in it, usually at the apex but at times in other parts. They may be slight, consisting of a few scattered points of caseation, or some indurated nodules, or dilated bronchi. In other cases the lobular caseation is but a terminal complication of an advanced nodose, caseous, or indurative bronchopneumonia. The lobular process may in fact be combined in a multitude of ways with the nodose.

Lobular caseous bronchopneumonia is most frequent in children, though it is by no means rare in adults. By many pathologists it is referred to as **scrofulous pneumonia**.

618. Bronchopneumonia from actinomycosis, glanders, and syphilis. The pulmonary affection set up by *Actinomyces* (Art. 134) takes the form of a bronchopneumonia, the diseased patches being of miliary size or larger. In cattle the patches are hard and nodular, and contain in the centre the ray-fungus as a kind of nucleus (PFLUG, HINK). In man the affection tends to be suppurative (ISRAEL, PONFICK), yellow or grayish-yellow patches being formed which presently by softening and suppuration give rise to corresponding cavities. These may become larger and larger, and at length break through the pleura. The characteristic feature of the process is of course the presence of the ray-fungus in the pus and in the infiltrated and disintegrated lung-tissue.

When glanders-bacilli (LÖFFLER and SCHUTZ, *Deut. med. Woch.* 52, 1882; CORNIL and BABES, *Les bactéries* Paris 1885) reach the lung by aspiration, they give rise to the formation of nodules and nodes chiefly beneath the pleura. At first they are soft and grayish, afterwards they become firmer and in part caseous. Patches of lobular extent and grayish-red in tint, and patches of bronchopneumonic suppuration, are also met with in glanders, and there may be a certain amount of hæmorrhagic inflammation. When the disease affects a number of contiguous lobules, large portions of the lung may in this way be infiltrated and ultimately break down. When the bacilli reach the lung through the circulation they induce pneumonia, which resembles in many respects the bronchopneumonic forms just referred to.

Syphilis first of all gives rise to bronchitis, which in course of time leads to peribronchial induration, with occlusion and dilatation of bronchi (Arts. 578-579). According to some catarrhal, indurative, suppurative, and caseous forms of bronchopneumonia may also result from syphilis. The caseous forms are said to include both lobular and nodular varieties.

References on pulmonary actinomycosis:—ISRAEL, *Virch. Arch.* vols. 74, 78, and *Beitr. z. Kenntn. d. Actin. d. Menschen* Berlin 1885; PONFICK, *Die Actinomycose des Menschen* Berlin 1882; PFLUG, *Cent. f. med. Wiss.* 14, 1882; HINK, *ibid.* 46, 1882; MARCHAND, Article *Aktinomykose*, *Eulenburg's Real-encycl.*

On pulmonary glanders see BOLLINGER, *Zeitschr. f. Thiermed.* 1876, *Ziemssen's*

Cyclop. III.; WERNER, *Der Lungenrotz* 1878; RABE, *Jahresber. d. Thierarznei-*
schule Hanover 1876; PÜTZ, *Seuchen u. Herdekrankheiten Stuttgart* 1882; DIECK-
ERHOFF, *Lehrb. d. spec. Path. f. Thierärzte* I. Berlin 1885.

On pulmonary syphilis see Art. 518.

CHAPTER LXXXVIII.

TUMORS AND PARASITES OF THE LUNGS.

619. **Primary tumors** of the lung or bronchi are rare. **Primary carcinoma** may occur in the larger bronchi as irregular nodose or papillary growths, starting either in the mucous glands or in the lining epithelium. Similar growths are also met with in the smaller bronchi, and these tend to spread over large portions of the bronchial ramifications. The disease may then extend to the peribronchial lymphatics, whereupon its generalization takes place with great rapidity, the air-passages both of the part originally affected and of remoter parts becoming studded with white marrowy nodes and nodules. The disease ultimately attacks the interlobular lymphatics and the lymphatic glands. In a third form of carcinoma large solitary nodes appear, of which we cannot say whether they start in the bronchioles or in the alveoli. They enlarge by the continual invasion and filling up of the alveoli at their borders with the cancerous epithelial growth. They also may invade the lymphatics and then extend in the same way as the second form. CHIARI has described a nodular **adenoma** of the mucous glands in the bronchial mucous membrane.

ROKITANSKY, MORGAN, RINDFLEISCH, and others have described cases of **fibroma**, in which nodules from the size of a hemp-seed to that of a hazel-nut were formed in large numbers around the bronchi. **Osteoma** also occurs in the form of irregularly-shaped structures with jagged processes, and of rounded nodules of the size of a pea; small globular chondrolipomata (ROKITANSKY, CHIARI), and **enchondromata** starting from the bronchial cartilages, have also been met with.

Of **secondary growths** examples of each kind that forms metastases at all have been found in the lungs. When the tumor-cells reach the lung as emboli they usually produce rounded nodules having the characters of the parent-tumor. These start from the embolized blood-vessels, and grow by radial extension or concentric accretion, partly invading and partly compressing the pulmonary tissue. The lymphatics may likewise be invaded by the growth, which then advances by this channel. When the tumor-cells originally reach the lung or pleura by the lymphatics, nodules of various sizes appear along the course of the latter. In the case of cancer the diffusion is often remarkably uniform, so that the lymphatics of a large portion or the whole of the lung are

distended with white marrow-like masses. On section such a lung exhibits a number of close-set whitish or reddish nodes along the course of the bronchi or interlobular septa.

The neoplastic growth often sets up inflammations especially of the pleura, and these not infrequently are hæmorrhagic in character.

Primary carcinoma of the lung:—ROKITANSKY, *Path. Anat.* iv.; EBERTH, *Virch. Arch.* vol. 49; LANGHANS, *ibid.* vol. 53; PERLS, *ibid.* vol. 56; WEICSELBAUM, *ibid.* vol. 85; SCHOTTELIUS, *Ein Fall v. prim. Lungenkrebs* In. Diss. Würzburg 1875; FENLEY and PARKER, *Med. chir. Trans.* LX. (1877); STILLING, *Virch. Arch.* vol. 83; REINHARDT, *Arch. d. Heilk.* IX. (1878); CHIARI, *Prag. med. Woch.* 1883; BECK, *Zeitschr. f. Heilk.* v. 1884.

Connective-tissue tumors of the lung:—ROKITANSKY, *Path. Anat.* iv.; MORGAN, *Trans. Path. Soc.* 1871; VIRCHOW, *Krankh. Geschwülste* II.; FÖRSTER, *Virch. Arch.* vol. 13; RINDFLEISCH, *ibid.* vol. 81; HESSE and E. WAGNER, *Arch. d. Heilk.* XIX.; HÄRTING and HESSE, *Eulenb. Vierteljahrsschr.* XXX., XXXI.; CHIARI, *loc. cit.*; RIBBERT, *Virch. Arch.* vol. 102 (lymphoma); COHN, *ibid.* vol. 101 (osteoma).

HESSE and WAGNER state that the Schneeberg miners frequently suffer from peculiar tumors in the lung, which WAGNER describes as lymphosarcomata. COHNHEIM (*Allgem. Pathol.* I.) suspects that they are due to some form of infective granuloma.

620. The **animal parasites** infesting the bronchi and the lungs are not numerous. The most important is *Echinococcus*, which may form hydatid cysts of considerable size, with or without daughter-cysts. *Cysticercus cellulosæ* is rare. *Strongylus longevaginat*us, a cylindrical worm 15-26 mm. long, has once been found in a boy's lung, and ORTH discovered a calcified *Pentastoma denticulatum* (Art. 225). KANNENBERG has in several cases of gangrene of the lung discovered *Monas lens* and *Cercomonas* (Art. 250), two flagellate infusorians, among the shreds of lung-tissue in the sputa. In the resting state they look not unlike white blood-corpuscles.

Of **vegetable parasites** in the lungs the most noteworthy are the numerous varieties of bacteria. Some of these, such as the bacilli of tuberculosis and of glanders, and the micrococcus of pneumonia, give rise to specific inflammations. Others again, such as those which inhabit the mouth, may possibly give rise to non-specific inflammations of various intensity when aspirated into the air-passages.

Gangrenous portions of the lung contain micrococci, bacilli, and spirilla. Some of these have probably much to do with the gangrenous decomposition, others probably settle only in the already disintegrated tissue.

In tuberculous cavities, disintegrating hæmorrhagic patches, croupous exudations within the bronchi and trachea, etc. we occasionally meet with a micrococcus which subdivides like *Sarcina* into tetrads, and has accordingly been regarded as a minute variety of that species (HEIMER). It usually occurs at the same time also in the pharynx and larynx, and has probably no causal connection with the respective diseases in ques-

tion. It is however not impossible that it may have the power of setting up inflammation where it settles.

Of the filamentous fungi or hyphomycetes we find in the lung the bovine *Actinomyces*, and various forms of *Aspergillus* and *Mucor*. The former is the only one that possesses any great pathological importance: the others, with *Oidium*, settle only in decomposing lung-tissue, stagnating secretions, or hæmorrhagic infiltrations. The above-named mould-fungi now and then proceed to the stage of fructification within the lung.

References on fungi in the lung or **pneumonomycosis**:—VIRCHOW, *Froriep's Notizen* 1846, *Virch. Arch.* vols. 9, 10; FRIEDREICH, *ibid.* vol. 30; COHNHEIM, *ibid.* vol. 33; BRISTOWE, *Trans. Path. Soc.* 1854; MUNK, *Cent. f. med. Wiss.* 1864; HELMER, *Ueber Pneumonomycosis sarcinica* In. Diss. Munich 1877; NAUWERCK, *Corresp. f. Schweiz. Aerzte* XI. (1881); FRIEDREICH, VON DUSCH, and PAGENSTECHER, *Virch. Arch.* vols. 10, 11; P. FÜRBRINGER, *ibid.* vol. 66; ROSENSTEIN, *Berl. klin. Woch.* 1867; LICHTHEIM, *ibid.* 1882; BOLLINGER, *Zur Aetiol. d. Infektionskrankheiten* Munich 1881; AUFRECHT, *Path. Mittheil.* II. 1883; KANNENBERG, *Virch. Arch.* vol. 75, *Zeitschr. f. klin. Med.* I. 1880.

According to BAELZ (*Cent. f. med. Wiss.* 39, 1880) a peculiar parasitic disease of the lung (*gregarinosis pulmonum*) is very common in Japan. Patients affected with it spit blood for a number of years, and their lungs contain encysted brownish-yellow ovoid *Psorospermia* and clear or pale-yellow non-encysted granular round or ovoid *Coccidia* (Art. 250). The affection is also met with in Formosa, and according to MANSON is due to the presence in the lung of *Distoma ringeri*, of which BAELZ'S *Psorospermia* are said to be merely the ova (*Med. Times and Gaz.* 2, 1881, and 2, 1882, *Brit. Med. Journ.* 2, 1882).

CHAPTER LXXXIX.

THE THYROID GLAND.

621. The **thyroid gland** is developed from a vesicular diverticulum of the throat-cavity, which afterwards becomes detached; its epithelium proliferates and grows into the surrounding fibrous tissue as cords and masses of cells, which form the primitive gland-tubes and follicles. Cavernous blood-vessels penetrate among these cell-masses and divide up the rudimentary gland into groups of cells of various sizes. These vessels are then differentiated into arteries, capillaries, and veins of ordinary dimensions, in the meshes of which the mature glandular structures make their appearance. These consist of rounded masses and cords of cells, forming follicles which at or soon after birth exhibit a central lumen distended with secretion or containing a little granular detritus. The cells surrounding the lumen are cubical or cylindrical and are seated directly on the blood-vessels. Between the follicles lie a number of what we may call unutilized epithelial cells; in the later stages of growth these may be fashioned into new follicles. Papillary overgrowth of the epithelium may also lead to the subdivision of an old follicle into two or more new ones.

In the fully-developed gland we can distinguish a cortical and a medullary substance: the latter contains radially disposed follicles and gland-tubes, the former masses and cords of cells concentrically arranged. In later life some of the glandular follicles contain colloid matter (Fig. 242 c).

In old age the substance of the gland undergoes more or less marked atrophy, the follicles shrinking to clusters of small cells or disappearing altogether, and the fibrous stroma becoming homogeneous and indurated, and at the same time increased in relative amount.

The adult thyroid consists of two lateral lobes and an isthmus uniting the two across the front of the trachea. The vertical diameter of a lateral lobe is 5-7 cm., the breadth 3-4 cm.; the width of the isthmus varies from 4 to 20 mm. Very frequently there is a middle lobe or pyramid, which rises from the isthmus and grows upward.

Absence of the thyroid is rare. More common **anomalies** are—abnormal smallness or absence of a lobe or of the isthmus, abnormal largeness, multiple lobes, and accessory glandular masses separate from the main mass and connected with the hyoid, the deeper parts of the

trachea, the supraclavicular fossæ, the interior of the larynx (P. BRUNS), the aorta, or the posterior wall of the pharynx. In very rare instances the isthmus is found to pass between the trachea and the œsophagus.

The most important of the morbid changes to which the thyroid is liable are those forms of enlargement of the whole gland or of particular parts of it included under the general term **goitre**, bronchocele or thyreocele (*struma*).

The gland may be enlarged from birth and constitute a **congenital goitre**. The enlargement may be due to over-distention or telangiectatic dilatation of the vessels, to hypertrophy of the gland-tissue, to premature and excessive colloid deposit, to increase of the fibrous stroma, or to adenomatous growth. The hyperæmic enlargement is of course transient, but the other varieties persist.

In later life also the thyroid may be enlarged by hyperæmic distention, constituting **vascular goitre**. The condition is not usually lasting, though it may become chronic.

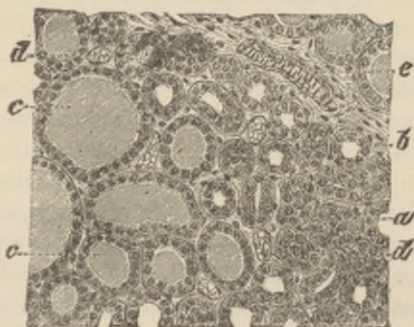


FIG. 242. GOITRE PARTLY HYPERTROPHIC AND PARTLY COLLOID.

(Alum-hæmatoxylin staining: $\times 60$.)

a, follicles filled with cells
b, empty follicle
c, colloid masses

d, capillaries
e, stroma with arteriole

A second form named **hypertrophic goitre** is due to multiplication and enlargement of the normal cell-masses (Fig. 242 a) and follicles (b), or to increase of the normal colloid contents (c). In the first case we have parenchymatous or follicular or **granular goitre**, in the second case colloid or **gelatinous goitre**.

The new follicles arise (WÖLFLE) from unutilized glandular cells, either by direct multiplication and grouping into orderly masses, or by endogenous multiplication of individual cells. The new follicles are separated from each other by fibrous tissue and blood-vessels. Pure hypertrophy of the thyroid is however not very common. It may be general or localized, and may exist from birth.

Adenoma of the thyroid is an epithelial new growth occurring in the form of isolated nodules, or diffused over one or both lobes. It consists

of vascular non-typical gland-like tissue, which persists in this form or is transformed more into the likeness of the normal gland-tissue. WÖLFLEER distinguishes four varieties—the foetal, the gelatinous, the myxomatous, and the columnar-celled. These adenomata occasionally recur after excision, and are not easily distinguished from carcinomata.

Foetal adenoma arises from some rudiment of embryonic tissue, though its growth may not be apparent till puberty or pregnancy: it occurs in nodes from the size of a pin's head to that of the fist. Its tint is pale-yellow, dark-red, or brownish-black, according as it is less or more vascular.

The nodes grow in much the same way as the gland originally develops; the smallest nodules accordingly consist of proliferous masses of round or oval not very sharply-defined cells, interspersed with dilated and varicose vessels. By degrees these vessels are differentiated into narrow capillaries and wider trunks, and then again assume gradually the typical configuration of the vascular system of the gland, while the proliferous epithelial cells become arranged in groups and follicles.

The nodes do not however reach this degree of development, but remain in various intermediate stages.

Adenomata, both small and large, which are traversed by numerous cavernous vessels, and so have a dark-red tint, are very liable to internal hæmorrhages. The glandular follicles within an area of extravasation not infrequently dilate into ramifying channels, which by and by are constricted off into vesicular cavities. Large extravasations are sometimes transformed into hyaline masses which afterwards becomes vascularized and traversed by bands and cords of proliferous glandular cells. In other instances scar-like or homogeneous cicatricial tissue is formed, and contains here and there dilated blood-vessels.

Gelatinous adenoma is a tumor, nodulated, tuberous, or smooth, occupying the whole gland or a single lobe, and on section appearing of a fairly uniform jelly-like consistence. The scanty stroma of the gland is in fact pervaded and distended by variously-sized lumps of colloid substance.

The growth starts in the granular cells which lie between the true follicles. As these cells multiply they give rise to new follicles or acini which secrete the colloid matter. These growths indeed are related on the one hand to the simple hypertrophies, on the other to medullary carcinoma. WÖLFLEER distinguishes two varieties of gelatinous adenoma—interacinous adenoma, and cyst-adenoma. **Interacinous adenoma**, as it may briefly be called, is the commonest form of goitre and the largest. It consists essentially of gland-like vesicles or cysts filled with colloid substance and lined with cubical or spherical epithelial cells. Between the fully-formed vesicles lie rudimental cell-masses and follicles in process of development. The epithelial cells of the older vesicles may multiply to such an extent as to fill them up (*adenoma interacinosum*

proliferans). Interacinous adenoma may co-exist with the foetal form. **Cystadenoma** is characterized by the formation of cysts varying in size from that of a lentil to that of a goose's egg. The proliferous cells which these cysts contain undergo fatty and colloid degeneration. The intercystic vessels and fibrous tissue become atrophied. In some parts the interacinous cell-groups grow and break into the cysts, and there undergo colloid change: or they may simply push the cyst-epithelium before them, and the papillary ingrowths thus formed tend to become covered with cylindrical cells. New cysts are sometimes formed in the substance of these ingrowths, and thus the original cysts may become filled with minor cysts. Nodes containing cysts and ingrowths of this kind are described as proliferous cystadenomata, and occasionally lead to the formation of enormous goitres in which the whole of the thyroid is included. In the human subject however they are not common: in the monkey and the dog these formations occur in the normal gland. The neoplasm is usually most characteristically developed in the central parts of the goitre; the periphery consists mainly of non-excavated follicles and cell-masses. The intercystic stroma is frequently fibromyxomatous, or consists of hyaline tissue resulting from hæmorrhagic infiltration. The colloid substance is formed only in small quantity by the cylindrical epithelium of the papillary ingrowths. Sometimes the glandular follicles and vesicles become calcified, their epithelium undergoing fatty degeneration.

Myxomatous adenoma (follicular and tubular) occurs both in young and in old patients: it takes the form of soft nodose growths of various sizes and often highly vascular. The neoplasm consists of a hyaline structureless or faintly striated matrix, occasionally in part calcified, interspersed with solid globular cell-masses, follicles, and cords of cells of various forms. Normal follicles are as a rule conspicuously absent.

The myxomatous condition is secondary, being a transformation of a foetal or interacinous adenoma. The transformation is due to hæmorrhagic infiltrations of the tumor-tissue such as are known to occur at puberty, during the catamenia, and during pregnancy. The infiltrated area assumes a hyaline appearance, or if it is partially vascularized it becomes more fibrous and ultimately fatty and calcareous: if the vascularization is more complete the glandular cells multiply and the growth is pervaded with new-formed cell-masses and tubules.

Columnar-celled adenoma is characterized by the presence in it of vesicles or acini lined with tall columnar epithelium, and traversed by irregular solid cords and bands made up of the same kind of cells. The new growth is distinguished from mere hypertrophy of the follicles that are lined with columnar epithelium in the normal gland by the presence of glandular tubules of the embryonic type. According to WÖLFLE this form is very rare.

Goitre is dangerous to the patient afflicted with it chiefly from

the pressure it may exert on the trachea, the œsophagus, or the large vessels of the neck. The trachea is compressed when the goitre grows down beneath the sternum, or when it reaches a very large size and surrounds the trachea and œsophagus or pushes them to one side. The continuous pressure sometimes causes atrophy of the tracheal cartilages, and the tumor then protrudes into the air-passage. Accessory thyroid glands may become goitrous like the principal mass.

References:—ECKER, *Zeitschr. f. rat. med.* VI. 1847; LEBERT, *Die Krankh. d. Schilddrüse* Breslau 1862; FRIEDREICH, *Virchow's Handb. d. spec. Path.* v. 1858; ROKITANSKY, *Anat. d. Kropfes* Vienna 1849; DAVIES, *Trans. Path. Soc.* 1849; VIRCHOW, *Krankh. Geschwülste* III.; LÜCKE, *Pitha u. Billroth's Handb. d. Chir.* III. 1875; DEMME, *Gerhardt's Handb. d. Kinderkr.* III.; STROMEYER, *Arch. f. phys. Heilk.* IX. (1850) GUILLOT, *Arch. générales* 1860; PARSONS, *Med. Times and Gaz.* 2, 1862; KÖNIG, *Arch. f. Heilk.* 1865; GEUZMER, *Virch. Arch.* vol. 74; LÜCKE, *D. Zeitschr. f. Chir.* VII.; KAUFMANN, *ibid.* XVIII.; W. MÜLLER, *Jena. Zeitschr. f. Med.* VI. 1871; COHNHEIM, *Virch. Arch.* vol. 68; BUOB, *Du goître congén.* Strasburg 1867; HECKER, *Monatsschr. f. Geburtskunde* XXXI. 1868; SPIEGELBERG, *Würzburg. med. Zeitschr.* 1864; NIËPCE, *Traité du goître* Paris 1851; LUTON, *Art. Goître. Nouv. dict. de méd.* XVI. 1872; BERGER, *Arch. de méd.* 1874; HILDEBRAND, *Art. Struma, Eulenburg's Real-encycl.*; WÖLFLE, *Ueb. d. Entwicklung u. d. Bau d. Schilddrüse* Vienna 1880 and *Entwick. und Bau d. Kropfes, Langenbeck's Arch.* XXIX. 1883; MADELUNG (accessory thyroids) *ibid.* XXIV.; LEITZ, *ibid.* XXIX.; GORE, *Fortschr. d. Med.* I. 1883; GUTKNECHT, *Virch. Arch.* vol. 99; STRECKEISEN, *ibid.* vol. 103.

The account in the text is based chiefly on the recent admirable researches of WÖLFLE: without agreeing with him in all details we think his work the best that has yet appeared on the structure and genesis of goitre.

622. The adenomata described in the last Article do not in general extend beyond the limits of the thyroid gland, and are therefore to be classed with the innocent or non-malignant growths. Varieties of proliferous cystadenoma and follicular adenoma do however occur, which are characterized by their vascularity, their highly cellular nature, and their rapid growth; and these are apt to recur after excision. Other varieties depart more or less from the adenomatous type, approaching that of carcinoma, and these may form metastases.

These transitional varieties are best described as **malignant adenomata** (WÖLFLE). They have in parts a grayish-white medullary or encephaloid appearance, and contain amid structures unmistakably adenomatous patches exactly resembling carcinomatous tissue. This is the case even when the metastatic growths have a structure almost exactly corresponding to that of the normal thyroid gland. In considering the statement of COHNHEIM and HESCHL—that normal thyroid hypertrophies and apparently innocent adenomata may give rise to metastases—we must therefore bear in mind also that malignant adenoma and carcinoma are occasionally accompanied by metastatic growths whose structure closely resembles that of non-malignant adenomatous tissue.

Even in the parent-tumor in the latter case we at times find structures very similar to normal thyroid acini with a lumen and a regular epithelial lining.

Carcinoma of the thyroid occurs in regions where goitre is endemic, and usually develops in an existing goitrous growth. As a rule it is soft and medullary, forming nodose tumors from the size of a hen's egg to that of a child's head, and seated in one of the lobes of the gland. It is usually surrounded by normal gland-tissue or adenomatous tissue. Rarely is the whole gland transformed to cancer-tissue. Secondary growths, and irruptions into the trachea or larynx, are common; but both are often absent for a long space of time, the tough cortical substance of the gland offering considerable resistance to the advancing growth.

WÖFLER distinguishes three forms of carcinoma—alveolar, columnar-celled, and squamous-celled. **Alveolar** carcinoma is the commonest, and occurs as grayish nodes surrounded by fibrous tissue and seated in the parenchyma of the gland, or as a uniform medullary infiltration of the goitrous tissue. The proliferous epithelial cells are usually rounded or oval, or sometimes polymorphous; they form globular or elongated masses or nests separated by fibrous bands of varying thickness. Between the nests we frequently find persistent remnants of normal follicles. The development of the growth begins in the epithelial cells which lie 'unutilized' or form compact masses between the gland-follicles. The lining epithelium of the follicles takes no part in the development of the cancer, which thus in its mode of growth recalls the gelatinous adenoma in which it often originates: it is indeed distinguishable from the latter only by the fact that no trace of reversion to any glandular type appears in it. The old gland-follicles often persist for a long time amid the advancing growth, but are ultimately encroached on or filled up by the new-formed cancer-cells. **Columnar-celled** carcinoma corresponds in structure to the columnar-celled parts of the normal gland and to columnar-celled adenoma. It takes the form of nodes whose cut surface is white or grayish-red. The neoplastic tissue is characterized by the presence in it of solid cords of cells, and of tubules and follicles clothed with cylindrical epithelium and containing papillary ingrowths exactly resembling those of papillary cyst-adenoma. WÖFLER regards this form also as originating in the interacinous epithelial cells. **Squamous-celled** carcinoma is a rare form (FÖRSTER, EPPINGER, LÜCKE, KAUFMANN, BRAUN). As there is normally no squamous epithelium in the thyroid it is not improbable that, in cases where the growth does not start from the œsophagus, it is due to the morbid development of embryonic epithelial cells accidentally enclosed in the gland on the closure of the branchial clefts.

Of the **connective-tissue tumors** of the thyroid **sarcoma** is the commonest, and usually originates in an already-existing goitre. Both

round-celled and spindle-celled sarcoma are described, and WÖLFLEER adds to the list of forms—giant-celled sarcoma, angiosarcoma, and alveolar sarcoma. They form irregular nodulated tumors extending over a part or the whole of a single lobe, seldom over the entire gland. The cut surface is generally smooth, though the tumor is usually more or less lobulated by the bands of firm fibrous tissue which traverse it. The tint is white or grayish, pink, reddish-brown, or dark-brown, according to the amount of blood present. The latter tint prevails where there are cavernous blood-vessels with hæmorrhagic infiltrations. The tumor is more or less firm according as it is fibrous or cellular: the round-celled form is the softest. The acini surrounded by neoplastic tissue often survive a long time. Tumors are described in which muscle-fibres appeared to be included. Secondary growths are set up in consequence of invasion of the lymphatics or blood-vessels. Sarcoma occurs in patients of all ages.

WÖLFLEER describes a case of **fibroma** in a man of 56; it took the form of multiple hard nodes of about the size of a walnut.

Carcinoma and sarcoma of the thyroid are often included under the term malignant goitre (*struma maligna*).

References:—VIRCHOW, *op. cit.*; EBERTH, *Virch. Arch.* vol. 55; EPPINGER, *Prager Viertelj.* 1875; KOCHER, *D. Zeitschr. f. Chir.* IV.; KAUFMANN, *ibid.* XI., XIV.; LÜCKE, *Arch. f. klin. Chir.* VIII.; ROSE, *ibid.* XXIII., W. MÜLLER, *Jena. Zeitschr. f. Med.* VI. 1871; VON WINIWARTER, *Beitr. z. Statistik d. Carcinome Stuttgart* 1878; CORNIL, *Arch. de physiol.* 1875; PAYNE, *Trans. Path. Soc.* XXII. 1871; DEMME, *Jahresber. d. Berner Kinderspitale* 1879 and *Gerhardt's, Handb. d. Kinderkr.* III.; GRIFFINI, *Arch. per le scienze med.* IV. 1880; PINNER, *D. Zeitschr. f. Chir.* XVII. 1882; BRAUN, *Langenbeck's Arch.* XXVIII.; E. NEUMANN, *ibid.* XXIII.; BIRCHER, *Sammlung klin. Vorträge* 222; HEATH, *Med. Times* 1879; HUGUENIN, *Arch. d. Heilk.* XV. 1874; WÖLFLEER, *loc. cit.*; HAWARD, *Trans. Path. Soc.* XXXIII. 1882.

623. In all forms of goitre certain retrogressive changes are apt to take place, and these to a greater or less extent alter the appearance of the growth.

Hæmorrhages are common, either in the form of small ecchymoses or of large extravasations extending over the greater part of the tumor and giving it a dark-brown tint. They sometimes constitute a large portion of its bulk, and when they occur within thin-walled cysts may lead to their rupture. These extravasations also lead to wide-spread disintegration and necrosis of the tissue of the tumor, forming foci of brown or yellow softening which ultimately take the form of cysts. As we mentioned in Art. 621 small extravasations may be followed by proliferation of the glandular parenchyma and formations of hyaline or fibrous tissue. If the fibrous overgrowth be marked indurations and cicatrices result, and these sometimes become in course of time calcified.

When the goitrous tissue disintegrates in consequence of hæmor-

rhagic infiltration **fatty change** often sets in round about the affected area, and oil-globules mingle with the necrotic detritus and disintegrated blood-cells; when the fatty change is marked this may give the pulpy contents of the softened patch a creamy or yellowish-white color. The tissue enclosing the patch is usually more or less inflamed, and as the detritus is gradually absorbed a cyst-wall of indurated fibrous tissue is developed.

Hæmorrhage, necrosis, and fatty degeneration of this kind, together with the inflammatory changes that accompany these, are the commonest causes of the **fibroid degeneration** and induration so frequently met with in goitres. When these changes affect the central parts they give rise to large white radiating cicatrices. Where hæmorrhages have been frequent a more diffuse induration is set up, which is then apt to spread over the whole tumor and cause the degeneration and atrophy of the glandular elements. The new-formed fibrous tissue is usually white and lustrous, often resembling hyaline cartilage.

Calcareous deposits occur in the gland-tissue as well as in the new-formed fibrous tissue, and are first seen in the colloid masses contained in the acini and in the interacinous tissue. In advanced cases the entire contents of the acini are transformed into shining stratified calcareous grains. In the interacinous tissue the deposit is most marked where fibrous hyperplasia has occurred, and it is consequently by no means uncommon to find the indurated parts transformed into gritty masses and the cysts of disintegration enclosed by capsules that are completely calcified. FÖRSTER and LÜCKE describe cases in which the fibrous tissue has become ossified.

A very common occurrence in goitrous tumors is the excessive development of **colloid substance**, especially when the interacinous vessels are few and narrow. The colloid substance is secreted by the epithelium in the form of clear colorless droplets, and the detached epithelial cells are themselves transformed into similar hyaline masses. When the secretion is exceptionally abundant the tumor consists almost entirely of a translucent honey-like substance lying in masses separated only by thin fibrous septa. This form is described as **gelatinous goitre** (*struma gelatinosa*). WÖLFLE describes it as a parenchymatous atrophy of the gland, and regards it as an advanced stage of gelatinous adenoma: he supposes that the intra-acinous elements are transformed into colloid substance, while the interacinous tissue becomes atrophied.

So-called **multilocular cystoma** probably arises in the same way: the atrophy of the interacinous tissue and its vessels goes on almost to complete disappearance, and the follicles thus come together and coalesce.

When the secretion of colloid substance is very rapid some of the acini may burst, and their contents pass into the surrounding tissue. This tissue is thus disintegrated and destroyed, and a cyst is formed contain-

ing colloid material and frequently extravasated blood. In other cases cicatricial tissue is developed. Sometimes an over-distended acinus ruptures through the skin or into the larynx or trachea.

Amyloid degeneration takes place in thyroid glands otherwise normal, and also in goitres: it chiefly affects the blood-vessels. Local amyloid deposits are also met with in the form of lardaceous or waxy nodes (BECKMANN).

Acute **inflammation** of the normal or goitrous gland (thyroiditis, and acute strumitis) occurs as a result of traumatic injury, of septic or pyæmic infection, after typhoid, diphtheria (BRIEGER), and rheumatism; it may also arise idiopathically, and causes more or less painful swelling of the part. If suppuration takes place one or more pus-cavities or abscesses or even patches of gangrene result, and these may rupture into surrounding parts. Chronic inflammation and induration are usually due to internal necroses: other forms are very rare.

Tuberculosis of the thyroid gland is not very common, though in hæmatogenous miliary tuberculosis eruptions of tubercle are met with in it; larger tuberculous foci have also been described.

Gummata of the thyroid are very rarely met with.

References on **thyroiditis** and strumitis:—BECK, *Arch. f. physiol. Heilk.* 1851; BAUCHET, *Gaz. hebdom.* 1857; MARTINACHE, *De l'inflam. aiguë du corps thyroïd.* Paris 1861; CHANTREUIL, *Gaz. des hôpitaux* 1866; STAUPENMEYER, *Zeitschr. f. chir. Med. u. Geburtsh.* 1870; KOCHER, *D. Zeitschr. f. Chir.* x.; ROELLINGER, *De la thyroïd. aiguë* Paris 1877; BÖGEHOLD, *Deut. med. Woch.* 1880; PUICHAUD, *Paris médical* 1881; WEIGERT, *Virch. Arch.* vol. 83 (tuberculosis); CHIARI, *Stricker's med. Jahrb.* 1878 (tuberculosis); VIRCHOW, *op. cit.*; DEMME, *loc. cit.*; WÖLFLE, *op. cit.*; DUMOLARD, *Lyon médical* 44, 1878; BRIEGER, *Charité-Annalen* VIII. 1883 (diphtheria); CORNIL and RANVIER, *Man. Path. Hist.* I. London 1882 (tuberculosis); BARTH and GOMBAULT, *Progrès médical* 1884 (syphiloma).

623 a. The **ætiology of goitre** is at present imperfectly understood, but we know something at least of the conditions under which it usually appears. We have already seen (Art. 621) that increased flow of blood to the thyroid body, or obstruction of the flow from it, may occasion a very marked swelling of the gland. Such a swelling is not always transient, but sometimes leads to permanent enlargement from dilatation of the vessels and hyperplasia of the gland-tissue. Excessive use of the voice, blowing of wind-instruments, carrying heavy loads, frequent ascending of steep hills, frequent sexual excitement, menstruation, pregnancy, infective diseases, heart-disease, etc. may all act in this direction. A striking instance is the chronic enlargement of the gland from persistent congestion in the peculiar vaso-motor disorder known as Graves' or Basedow's disease (**exophthalmic goitre**); a disease characterized by increased rapidity of the heart's action, increased pulsation in the arteries of the neck and head, and protrusion of the eyeballs from the orbits. If a goitrous tumor can be thus produced it is natural to regard it as due to

the increased blood-supply of the organ, which leads to increased nutrition and therefore hypertrophy of the gland-tissue. Such goitres are always found to be highly vascular.

But hyperæmia alone is not enough to account for all goitres, and it fails entirely to explain the fact that goitre prevails much more in some regions than in others. In certain regions indeed a large proportion of the inhabitants are goitrous. Moreover it is observed that families hitherto free from goitre acquire the disease when they move into regions where it is common, and that goitrous patients lose the disease when they are removed to regions where it is unknown. These facts require us to assume that the conditions which favor goitre are to some extent local. This view is corroborated by the fact that even in regions where goitre is endemic there are occasionally regular epidemics of the disease, in which *e. g.* the inmates of garrisons or of institutions simultaneously suffer from rapidly growing thyroid tumors.

This endemic and epidemic mode of occurrence has been accounted for in the most various ways: the air, the soil, the water, the social conditions, all have at one time or another been accused. None of these theories however have met with general acceptance. The most probable explanation seems to be that the local exciting cause of goitre is of a miasmatic nature, independent of the altitude and of the temperature of the region, but developing only over certain kinds of rock or soil. BIRCHER, one of the latest writers on the subject, concludes from his minute researches on the distribution of goitre in Switzerland, where the disease is in many parts endemic, that it occurs only on marine deposits of palæozoïc, triassic, or tertiary age; while eruptive volcanic rocks, the older crystalline formations, jurassic and calcareous deposits, and fresh-water deposits generally, are exempt.

The exact nature of the miasma, and its mode of entrance into the body, are as yet unknown. KLEBS and BIRCHER suspect the existence of some specific micro-organism, though they have not succeeded in obtaining any experimental basis for the supposition. It will very probably be found that the exciting agent enters the body in drinking water. We are also unaware of the manner in which the exciting agent works, but it is not unlikely that it sets up hyperæmic conditions in the thyroid. As infants are sometimes born goitrous, we must assume that it may pass from mother to fœtus and influence the latter within the womb. Epidemics of goitre in goitrous regions indicate that at certain times the conditions favoring infection are exceptionally intense, and cause either an unusual development of the miasma or a temporarily increased predisposition on the part of the persons affected.

In places where goitre is endemic, deaf-mutes, idiots, and so-called cretins are exceptionally numerous. **Cretinism** is a disorder of development essentially affecting the growth of the bones, but accompanied also by morbid changes in the soft parts. These forms of imperfect

development have often been correlated with the occurrence of goitre; and it has been suggested that cretinism may be due to the miasma which induces goitre, the latter being as it were a milder form of the same disorder.

BIRCHER formally states his belief that endemic goitre, endemic deaf-mutism, cretinism, and cretinoid idiocy are all due to one and the same miasma. Further research is required before this view can be either accepted or rejected. It has in its favor the fact that cretins and cretinoid idiots are usually also goitrous, and that they are more numerous in regions where goitre is endemic.

HORSLEY (*Brown Lectures, Brit. Med. Journ.* 1, 1885) has shown experimental evidence for the view that cretinism, as also the peculiar cachexia which occasionally follows the extirpation of a goitre (*cachexia strumipriva*), and **myxœdema** are consequences of arrest of the function of the thyroid gland. By removing the gland he succeeded in producing in monkeys a cretinoid state, characterized by hebetude, malnutrition, muscular tremor, puffy œdema, leucocytosis, and the presence of mucin in the blood and connective tissues. Myxœdema in the human subject is a state having the same general characters, and it is associated with wasting of the thyroid gland or its destruction by a new growth.

References:—VIRCHOW, *Gesammelte Abhandl.* 1856; ST. LAGER, *Étude sur les causes du crétinisme et du goître endémique* Paris 1867; LÜCKE, *Pitha u. Billroth's Chirurgie* III.; BAILLARGER, *Enquête sur le goître et le crétinisme* Paris 1873; DEMME, *loc. cit.*; FREUND, *Die Bezieh. d. Schilddrüse zu d. weibl. Geschlechtsorganen* In. Diss. Strasburg 1882; KLEBS, *Stud. üb. d. Verbreitung d. Kropfes in Oesterreich* Prague 1878; RÖLL, *Spec. Path. und Therap. d. Haustiere* 1876; HIRSCH, *Handb. d. histor. geograph. Path.* II. 1883, trans. by CREIGHTON (New Syd. Soc.) II. London 1885 (with ample references to the literature of the subject); BIRCHER, *Der endemische Kropf* Basle 1883; KRATTER, *Der alpine Cretinismus* Graz 1884; HILTON FAGGE, *Prin. and pract. of med.* I. London 1886.

On the *cachexia strumipriva*, surgical and experimental, see KOCHER, *Arch. f. klin. Chir.* XXIX. 1883; REVERDIN and SCHIFF, *Rev. méd. de la Suisse romande* 1883-84; WAGNER, *Wiener med. Blätter* 1884; SANQUIRICO and CANALIS, *Arch. p. l. sci. med.* VIII. 1884; BRUNS, *Sammlung klin. Vorträge* 244; JULLIARD, *Revue de chirurgie* 1883; BAUMGÄRTNER, *Arch. f. klin. Chir.* XXXI. 1884; GRUNDLER, *Zur Cachexia strumipriva* Tübingen 1884; ZESAS, *Deut. Medicinalzeitung* 1885; ALBERTONI and TIZZONI, *Cent. f. med. Wiss.* 24, 1885; FUHR, *Arch. f. exp. Path.* XXI. 1886 (with a discussion of the literature).

For cases of myxœdema see GULL, *Trans. Clin. Soc.* VII. 1879; ORD, *Med. chir. Trans.* XLIII. 1878, *Trans. Clin. Soc.* VIII. 1880; DYCE DUCKWORTH, *ibid.*; CAVAFY, *ibid.* XV. 1882; HARLEY, *Med. chir. Trans.* LXVII. 1884; Discussion, *Brit. Med. Journ.* 2, 1883; WHITE, *Lancet* 1, 1885.

CHAPTER XC.

THE THYMUS GLAND.

623 *b*. The **thymus** is a gland-like body, which grows to a considerable size in the foetus and during the first two years of infancy: after that however it ceases to grow, and about the tenth year undergoes retrograde change into fibrous and adipose tissue.

It lies in the superior mediastinum behind the first piece of the sternum, extends upwards nearly to the thyroid, and is made up chiefly of two flat elongated lobes which are in contact or coherent along their medial borders and are enclosed in a thin connective tissue. The lobes are subdivided into lobules by fibrous septa. The structural units or acini closely resemble lymphatic glands, and are composed of a loose reticular or adenoid stroma, filled with indifferent or lymphoid elements and larger multinuclear cells. In the peripheral parts of the acinus the stroma is somewhat closer and more densely filled with cells than in the centre, and thus a cortical and a medullary layer are distinguished. The thymus possesses no duct, but it has numerous lymphatics whose exact course is however only imperfectly understood.

Small **accessory glands** are not uncommon; they usually lie above the gland and near the thyroid. Congenital absence of the gland occurs only in highly malformed foetuses.

The weight of the thymus in a new-born infant is about 14 grammes; in a child of two it is about 26 grammes: this is subject however to considerable variation.

According to STIEDA, KÖLLIKER, HIS, and WATNEY, the thymus develops from the epithelium of a branchial cleft, and is thus originally an epiblastic or epithelial structure. The epithelial cells however disappear after a time, and the development of the characteristic lymph-adenoid tissue starts from mesoblastic (connective-tissue) elements.

The **function** and exact significance of the thymus is not certainly known. WATNEY, who has made it the subject of extensive investigation, thinks that it takes part in the formation of red and white blood-cells. The former are supposed to be developed in certain nucleated cells containing hæmoglobin.

Before birth, and in larger numbers during infancy, the thymus contains homogeneous or indistinctly-laminated partially-calcified bodies known as Hassall's concentric corpuscles. They lie chiefly in the centre

of the acini, and are composed of cells closely applied to each other like the coats of an onion. STIEDA regards these as the remains of the rudimentary epithelial structures; AMMANN thinks they develop from the stroma-cells or the perithelium of the blood-vessels, or from lymphoid elements whose nucleus and protoplasm have undergone colloid degeneration. The laminated bodies, calcified and uncalcified, break down and disappear during the retrogression of the gland, which is manifested chiefly by the dwindling and disappearance of its cells.

Of **morbid changes** in the thymus the commonest is imperfect retrogression, by which it sometimes persists till the thirtieth or fortieth year.

Hæmorrhage into the gland is met with chiefly in asphyxia, or in connection with the hæmorrhagic diathesis (BOUCHER *Bull. de la soc. anat.* II. 1857; ACLAND, *Lancet* 2, 1884 and *Trans. Path. Soc.* XXXVI. 1885).

Hæmatogenous purulent inflammation is usually due to pyæmia and may lead to multiple abscesses or to general suppuration. Suppuration affecting the structures of the neck is apt to extend to the thymus. Nothing is known of chronic indurative change in the gland.

Tuberculosis appears in the form of disseminated nodules, and of large caseous foci.

Gummatous inflammatory change due to syphilis has been several times described.

Primary tumors having the structure of soft or hard lymphosarcoma or of simple sarcoma occur in connection with general leukæmia and also independently. They appear as soft and marrowy or sometimes moderately firm growths, and at times reach a considerable size. They may compress the air-passages or blood-vessels, or displace the heart or lungs.

References:—KÖLLIKER, *Gewebelehre* Leipzig 1867, and *Entwickelungsgeschichte* Leipzig 1879; AFFANASIEW, *Arch. f. mikrosk. Anat.* XIV. (1877); FRIEDLEBEN, *Die Physiol. d. Thymusdrüse* Frankfort 1858; HIS, *Zeitsch. f. wiss. Zoologie* x., XI., and *Menschliche Embryonen* I. Leipzig 1880; STIEDA, *Unters. üb. d. gland. thymus, gland. thyr. und gland. carotica* Leipzig 1881; VIRCHOW, *Virch. Arch.* vol. 3; GEGENBAUR, *Anatomie* Leipzig 1883; WATNEY, *Phil. Trans.* III. 1882; AMMANN, *Beitr. z. Anat. d. Thymus* In. Diss. Basle 1882; DUBOIS, *Gaz. méd. de Paris* 1850 (inflammations); DEPAUL, *Mém. d. l'acad. de méd.* XVII. (inflammations); EBERTH, *Virch. Arch.* vol. 40 (gumma); LANCEREAUX, *Traité d'anat. path.* II. Paris 1881; VIRCHOW, *Krankhafte Geschwülste* II.; WITTICH, *Virch. Arch.* vol. 8 (lymphoma); STEUDENER, *ibid.* vol. 59 (sarcoma); HAHN and THOMAS, *Arch. générales* 1879; HEDENIUS, *Nord. med. Arkiv* 24, 1878.

SECTION XI.

THE CENTRAL NERVOUS SYSTEM.

CHAPTER XCI.

STRUCTURE AND FUNCTIONS.

624. The **central nervous system** consists of the spinal cord, the cerebral axis, and the cerebrum. These parts are made up of nerve-cells and nerve-fibres, together with a framework of connective tissue which carries the nutrient vessels. The nerve-cells or ganglion-cells are for the most part aggregated in masses which are known as nerve-centres or gray nuclei. The nerve-fibres form either plexuses or tracts, and serve to connect the ganglion-cells of one group with those of another or with the peripheral terminations (end-organs) of certain nerves.

The cord and the cerebral axis contain centres of subordinate importance, forming as it were intermediate stations between the central and peripheral extremities of the nerve-tracts. The cerebrum is the central terminus with which the peripheral sensory and motor end-organs are connected either directly or through the intermediate stations.

The **cerebrum** consists of two hemispheres connected by a commissure, the *corpus callosum*. The outer surface of the hemispheres is thrown into a series of complicated convolutions consisting of ridges and furrows (*gyri* and *sulci*), the latter ramifying and intercommunicating in a remarkable way.

Some of the sulci are characteristic of the human brain, and are always present; others vary in different brains, and thus the configuration of the convolutions is by no means absolutely constant. The most important sulci are—the **sylvian** fissure (Fig. 243 *e*), the **central** or rolandian fissure (*a*), the **præcentral** or transverse-frontal furrow (*b*), the **intraparietal** furrow (*d*), the **first-temporal** or parallel furrow (*f*), the **parieto-occipital** furrow (*c*), the **anterior-occipital** furrow (*i*), and the **inferior-occipital** furrow (*h*).

The central fissure divides the cerebral hemisphere into an anterior and a posterior portion; the (central) convolutions which form its anterior and posterior borders are known as the anterior-central or **ascending-frontal** (*A*), and the posterior-central or **ascending-parietal** (*B*). The portion of the hemisphere in front of the central fissure is the **frontal lobe**, and includes the ascending-frontal (*A*), the superior frontal (*C*₁), middle-frontal (*C*₂), and inferior-frontal (*C*₃) convolutions. The last three convolutions all pass round to the orbital surface of the hemisphere.

Immediately behind the ascending-parietal convolution (*B*), and divided from it by the intraparietal furrow (*d*), lies the superior-parietal lobule (*D*); the inferior-parietal lobule being made up of the marginal (or supramarginal) convolution (*E*) and the angular convolution (*F*). These (*BDEF*) constitute the **parietal lobe**.

The parieto-occipital furrow (*c*) and the anterior-occipital furrow (*i*) separate the parietal from the **occipital lobe** (*G*), and in the space between the two furrows the so-called annectant (or connecting) convolutions pass over from the parietal lobe to the occipital lobe.

The sylvian fissure (*e*) forms the boundary between the outer and lower portions of the frontal and parietal regions and the **temporal lobe**. The convolution bordering the lower side of the fissure is the first-temporal or superior temporo-sphenoidal (*H₁*). The convolution

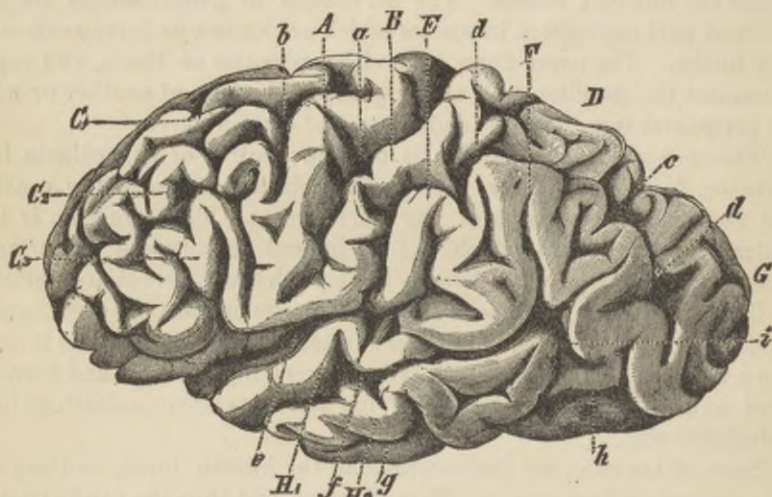


FIG. 243. OUTER SURFACE OF THE LEFT CEREBRAL HEMISPHERE.

(From a brain hardened in nitric acid and dried.)

- | | |
|--------------------------------------|---|
| a, central or rolandian fissure | A, ascending-frontal convolution |
| b, præcentral furrow | B, ascending-parietal convolution |
| c, parieto-occipital furrow | C ₁ , superior-, C ₂ middle-, C ₃ inferior-frontal convolution |
| d, intraparietal furrow | D, superior-parietal lobule |
| e, sylvian fissure | E, marginal convolution ^a } inferior-parietal lob- |
| f, first-temporal or parallel furrow | F, angular convolution } ule |
| g, second-temporal furrow | G, occipital lobe |
| h, inferior-occipital furrow | H ₁ , first-temporal, H ₂ second-temporal, convolution. |
| i, anterior-occipital furrow | |

which curves round the upper end of the sylvian fissure is assigned to the parietal lobe and is called the marginal convolution (*E*). Beneath the first-temporal convolution lies the first-temporal or parallel furrow (*f*), and beneath that the second-temporal convolution (*H₂*). Springing from the upper part of the latter convolution the angular gyrus or

convolution (*F*) curves round the end of the first-temporal furrow (*f*): it also is assigned to the parietal lobe. Beneath the second-temporal furrow (*g*) lies the third-temporal convolution (Fig. 244 *t*³).

If next the lips of the sylvian fissure be separated the **central lobe** or island of Reil becomes visible.

The **median surface** of the superior-frontal convolution (*mF*¹) has no special name: the median surface of the ascending (frontal and parietal) convolutions that border the central fissure is called the paracentral lobule (*Parc*). Both are bounded inferiorly by the callosomarginal fissure (*cm*), which anteriorly separates the superior-frontal convolution from the convolution of the corpus callosum (*gyrus fornicatus*

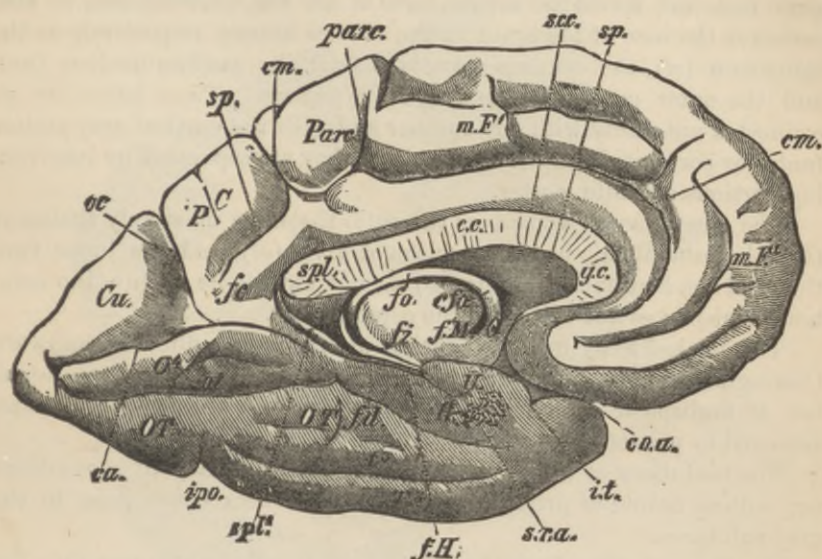


FIG. 244. MEDIAN SURFACE OF THE LEFT CEREBRAL HEMISPHERE (after SCHWALBE).

<i>cm</i> , callosomarginal fissure	<i>coa</i> , corpus albicans
<i>sc</i> , sulcus of the corpus callosum	<i>mF</i> ¹ , superior-frontal convolution
<i>oc</i> , parieto-occipital furrow	<i>H</i> , hippocampal gyrus
<i>sp</i> , subparietal furrow	<i>Parc</i> , paracentral lobule
<i>s.p.</i> , septum lucidum	<i>PC</i> , quadrate lobule (præcuneus)
<i>ca</i> , calcarine fissure	<i>Cu</i> , cuneus
<i>ipo</i> , <i>incisura præoccipitalis</i>	<i>O</i> , uncinatè gyrus (lingualis)
<i>ot</i> , occipito-temporal (or collateral) furrow	<i>OT</i> , occipito-temporal convolution
<i>t</i> , third-temporal furrow	<i>T</i> ³ , third-temporal convolution
<i>fH</i> , hippocampal (or dentate) fissure	<i>U</i> , uncus of uncinatè gyrus
<i>it</i> , <i>incisura temporalis</i>	<i>fd</i> , fascia dentata
<i>cc</i> , corpus callosum	<i>fl</i> , fimbria
<i>gc</i> , genu	<i>fM</i> , foramen of Monro
<i>spl</i> , splenium	<i>sra</i> , substantia reticularis alba
<i>fo</i> , fornix	<i>fc</i> , gyrus fornicatus or convolution of the corpus callosum
<i>cfo</i> , anterior pillar (columna) of the fornix	

or *cinguli fc*), and posteriorly separates the paracentral lobule from the quadrate lobule (or *præcuneus PC*), the median portion of the superior-

parietal lobule. The median portion of the occipital lobe is called the *cuneus* or cuneate lobule (*Cu*), and is parted from the quadrate lobule by the parieto-occipital furrow (*oc*).

The calcarine fissure (*ca*) separates the cuneus from the uncinatè gyrus (*gyrus lingualis O'*); the latter passes forward and becomes the hippocampal gyrus (*H*).

Beneath the uncinatè gyrus lies the occipito-temporal or collateral furrow (*ot*), and beneath this the occipito-temporal convolution (*gyrus fusiformis OT*).

625. The mass of the cerebrum consists of cortical or gray matter (Fig. 245 *co*) and medullary or white matter. The former is of a soft-gray tint and forms the surface layer of all the convolutions; it also occurs at the base of the brain in the masses known respectively as the claustrum (*cl*), the nucleus amygdalæ (*na*), the caudate nucleus (*nc*), and the outer portion of the lenticular nucleus. These latter are all connected anteriorly with one another and with the cortical gray matter (anterior perforated space). Posteriorly they are separated by intervening portions of white matter.

The gray masses known as the optic thalamus or simply thalamus (*th*), the subthalamie body or nucleus of Luys (*cs*), and the inner two-thirds of the lenticular nucleus (*nl*) do not strictly lie within the cerebral hemispheres but belong to the cerebral axis.

The cortical **gray matter** consists of a delicate fibrous meshwork (neuroglia) which in the dead brain is finely granular, enclosing a number of multipolar ganglion-cells, and nerve-fibres of various thickness arranged in plexuses and tracts.

The medullary or **white matter** is composed chiefly of medullated nerve-fibres devoid of primitive sheaths, all of them originating in the gray substance.

The fibres starting from the cortex form bundles which pass into the white *centrum ovale* of the hemisphere. Those from the central region form the *corona radiata*, and for the most part pass down to the base of the brain; the others connect the various convolutions with one another and are spoken of as associating or interconnecting fibres.

Some of these bundles or tracts have received special names: adjacent convolutions are connected by the *fibræ propriæ* (GRATIOLET); the orbital convolutions of the frontal lobe are connected with the anterior parts of the temporal lobe by the fibres of the uncinatè fasciculus, which passes across the bottom of the sylvian fissure; the corpus callosum connects corresponding cortical regions in the two hemispheres; the anterior (or white) commissure connects the two olfactory lobes and the two temporal lobes; the arcuate fasciculus consists of fibres passing over the corpus callosum from the frontal lobe to the occipital lobe; and so on.

The **cortex** is the terminal station for all nerves. Every part of the sensorial surface of the body and the whole muscular system are con-

ned by nerve-tracts (the 'projective system') with the cortex. By means of these tracts impressions corresponding to every sensory stimulus and to every muscular movement are conveyed to the cortex; and these impressions probably leave traces of 'memories' in the ultimate structure of the gray matter (MEYNERT). These traces or memories form the physical substratum of our psychical existence, of our consciousness. The traces are not diffused indiscriminately over the surface of the brain, but tend to become associated with certain parts; and thus the various sensory surfaces and the various groups of muscles come into definite relation with certain definite regions of the cortex. These

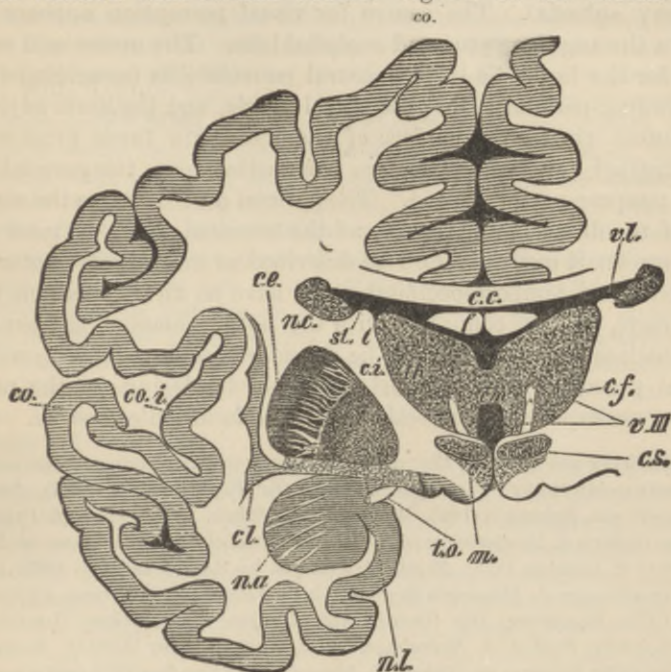


FIG. 245. DIAGRAMMATIC TRANSVERSE VERTICAL SECTION OF THE CEREBRUM (after SCHWALBE).

co, cortex

coi, island of Reil

cl, claustrum

na, nucleus amygdalæ

nc, caudate nucleus

th, optic thalamus

cm, middle commissure

cs, subthalamic body

m, substantia nigra

nl, lenticular nucleus

ci, internal capsule

ce, external capsule

st, stria terminalis (tænia semicircularis)

cf, anterior pillar of the fornix

f, fornix

cc, corpus callosum

vIII, third ventricle

vl, lateral ventricle

to, optic tract

cortical centres or areas are however not sharply circumscribed, but encroach upon one another at many points.

The researches of BOULLAUD, BROCA, MEYNERT, KUSSMAUL, HUGHLINGS-JACKSON, HITZIG, FRITSCH, FLECHSIG, WERNICKE, MUNK, FERRIER, CHARCOT, HUGUENIN, PITRES, LÉPINE, MARCACCI, BÄUM-

LER, EXNER, TRIPIER, PETRINA, KAHLER, PICK, and others have determined the position of these areas or centres for various functions and movements, and this not only in man but in a number of other animals. Thus it is almost certain that the centre for the co-ordination of the movements of speech is placed chiefly in the inferior-frontal convolution on the left side, and the centre for auditory perception in the first-temporal convolution. Destruction of the former centre involves the loss of power to perform the movements necessary for articulate speech (aphemia or motor aphasia); and on destruction of the latter centre the patient is unable to understand spoken words (word-deafness or sensory aphasia). The centre for visual perception appears to lie chiefly in the angular gyrus and occipital lobe. The motor and sensory centres for the limbs lie in the central convolutions (ascending-frontal and ascending-parietal), the paracentral lobule, and the parts adjoining.

FLECHSIG divides the surface of the brain into three great regions having distinct functions—they are the frontal zone, the parietal zone, and the temporo-occipital zone. The parietal zone contains the starting-points of the direct motor tracts and the terminal-points of most of the sensory tracts: it may therefore be described as the sensory-motor zone. The frontal and temporo-occipital zones have no direct relations to the motor tracts, but are connected with the optic thalamus, the pons, and the cerebellum. Both zones are, he considers, in close relation with the psychical processes, and the parts of them bordering on the parietal zone have an important connection with the function of speech.

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HITZIG, *Unters. üb. das Gehirn* Berlin 1874; VEYSSIERE *L'hémianesthésie de cause cérébrale* Paris 1874; CARVILLE and DURET, *Arch. de physiol.* II. (1875); NOTHNAGEL, *Virch. Arch.* vols. 57, 58, 60, 62; SCHIFF, *Lezione sopra il syst. nerv. encephal.* Florence 1874, *Arch. f. exper. Pathol.* III. (1875); FERRIER, *West Riding Asylum Reports* 1873, *Phil. Trans.* CLXV. (1875), *Functions of the brain* London 1886; GOLTZ, *Pflüger's Arch.* vols. 13, 14 and 20, *Trans. internat. med. congress* I. London 1881, *Ueber die Verrichtungen d. Grosshirnes* Bonn 1881; BURDON-SANDERSON, *Proc. Roy. Soc.* XXII. (1875); HERMANN, *Pflüger's Arch.* vol. 10; MUNK, *Ueber d. Functionen d. Grosshirnrinde* Berlin 1881, *Sitzungsber. d. Berlin Acad.* XXXVI. (1882); VETTER, *D. Arch. f. klin. Med.* xv., xxii., xxxi.; MEYNERT, *Wiener Sitzungsber.* 1869, *Arch. f. Psych.* II. (1870), *Mechanik d. Gehirnbaues* Vienna 1874; LÉPINE, *Localisat. dans les malad. cérébrales* Paris 1875; HUGHLINGS-JACKSON, *Researches on the nervous system* London 1875, *Croonian lectures on The evolution and dissolution of the nervous system* London 1884; CHARCOT and PITRES, *Revue mens. de méd.* 1877-79, *Revue de méd.* 5, 1883; NOTHNAGEL, *Topische Diagnostik d. Gehirnkrankh.* Berlin 1879; KAHLER and PICK, *Prager Vierteljahrs.* 141, *Prager Zeitschrift f. Heilk.* I.; FÜRSTNER, *Arch. f. Psych.* VIII.; PITRES, *Rech. sur les lésions du centre ovale des hémisphères cérébr.* Paris 1878; BROCA, *Bull. de la soc. anatom.* 1861 and 1863, *Revue d'anthropologie* v. (1876); KUSSMAUL, *Die Störungen d. Sprache* Leipzig 1877; BERGER, *Arch. d. Heilk.* 1878; OBERSTEINER, *Wien. med. Jahrb.* 1878; WERNICKE, *Der aphasische Symptomencomplex* Breslau 1874; BASTIAN, *Brain as an organ of mind* (Int. scientific series) London 1885; MARCACCI, *Arch. ital. de biol.* I., II.; GOLGI, *ibid.* II.; CHARCOT, *Leçons sur les localisations dans les maladies du cerveau* Paris 1878, trans. by HADDEN (New Syd. Soc.) London 1883; EXNER, *Unters. üb. die Function d. Grosshirnrinde* Vienna 1880; SKWORTZOFF, *De la cécité et de la surdité des mots dans l'aphasie* Paris 1881; TRIPIER, *Revue mens.* 1880; PETRINA, *Zeitschr. f. Heilk.* II.; ROSS, *op. cit.*; GOWERS, *Diseases of the brain* London 1885; LANDOIS and STIRLING, *Human Physiology* II. London 1886.

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626. The **spinal cord** is an elongated cylindrical body, somewhat flattened antero-posteriorly, and composed of gray matter and white matter. The **gray matter** is in the interior, extending throughout the length of the cord, the cross-section being roughly H-shaped (Fig. 246) and forming two **anterior horns** (or *cornua, ca*) and two **posterior horns** (*c p*), united by a gray commissure. The commissure contains the **central canal** (*cc*), a slender tube lined with epithelium. The

anterior horns are of larger sectional area than the posterior, but their size and configuration vary remarkably in different parts of the cord: they are smallest in the dorsal region.

In numerous places, especially about the region midway between the anterior and posterior horns, radiating processes of gray matter pass into the white (near *cl*), and are known as *processus reticulares*. They interlace and form a network enclosing portions of white substance in its meshes. In the cervical and upper dorsal regions a lateral projection of the anterior horn appears, and is called the **intermedio-lateral tract** or lateral horn (*cl*).

The gray substance contains a multitude of ganglion-cells and nerve-fibres of various thicknesses, enclosed in a delicate neuroglia. Round the central canal and at the extremity of the posterior horn the neuroglia

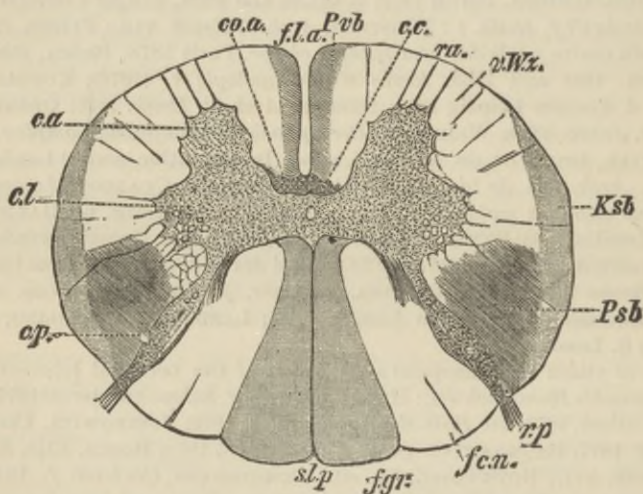


FIG. 246. DIAGRAMMATIC SECTION OF THE SPINAL CORD ($\times 6$).

<i>ca</i> , anterior horn	<i>rp</i> , posterior root
<i>cl</i> , lateral horn (so-called)	<i>fl.a</i> , anterior longitudinal fissure
<i>cp</i> , posterior horn	<i>fl.p</i> , posterior longitudinal fissure
<i>cc</i> , central canal	<i>fgr</i> , funiculus gracilis (column of Goll)
<i>coa</i> , anterior or white commissure	<i>Psb</i> , lateral (or crossed) pyramidal tract
<i>fen</i> , funiculus cuneatus (posterior root-zone or column of Burdach)	<i>Pvb</i> , anterior (or direct) pyramidal tract (column of Türck)
<i>Ksb</i> , direct cerebellar tract	<i>vWz</i> , anterior root-zone
<i>ra</i> , anterior root	

is rich in cells, and ganglion-cells are absent: these parts are spoken of as the *substantia gelatinosa*, the parts containing ganglion-cells as the *substantia spongiosa*.

In the anterior horn the ganglion-cells (motor cells) are large and multipolar; they possess numerous processes, one long and unbranched is the axis-cylinder process, the others subdividing and interlacing into a delicate network of fibrils. The anterior ganglion-cells are gathered into clusters, corresponding apparently to the territories of the blood-

vessels. In the posterior horns they are much smaller and more uniformly distributed. Two longitudinal columns of bipolar ganglion-cells exist in the dorsal region of the cord, lying to the median side of the inner portion of the posterior horns and known as Clarke's vesicular columns; these contain ganglion-cells intermediate in size between those of the anterior and those of the posterior horns.

The **white matter** of the cord forms a sheath surrounding the gray columns and filling up their irregularities. It is cleft behind by the slender posterior sulcus or fissure (*slp*) which extends to the gray matter, and anteriorly by the wider anterior fissure (*fla*) which does not quite reach the gray matter but leaves a narrow white or anterior commissure (*coa*) to unite the lateral halves of the cord. The white matter consists of large and small medullated nerve-fibres (without the primitive sheath of Schwann) running for the most part longitudinally; only a few run horizontally or obliquely. These fibres are divided into bundles by fibrous and neuroglial dissepiments extending inwards from the surface. Externally the cord is covered with a thin layer of grayish neuroglia. Very few ganglion-cells are met with in the white matter.

The **roots** of the spinal nerves are bundles of fibres leaving the cord anteriorly and posteriorly in more or less parallel directions. The anterior root (*ra*) contains motor fibres and starts proximately from the anterior horn: the posterior root (*rp*) conveys centripetal or sensory fibres to the posterior horn. A certain number of anterior-root fibres and posterior-root fibres unite into a nerve, and to each pair of nerves corresponds a more numerous aggregation of ganglion-cells; consequently the cord is subdivided into a number of natural segments whose number corresponds to that of the spinal nerves.

The portion of white matter between the anterior fissure and the anterior root is called the **anterior column**; that between the anterior and posterior root on the same side is the **lateral column**; that between the posterior root and the posterior fissure is the **posterior column**.

The fibres passing into the roots are connected with the ganglion-cells of the anterior horn by means of the axis-cylinder process, with those of the posterior horn by the network of fibrils; in the latter the ganglion-cell processes and the nerve-fibres interlace. From the gray matter other nerve-fibres pass into the neighboring white columns, which either serve to connect parts of the gray matter on different levels or pass directly upwards to the base of the brain or the cerebrum.

The longitudinal columns are subdivided into various tracts according to their physiological function. The best-known are the anterior (or direct) and lateral (or crossed) pyramidal tracts (*Pvb*, *Psb*), the lateral or direct cerebellar tract (*Ksb*), the column of Goll or *funiculus gracilis* (*fgr*), and the posterior root-zone or *funiculus cuneatus* (*fcn*).

The **anterior pyramidal tract** (column of Türek) and the **lateral pyramidal tract** contain centrifugal or efferent fibres, and form the

direct path of communication between the gray matter of the parietal zone of the cerebral cortex and that of the anterior horns. They traverse the internal capsule (Fig. 245 *ci*) and the peduncular tract, the lateral tract passing to the opposite side at the decussation of the pyramids, and the anterior tract passing directly down on the same side and crossing at some point in the cord by means of the anterior commissure to join the anterior horn of the opposite side.

The anterior tract (*Pvb*) lies medially in the anterior column, the

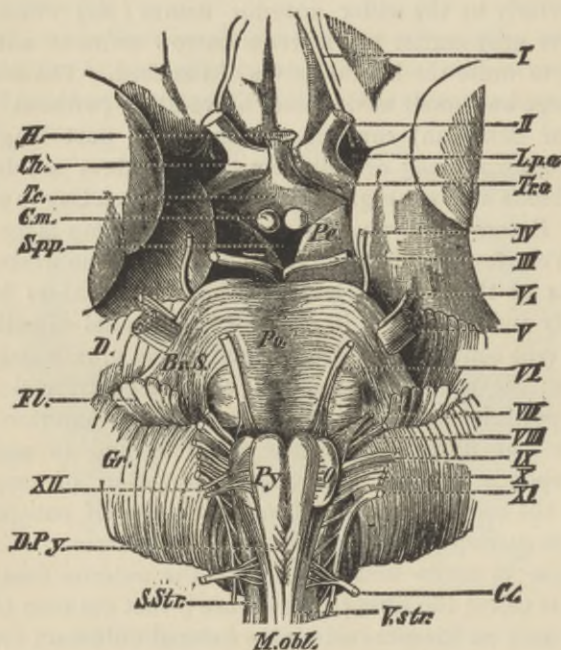


FIG. 247. BASAL ASPECT OF THE CEREBRAL AXIS.

<i>Mobl</i> , medulla oblongata	<i>H</i> , stem of the hypophysis or pituitary body
<i>Sstr</i> , lateral column	<i>TrO</i> , optic tract
<i>Vstr</i> , anterior column	<i>Ch</i> , optic chiasma
<i>Py</i> , pyramid	<i>I</i> , olfactory nerve
<i>DPy</i> , decussation of the pyramids	<i>II</i> , optic nerve
<i>O</i> , olivary body	<i>III</i> , oculomotor nerve
<i>Po</i> , pons	<i>IV</i> , trochlear nerve
<i>D</i> , anterior lobe of the cerebellum	<i>V</i> , trigeminal nerve
<i>Gr</i> , digastric lobe of the cerebellum	<i>VI</i> , abducens nerve
<i>Fl</i> , flocculus of the cerebellum	<i>VII</i> , facial nerve
<i>Br.S</i> , middle peduncle of the cerebellum	<i>VIII</i> , auditory nerve
<i>Pe</i> , crus cerebri (cerebral peduncle)	<i>IX</i> , glossopharyngeal nerve
<i>Spp</i> , posterior perforated space	<i>X</i> , vagus nerve
<i>Lpa</i> , anterior perforated space	<i>XI</i> , spinal accessory nerve
<i>Cm</i> , corpora albicantia (mammillaria)	<i>XII</i> , hypoglossal nerve
<i>Tc</i> , tuber cinereum with infundibulum	<i>C₁</i> , anterior root of first cervical nerve

lateral tract (*Psö*) in the posterior part of the lateral column. The cross-section of each diminishes as we pass downwards from the medulla.

The relative size of the crossed and uncrossed portions is very variable and in some cases unequal on the two sides, the section of the cord being then unsymmetrical. Usually the anterior tract disappears about the middle of the dorsal region. In some cases however it extends down to the lumbar region, and in others is entirely absent, that is to say the decussation at the pyramids is complete.

The **direct cerebellar tract** (*Ksb*) connects the gray matter of Clarke's column with the cerebellum. It runs along the outer margin of the posterior portion of the lateral column, and extends as far as the end of the dorsal region.

The remaining region of the anterior column is termed by FLECHSIG the **principal tract** of the anterior column, and that of the lateral column the **mixed lateral tract**. The fibres in these regions serve ap-

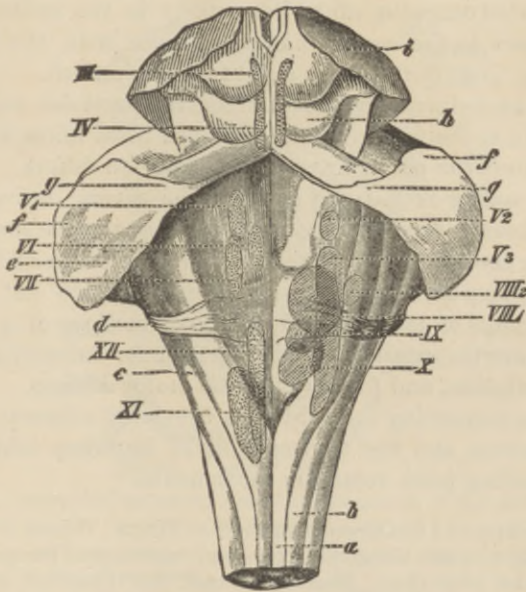


FIG. 248. DIAGRAM OF THE NUCLEI OF THE CRANIAL NERVES.

- | | |
|---|--|
| a, funiculus gracilis | III, nucleus of the oculomotor |
| b, funiculus cuneatus | IV, nucleus of the trochlear |
| c, restiform body | V ₁ , nucleus of the motor, V ₂ V ₃ nuclei of the sensory, root of the trigeminus |
| d, stria acustica | VI, nucleus of the abducens |
| e, posterior peduncle of the cerebellum | VII, nucleus of the facial |
| f, middle peduncle of the cerebellum | VIII ₁ VIII ₂ , nuclei of the auditory |
| g, anterior peduncle of the cerebellum | IX, nucleus of the glossopharyngeal |
| h, corpora quadrigemina | X, nucleus of the vagus |
| i, crus cerebri | XI, nucleus of the spinal accessory |
| | XII, nucleus of the hypoglossal |

parently to connect different portions of the gray matter of the cord with one another and with the brain, and include root-fibres which

course longitudinally for a short distance along the cord before entering the gray horns.

The median portion of each **posterior column** is called the **column of Goll** or *funiculus gracilis* (*fgr*); the lateral portion (*fcn*) is the **column of Burdach** or cuneate funiculus. The column of Goll connects the posterior roots of the cord with the tegmental region of the medulla, *i. e.* with the nucleus of the funiculus gracilis (Fig. 249 *ng*), probably also with the internal accessory olivary nucleus (*oam*), and thence by way of the internal capsule and the corona radiata with the parietal zone of the cortex and the lenticular nucleus. The column of Burdach (Fig. 243 *fcn*) contains fibres which enter with the posterior roots and then pass upwards for a certain distance, ultimately entering the posterior horn. It also contains fibres interconnecting various portions of gray matter in the cord, and connecting these with the nucleus of the funiculus cuneatus and olivary body in the medulla, with the dentate nucleus in the cerebellum, and thence with the parietal zone of the cortex and the corpus striatum (FLECHSIG). According to KAHLER the ascending nerve-fibres from the posterior roots are so arranged that in any given section of the cord those fibres which entered lowest lie nearest the posterior end of the median fissure.

The gray matter of the cord contains the several nerve centres subordinate to those in the medulla; these centres subserve simple or partial and diffuse or co-ordinated reflexes, and on stimulation of the sensory or afferent fibres may give rise to motor impulses which act on associated or distinct groups of muscles and result in motions of a complicated kind. Such are the centres for defæcation, for micturition, for erection and ejaculation, and for various vaso-motor actions.

The fibres connecting the cord with the brain subserve the perception of sensations, and the transmission of impulses inhibiting reflex actions and calling forth voluntary movements.

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BYROM BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; KAHLER, *Naturforscherversammlung in Eisenach* 1882; LAURA, *Arch. ital. de biol.* I. (1882); Quain's *Elements of anatomy* II. London 1883; BECHTEREW, *Neurol. Centralb.* 1885; HOMÉN; *Fortschritte d. Med.* III. 1885; LANGLEY, *Brain* VIII. 1886 (a critical digest of memoirs on the tracts of the cord, with references); FERRIER, *Functions of the brain* London 1886.

627. The cerebral axis consists of the medulla oblongata (Fig. 247 *Mobl*), the pons Varolii (*Po*), the crura cerebri (*Pe*), the subthalamie (or interpeduncular) region (Fig. 245 about *cs*) with the tuber cinereum (Fig. 247 *Tc*), corpora albicantia (or mammillaria *Cm*), the cerebellum (*D, Gr, Fl*), the corpora quadrigemina (Fig. 248 *h*), and the optic thalamus (Fig. 245 *th*).

Genetically all these are but modified parts of the spinal cord

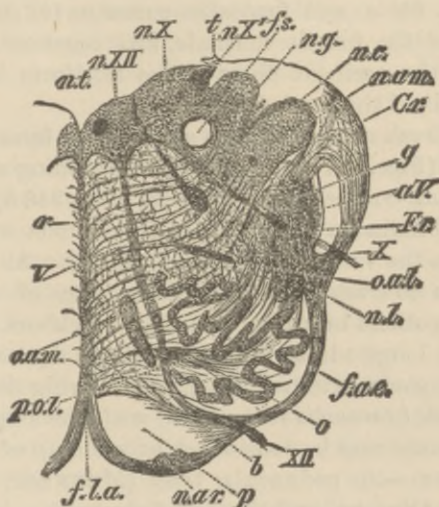


FIG. 249. SECTION OF THE MEDULLA THROUGH THE MIDDLE OF THE OLIVARY BODY.

(After SCHWALBE: $\times 4$.)

<i>nt</i> ,	nucleus of the funiculus teres	<i>t</i> ,	origin of the ligula (tænia sinus rhomboidalis)
<i>nXII</i> ,	nucleus of the hypoglossal nerve	<i>Cr</i> ,	restiform body
<i>nX nX₁</i> ,	nucleus of the vagus nerve	<i>p</i> ,	pyramid
<i>XII</i> ,	hypoglossal nerve	<i>fae</i> ,	external arciform fibres passing in part through the substantia gelatinosa (<i>g</i>), in part external to the restiform body (<i>Cr</i>)
<i>X</i> ,	vagus nerve	<i>Fr</i> ,	formatio reticularis, showing internal arciform fibres; the latter partly continuous with the external arciform fibres, partly arising from the various gray nuclei and passing towards the raphe (<i>r</i>)
<i>o</i> ,	olivary nucleus (<i>corpus dentatum</i>)	<i>pol</i> ,	olivary arciform fibres (<i>pedunculus olivæ</i>)
<i>oal</i> ,	exterior accessory olivary nucleus	<i>V</i> ,	continuation of anterior column of cord
<i>oam</i> ,	interior accessory olivary nucleus	<i>fla</i> ,	anterior median fissure
<i>nam</i> ,	nucleus ambiguus		
<i>nl</i> ,	nucleus of lateral column		
<i>ng</i> ,	nucleus of funiculus gracilis		
<i>nc</i> ,	nucleus of funiculus cuneatus		
<i>nar</i> ,	nucleus arciformis		
<i>g</i> ,	substantia gelatinosa		
<i>aV</i> ,	ascending root of trigeminus		
<i>fs</i> ,	funiculus solitarius		

(SCHWALBE), and from this region arise those cranial nerves which are homologous with the spinal nerves.

The modifications which the cord undergoes in this region are chiefly these—the central canal becomes more and more posterior and is continued into the cerebral axis as the fourth ventricle, the aqueduct of Sylvius, and the third ventricle. At the same time the gray matter subdivides, and interpenetrating the white assumes a peculiar reticulated structure (Fig. 249 *Fr*) with numerous detached clusters of ganglion-cells from which the cranial nerves take their origin (Fig. 248).

This subdivision of the gray matter is accompanied by certain rearrangements of the nerve-tracts. The pyramidal lateral columns cross each other at the decussation (Fig. 247 *DPy*), and pass to the ventral surface of the medulla (Fig. 248 *p*), while the shorter tracts connecting the several portions of the gray matter become less and less superficial. The column of Goll and the column of Burdach pass up (as the funiculus gracilis (Fig. 248 *a*) and funiculus cuneatus (*b*) respectively) to the lateral margin of the fourth ventricle, and together with lateral cerebellar tract and the arciform fibres of the restiform body (*c*) form the posterior peduncle of the cerebellum (*e*).

At this level fresh nuclei begin to appear, and form the substance of the olivary body (Figs. 247, 249 *o*), and the beginning of the gray matter of the cerebellum, corpora quadrigemina (Fig. 248 *h*), optic thalamus (Fig. 245 *th*), subthalamie body (*cs*), and numerous small masses (Fig. 249) embedded in the various columns and tracts. All these nuclei give rise in their turn to fresh bundles of fibres, some of which run in distinct tracts while others interlace with their neighbors.

Presently the longitudinal fibres are crossed by numerous arciform fibres (Fig. 249) some external (*fae*), others lying deeper (*Fr*, *b*) and forming a network (*formatio reticularis*) with the longitudinal fibres.

The cerebral axis may be considered as made up of three regions or strata (SCHWALBE)—the peduncular tract (MEYNERT, SCHWALBE), the tegmental region (FOREL), and the dorsal stratum.

The **peduncular tract** is in the **medulla** represented by the pyramidal columns (Fig. 249 *p*), which are surrounded and in part reinforced by the external arciform fibres (*fae*). The external arciform fibres enclose a nucleus known as the arciform nucleus (*nar*). In the **pons** the peduncular tract lies in the ventral stratum, being crossed and interlaced by the transverse arciform fibres derived from the middle peduncle of the cerebellum (Fig. 247 *BrS*). Some of these fibres are commissural and connect the two halves of the cerebellum; others penetrate the gray masses embedded among the arciform fibres and known as the nuclei of the pons. Certain of the nerve fibres which start from these nuclei join the bundles of pyramidal fibres and pass with them up to the cerebrum.

The bundles of pyramidal fibres, which in the pons are more or less subdivided and scattered, unite again into compact bundles on the anterior or cerebral side of the pons and, reinforced by the nuclear fibres

just referred to, form the pes or crusta of the **crura cerebri** (Fig. 247 *Pe*). The crusta is covered on the upper or dorsal surface by the substantia nigra, a layer of pigmented ganglion-cells, which in their turn give off fibres to join the crustal fibres. These latter then pass (mainly through the internal capsule) up to the cortex. The pyramidal fibres terminate in the ascending frontal and parietal convolutions and the parts adjoining, the other fibres pass to the frontal, temporal, and occipital lobes. A few enter the lenticular and caudate nuclei.

The **tegmental region** lies to the dorsal surface of the peduncular tract, and consists chiefly of the *formatio reticularis* (Fig. 249 *Fr*). The reticular structure is due to the subdivision into fibres of part of the gray matter of the anterior horn, with which are interlaced numerous arciform fibres. It includes in every part longitudinal fibres which are the continuation of the anterior and lateral columns of the cord, together with arciform fibres and scattered ganglion-cells. Posteriorly there is a so-called raphe (*r*), due to the decussation of some of the fibres in the middle line.

The tegmental portion of the **medulla** contains the nuclei of the twelfth, eleventh, tenth, ninth, and part of the eighth cranial nerves (Figs. 248, 249), the olivary nucleus (Fig. 249 *o*), the accessory olivary nuclei (*oam*, *oal*), the nucleus of the funiculus gracilis (*ng*), the nucleus of the funiculus cuneatus (*nc*), and other nuclei. The restiform body (Fig. 248 *c*) also belongs to this region, through which pass fibres from the lateral cerebellar tract of the cord, from the olivary body, and from the *formatio reticularis*, to the cerebellum.

The tegmental portion of the **pons** contains the nuclei of the fifth, sixth, seventh, and part of the eighth cranial nerves (Fig. 248). Fibres pass from the cerebellum into the *formatio reticularis* through the anterior peduncle of the cerebellum.

The tegmental portion of the **crura cerebri** lies beneath the aqueduct of Sylvius and is connected with the corpora quadrigemina and the anterior medullary velum. Beneath the aqueduct lies the nucleus of the third and fourth cranial nerves (Fig. 248). The *formatio reticularis* which lies to the ventral side of these nuclei contains (in addition to longitudinal bundles of fibres from the anterior and lateral columns of the cord) fibres from the corpora quadrigemina and anterior medullary velum, and from the cerebellum. The former proceed to the pons by way of the arcuate fibres, the latter by way of the anterior peduncles. The bundles from the cerebellum enclose in the part beneath the anterior corpora quadrigemina a reddish island of gray matter known as the red nucleus. Many of the fibres of these bundles terminate in this nucleus (GUDDEN), a few are seen to pass beyond it (FLECHSIG). These latter fibres pass to the exterior parts of the lenticular nucleus, to the optic thalamus, and to the cortex of the parietal lobe. The fibres thus proceeding to the cortex pass through the internal capsule and form the

largest part of the sector of the corona radiata called by FLECHSIG the tegmental radiations (*Haubenstrahlung*).

The tegmental portion of the **inter-brain** (Art. 630) consists of the subthalamic region, and the gray matter forming the floor of the third ventricle and called the interpeduncular region, the latter being made up of the posterior perforated lamina (Fig. 247 *Spp*), the corpora albicantia (or mammillaria *Ca*), and the tuber cinereum (*Tc*). The subthalamic region lies between the optic thalamus and the prolongation of the substantia nigra of the crura cerebri, and extends forwards to the anterior perforated lamina (*Lpa*). It is made up of a gray nucleus, the corpus subthalamicum (Fig. 245 *cs*) or body of Luys, and a dorsal layer of white matter connected with the optic thalamus and containing fibres proceeding to the corpus striatum from the red nucleus and superior cerebellar peduncles.

The **dorsal stratum** of the cerebral axis includes the cerebellum, the corpora quadrigemina, and the thalamus.

The **cerebellum** contains gray matter partly spread over the cortex, partly collected in the interior in masses known as the nucleus dentatus, nucleus emboliformis, nucleus globosus, and nucleus fastigii, respectively (STILLING). These nuclei are by means of the fibres of the white matter of the cerebellum connected not only with each other, but also (through the several cerebellar peduncles) with various nuclei and tracts already described in the tegmental and peduncular regions; they are thus in relation with the cord on the one hand and with the optic thalamus, lenticular nucleus, and cerebrum on the other.

The **quadrigeminal region** consists of two anterior and two posterior quadrigeminal bodies enclosing gray nuclei, and the gray lamina which forms the roof or dorsal covering of the aqueduct of Sylvius. The posterior bodies are connected by means of the lower fillet with the ventral aspect of the tegmental region, and by the inferior brachium with the internal geniculate body, a gray nucleus beneath and contiguous to the optic thalamus. They are probably also in connection with the optic nerves and the cortex cerebri. The anterior bodies are connected with the optic nerves, with the tegmental region (through the upper fillet) and with the cortex cerebri.

The **thalamus** consists of the optic thalamus in the narrower sense of the term, of the gray matter lining the cavity of the third ventricle, and of the external corpus geniculatum. The optic thalamus has extensive connections with the cortex cerebri (these pass outwards chiefly through the internal capsule, but in part also beneath the lenticular nucleus), with the tegmental region, and also with the optic tract. The outer corpus geniculatum lying towards the outward extremity of the pulvinar or posterior tubercle of the thalamus is of a dark-gray tint; it is a centre for the nerves of vision.

The cerebral axis contains no elements subserving any psychical

function; the **functions** of its centres are partly involuntary or **automatic**, partly **reflex**.

Thus the medulla contains the reflex-centres for closure of the eyelids, for coughing, sneezing, sucking, and so on, together with centres which co-ordinate certain subordinate reflexes within the spinal cord. It also contains the centres which control respiration and the movements of the heart, the vaso-motor centre, and a region which when stimulated gives rise to general convulsions.

Stimulation of the pons causes spasmodic movements and pain; its destruction is followed by paralysis—motor, sensory, and vaso-motor. In the cerebellum and quadrigeminal bodies lie centres for co-ordinating locomotion and other muscular movements.

The functions of the thalamus and of the nuclei of the pons are not certainly known.

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628. The central nervous system is enclosed in three fibrous envelopes or **meninges**—the dura mater, the arachnoid, and the pia mater.

The **dura mater** is a tough vascular membrane traversed by numerous lymphatics. In the cranium it is closely adherent to the bones of the skull: in the vertebral canal it splits into two laminae, the exterior forming the periosteum of the bony walls, the interior loosely surrounding the cord. Its gives off a fibrous dural sheath to each of the nerves.

The **arachnoid** is a delicate non-vascular membrane everywhere closely applied to the dura mater, with only a capillary space intervening (the subdural space). This interstice is a lymph-space, which communicates with the adjacent lymphatics of the neck, nose, eye, and dura mater, and also with the venous sinuses in the latter (by means of the arachnoidal villi or pacchionian bodies): it is continuous with the subdural spaces within the dural sheaths of the nerves (KEY and RETZIUS), and is everywhere clothed with endothelium.

The **pia mater** is a delicate highly vascular membrane which closely invests the brain and spinal cord. Between the pia mater and the arachnoid lies the subarachnoid space, whose dimensions vary greatly with the varying relations of the two membranes. It is everywhere traversed by delicate fibrous trabeculæ or membranous expansions covered with endothelium (the **subarachnoid tissue**), and contains a liquid known as the cerebrospinal or subarachnoid fluid. The space is narrow over the gyri and wider over the sulci. It is wider still in the spine, and at certain places within the skull where it expands into regular sinuses or **cisterns**. Such for example occur between the dorsal surface of the medulla and the posterior part of the cerebellum, in the interpeduncular space (between the crura cerebri), in front of the optic chiasma, between the under surface of the cerebellar hemispheres and the lateral portions of the medulla, on both sides of the transverse fissure, and at the lower ends of the sylvian fissures.

The pia mater and subarachnoid tissue send processes into the cleft between the cerebellum and medulla, and into that between the upper surface of the cerebellum and corpora quadrigemina and the under surface of the cerebrum: these processes are continued into the interior of the adjoining ventricles and form the telæ choroideæ and **choroid plexuses**. Here also are the chief channels of communication between the subarachnoid cisterns and the cavities of the fourth (foramen of Magendie) and third ventricles.

The subarachnoid spaces thus communicate not only with each other but also with the cerebral ventricles. The spaces also communicate with the lymphatics of the head, with the lymph-spaces of the nerves as they take their exit, and with the dural venous sinuses. Communication with the lymphatics of the neck and of the nerves takes place by means of the pia mater (**pial sheaths**) which surround the vessels and nerves as they enter or leave. With the dural sinuses communication takes place by means of the pacchionian bodies, which are rounded excrescences of arachnoid and subarachnoid tissue penetrating into the dura, and separated only by a thin dural film from the venous blood in the sinuses.

The cerebral **blood-vessels** before they enter the brain all pass through the subarachnoid space and the pia mater, and carry with them a pial sheath. They are thus even within the brain surrounded by lymph-spaces, which are known as adventitial **lymph-sheaths** (VIRCHOW, ROBIN) and communicate freely with the pial spaces. The central nervous system is thus not only surrounded on all sides by lymph-spaces but also traversed in all directions by lymph-channels, and its blood-vessels all lie in lymph-sheaths.

The arteries of the brain are divided into basal or ganglionic and cortical (HEUBNER, DURET). The former are terminal arteries, ramifying in the basal ganglia and the internal capsule; the latter anastomose

freely within the pia mater. The choroid plexuses also carry vessels into the interior of the ventricles; they may be described as villous processes covered with polygonal epithelium and containing a multitude of capillary loops of large size.

The vessels of the cord pass into the nerve-substance partly from the periphery, partly by way of the longitudinal fissures.

Many authors (such as HIS, ROTH, etc.) affirm that circumvascular and epi-cerebral lymph-spaces exist outside the adventitia of the vessels and beneath the pia mater, and that these spaces are traversed by fine trabecula emerging from the brain-substance and passing into the adventitia of the vessels. ZIEGLER, with BOLL, GOLGI, and others, makes out that these spaces, when they are met with at all, are due to artificial causes such as the hardening of the brain in solutions of chromic acid and so on.

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629. The central nervous system is composed of tissue the normal performance of whose functions depends greatly on the normal circulation of healthy blood within it.

A brief obstruction to the inflow or outflow of blood is sufficient to give rise to grave disorder of the nervous functions, and in like manner an excess of carbonic acid or a deficiency of oxygen may give rise to serious irritation or paralysis of particular parts. When such disturbances of circulation or nutrition reach a certain degree of gravity they are apt to be followed by transient or permanent degenerative changes in the nervous structures. Such **degenerations** form the basis of an important group of diseases of the brain and cord.

In many acute febrile disorders disturbance of the cerebral functions is a symptom. This disturbance is due partly to over-heating of the tissues, partly to disorder of the circulation, partly to impurities and changes in the composition of the blood. The fact that permanent lesions of the brain and cord are comparatively rare sequelæ of such fevers shows that nerve-substance has a remarkable power of resistance to a number of injurious agencies, that in other words the brain and

cord like other organs can be permanently injured only by agencies of particular kinds. That these agencies have about them something special is made likely by the fact—that many **poisons** when introduced into the blood exert a marked specific action on the nerve-cells and nerve-fibres, while others have no action whatever on these structures.

Every-day experience shows that personal **predisposition** plays an unusually important part in the genesis of central nervous diseases. This predisposition is usually inherited, seldom acquired. According to WESTPHAL in 50 per cent of insane patients the occurrence of disease of the central nervous system in some blood-relation of the ascending line can be demonstrated. It is not actual disease which is thus transmitted from parent to child but only a liability to disease, a lack of resisting-power, in consequence of which influences (unable in a normal individual to produce any abiding disturbance) are capable of setting up disorders of function and often alterations of structure. The morbid influences may be of any kind, and may reach the central nervous system either by way of the circulation or as morbid stimuli by way of the nerves.

Predisposition to nervous disease is usually a matter beyond the scope of anatomical research, but cases do occur in which the inherited or at least congenital pathological condition manifests itself as a defect of development in the central nervous system. In other words **malformations** of the brain are very commonly associated with defective brain-function, and constitute a predisposition to further nervous disease.

Inherited and acquired predisposition is of special importance in connection with diseases of the central nervous system that are chronic. It has little to do with the genesis of acute and particularly of inflammatory disorders, which are as a rule set up by irritant matters reaching the nerve-tissues through the **circulation**.

A common source of brain-affections, especially of the inflammatory kind, is disease of the adjacent structures, such as the base of the skull, the petrous bone, the skull-cap, the nose and its cavities, etc. The contents of the cranium and vertebral canal are in communication by means of blood-vessels and lymphatics with the surrounding parts, and thus inflammatory mischief may invade the brain and cord not only by **direct extension** but also through the blood and lymph.

Lastly, both brain and cord are much exposed to injury by **traumatic violence** of the most various kinds, and in consequence undergo a great variety of morbid changes which are often extremely grave.

CHAPTER XCII.

MALFORMATIONS OF THE BRAIN AND SPINAL CORD.

630. The cerebrospinal system takes its origin from the **medullary tube** or canal formed by the infolding of the epiblast along the medullary groove. The cells lining the lumen of this tube become the ciliated epithelium of the central canal and ventricles of the cord and brain, the remaining cells develop into the ganglion-cells and their processes.

The rudiment of the brain appears as three primary **cerebral vesicles**, which are simply dilatations of the anterior end of the medullary tube. The first and third vesicles each divide into two, and thus five vesicles are produced from whose walls the various parts of the brain are developed. From the first vesicle (**fore-brain** or prosencephalon) are formed the cerebral hemispheres, the corpora striata, the lenticular nucleus, the corpus callosum, and the fornix: from the others, which are known as the **inter-brain** (thalamencephalon), **mid-brain** (mesencephalon), **hind-brain** (epencephalon), and **after-brain** (metencephalon), are derived the various parts of the cerebral axis and its dorsal stratum.

In the region of the after-brain (or medulla oblongata) the medullary tube never completely closes, so that here a communication with the interior of the tube remains open. The development of the fore-brain proceeds rapidly, and the cerebral hemispheres thus produced in the human adult ultimately overlie almost all the rest of the brain.

If the formation of the medullary tube from the medullary groove of the embryo is for any reason interfered with, or if the dorsal wall of the tube is imperfectly formed or destroyed, the cerebrum and part of the cerebral axis remain undeveloped, and we have the condition known as **total anencephalia**. According to LEBEDEFER the same result may take place if the cranial flexure of the embryo be abnormally sharp. G. ST. HILAIRE, FÖRSTER, and PANUM think that the absence of the brain is chiefly owing to an excessive accumulation of liquid in the medullary tube. DARESTE and PERLS on the other hand are of opinion that anencephalia is due to an abnormal pressure of the head-fold of the amnion on the cephalic end the embryo (Art. 7). When for any reason some part of the medullary tube is destroyed or hindered in its development the growth of the lateral medullary plates does not entirely cease (LEBEDEFER); they enlarge and form a number of folds buried in the

substance of the mesoblast, and becoming partially abstricted take the form of irregular cysts and cavities. When the liquor amnii makes its appearance the exposed medullary plates are usually much damaged; the underlying mesoblast develops at the same time into the cerebral membranes, and the result is that instead of a brain we have covering the base of the skull a mass of vascular connective tissue containing cystic cavities and marrow-like remnants of brain-substance. As the dorsal wall of the medullary tube was defective or absent, the cranial vault is more or less defective or absent, and the anencephalia is thus associated with conditions known as **acrania**, **hemicephalus**, or **cranioschisis** (Art. 7).

When the development of the brain is only in part interfered with, or when parts only of the rudimental structures have been destroyed in an early stage, the result is some partial deficiency which we may appropriately call **partial anencephalia**.

The situation, size, and extent of such deficiencies may of course vary greatly in different cases, and give rise to a great variety of brain-deformities. If the skull is closed (and in these cases it usually is closed) the space left vacant by the ill-developed brain becomes filled with liquid, which gathers either in the subarachnoid tissue outside the existing brain-mass, or within it in one of its ventricles, or in both places together. The latter forms have been described by CRUVEILHIER as hydrocephalic anencephalia.

Cases of anencephalia also occur in which more or less important parts of the base of the brain (*e. g.* the basal ganglia) are properly developed, and others in which while one hemisphere is developed (though perhaps malformed) the other hemisphere is wanting. The cranial vault in such cases may either be entire, defective, or distended as in hydrocephalus (Art. 631). When the vault is closed the fragments of brain-substance are shut off from the space filled with liquid by a fibrous partition representing some of the cerebral membranes. If the defect of development has mainly affected the anterior part of the fore-brain we have the malformation known as **synophthalmia** or **cyclopia**, and **arhinencephalia** (KUNDRAT). In the latter form the nose is undeveloped, in the former the eyes (Art. 7). The nose sometimes takes the form of a snout-like projection (*ethmocephalia*), sometimes it is a mere stunted remnant (*cebocephalia*); in other cases again there is a median fissure of the upper lip and of the septum of the nose, or a single or double lateral hare-lip and cleft-palate. In the slightest variety of the malformation the face is normal, the brow alone being narrow and tapering.

In both *synophthalmia* and *arhinencephalia* the cerebrum is more or less malformed: in the gravest variety the brain is represented by a mere pointed vesicle. In slighter cases particular parts are wanting, such as the olfactory nerve and lobe, the corpus callosum, some of the convolu-

tions, etc. The quadrigeminal bodies are often coalescent. The optic chiasma and tracts are sometimes absent, sometimes normal.

Between such grave defects and the slightest, involving perhaps merely a portion of one convolution, all intermediate varieties of malformation are met with.

The slightest kind of defect occurring on the outer surface of the brain takes the form of shallow depressions or excavations of the gyri, the hollows being lined with pia mater. When entire gyri or considerable portions of gyri are wanting the defects appear as open clefts or funnel-shaped pits or perforations extending sometimes to the walls or even into the interior of the ventricles. This condition has been called **porencephalia** (HENSCHL). The cavities are lined with pia mater, which is discontinuous only where they communicate with the cavity of the ventricle. The spaces thus formed are in general filled up with liquid collected in the subarachnoid tissue, and are bridged over and enclosed by the arachnoid membrane. In other cases the adjacent convolutions are pressed together over the gap, which then takes the form of a deep cleft or interstice.

When the defect is larger (involving it may be a lobe or more) similar conditions obtain. The neighboring ventricles are seldom of normal size, being usually more or less dilated or showing local sacculations opposite to the missing regions. The surrounding convolutions tend to be arranged radially round the gap as if puckered and drawn into it. The remainder of the brain may be quite normal, but at times the convolutions are abnormally arranged or ill-developed. The basal ganglia on the side of the dilated ventricles are flattened. The cranium is either normal or somewhat asymmetrical. When the brain is imperfect the skull is usually small, but in marked ventricular hydrocephalus it is enlarged.

Another variety of partial anencephalia is the absence of some of the deeper structures and especially of the basal ganglia. Thus the corpus callosum and fornix may be wanting or imperfect, and so likewise may the gray commissure of the third ventricle, the corpora albicantia, the corpora quadrigemina, etc. When the corpus callosum is absent the gyrus fornicatus and gyrus hippocampi are usually absent also, and some of the other convolutions are frequently irregular in form or arrangement.

The causation of partial anencephalia is not the same in all cases. Porencephalia is probably in many cases due to intra-uterine disorders of circulation, hæmorrhages, and inflammations, by which portions of the brain already developed are damaged or destroyed. In favor of this view is the fact—that the brain-substance and the membranes in the neighborhood of the defect often show changes similar to those which in later life are known to follow upon submeningeal anæmic and inflammatory softening (Art. 642). Pressure from without or a blow on the cranium may in some cases bring about a like result.

In others internal or ventricular hydrocephalus (Art. 631) may disturb the circulation of the part and lead to its wasting or disappearance. When the convolutions about the defect are normal it is probable that the destruction took place at a time when the brain was fairly developed, say not later than the fifth month. Obvious disturbance of the configuration of the brain would imply an earlier date. Occasionally such local defects must be due to actual failure of development, or **agenesis** as it might be called. Deficiencies in the deeper parts of the brain are usually unaccompanied by any signs of destructive disease; they would therefore seem to be due to primary failure of development.

The condition of the cord corresponding to anencephalia is called **amyelia**. Most frequently the two go together, and are accompanied by defects of the vertebral arches and of the meninges and integuments. A cleft thus extends from the opening in the cranium down to the cervical, dorsal, or it may be to the sacral region (**rhachischisis**). Clefts of the dorsal or lumbar spine alone, extending through the skin, are more rare. Where the vertebral arches are absent the cord is also wanting, so that the vertebral bodies are covered only by membranes. Such defects are due either to some sharp flexure of the embryo, to imperfect separation of the medullary plate from the superficial or epidermic epiblast, or to dropsical distention of the medullary tube. Partial defects of the cord are very rare when the spinal canal is closed. On the other hand ADAMKIEWICZ states that in 80 persons out of 100 some of the 31 pairs of roots of the spinal nerves will exhibit more or less marked defects, especially in the anterior roots. Slight asymmetry of the cord, chiefly in the decussation of the pyramids in the medulla, is an extremely common phenomenon.

The term **porencephalia** (or porencephalus) is used in different senses by different writers, some confining it to congenital defects, others applying it to those which are acquired after birth. Many apply it only to small and localized defects, others extend it so that it might imply the absence of an entire cerebral hemisphere. It seems better to limit its application to localized defects that are congenital or at least acquired in early infancy.

When in total or partial anencephalia the motor centres and tracts are wanting, the pyramidal tracts and columns of the cord do not develop (FLECHSIG). And in partial failure of development (agenesis) of the brain FICK observes that the pyramidal tracts are imperfectly differentiated, the medullary sheath of the fibres being ill-developed.

References on anencephalia and amyelia:—DARESTE, *Recherches sur la production des monstruosités* Paris 1877; PERLS, *Allg. Path.* II. 1879; LEBEDEFF, *Virch. Arch.* vol. 86; FÖRSTER, *Missbildungen d. Menschen* Jena 1865, *Handb. d. path. Anat.* 1865; HESCHL, *Prager Vierteljahrsschrift* 1859, '61, '68, *Jahrb. f. Kinderheilk.* xv., *Arch. d. Gesell. f. Aerzte in Wien* 1878; KUNDRAT, *Die Porencephalie* Graz 1882, *Die Arhinencephalie* Graz 1882; KLEBS, *Ueber Hydro- u. Mikroanencephalie, Oesterreich. Jahrb. f. Pädiatrik* 1876; SCHÜLE, *Zeitschr. f. Psych.* xxvi.; BINSWANGER, *Virch. Arch.* vol. 87; WILLE, *Arch. f. Psych.* x. (1880); CHIARI, *Jahrb. f. Kinderheilk.* xv.; AHLFELD, *Die Missbildungen d. Men-*

schen II. (1882); KIRCHHOFF, *Arch. f. Psych.* XIII. (1882); SPERLING, *Virch. Arch.* vol. 91; RIBBERT, *ibid.* vol. 93; DE LA CROIX, *ibid.* vol. 97; HEYDENREICH, *ibid.* vol. 100; ROSS, *Diseases of the nervous system* II. London 1888; CLELAND, *Journ. of Anat. and Physiol.* XII., XVII.

On absence of the corpus callosum:—PAGET, *Med. chir. Trans.* XXIX. (1846); SANDER, *Arch. f. Psych.* I. (1868); JOLLY, *Zeits. f. ration. Med.* XXXIV. (1869); HUPPERT, *Arch. d. Heilk.* 1871; MALINVERNI, *Gaz. delle cliniche* 1874, *London Med. Record* 1874.

On rhachischisis see Art. 632.

On defects of the spinal cord:—FROISIER, *Arch. de physiol.* 1872; ADAM-KIEWICZ, *Virch. Arch.* vol. 88; LEYDEN, *Klinik d. Rückenmarkskr.* I. (1874); FLECHSIG, *Ueb. Systemerkrank.* Leipzig 1878; PICK, *Prager Med. Woch.* 1880; ROSS, *Brain* v. (1882). See also Arts. 632, 637.

631. An increased quantity of liquid may collect in the medullary tube or in the ventricles of the brain at any stage of foetal development or after birth. If the accumulation take place very early the development of the brain may be seriously interfered with (Art. 630), its cavities are distended, and the resulting condition is described as **congenital internal hydrocephalus**. The liquid most frequently collects in the lateral ventricles, the other cavities being rarely involved. The affection is usually bilateral, though it is sometimes confined to one side.

At the time of birth the dilatation is sometimes slight, sometimes already considerable, the cranium being visibly enlarged. It often increases steadily until it reaches an enormous size, the skin is stretched and thin, and the subcutaneous veins show through its semi-transparent texture. The cranial bones become widely separated, and even though they grow to an abnormal size they do not keep pace with the distention of the whole. The fontanelles become larger and the sutures wider, and at times accessory bones make their appearance in the fibrous tissues that bridge over these spaces.

When death occurs the dura mater and the underlying membranes are found stretched to the utmost, the convolutions flattened and depressed, the sulci effaced. The brain-substance forms a mere capsule round the dilated ventricles, the thickness on the convexity of the hemispheres being sometimes not more than a few millimetres.

The liquid in the ventricles is clear and colorless or pale-yellow. The ependyma is stretched but not otherwise altered. The basal ganglia are flattened out. The fourth ventricle and the cerebellum are usually unaltered, though the former is sometimes partially dilated.

The above is the usual condition of things: in some instances however the distention of the lateral ventricles is less extreme, or it is confined to one or a part of one only. Thus one ventricle may be so distended that it is bounded only by a thin film of membrane, while the other is undilated. In like manner the fourth ventricle alone may be dilated. In these cases the general dilatation of the cranium does not

take place, the enlargement of the ventricle being accompanied by atrophy of the rest of the brain.

Extreme hydrocephalus terminates fatally. The less-marked forms are compatible with continued life. But if the dilatation is at all considerable the compressed parts of the brain undergo partial atrophy, that is to say disappearance and calcification of nerve-cells and nerve-fibres.

Great dilatation of the fourth ventricle is often accompanied by wasting of the cerebellum, pons, and medulla, or by actual disappearance of some parts of them.

Slight congenital hydrocephalus, especially if it does not increase after birth, is not altogether incompatible with a subsequent normal development of the brain.

The cause of congenital hydrocephalus is far from clear. Often no morbid changes of an inflammatory kind are to be seen, and it is usually hard to demonstrate any impediment to the outflow of venous blood from the cranium. Occasionally however thickenings of the meninges or of the plexuses are discovered, and these appear to indicate antecedent inflammation. The presence of pus-corpuscles in the hydrocephalic liquid is a surer indication. Probably in many cases the cause is to be found in some abnormal closure of the communications between the ventricular cavities and the subarachnoid spaces. These have at least in some cases been found obstructed (HUGUENIN, ZIEGLER). As moreover in such cases the pia mater over the transverse fissures at the base has been denser than usual, it is possible that the circulation in the veins of Galen was impeded. In certain instances hydrocephalus seems to be a result of rickets or of syphilis. When the skull-cavity is not dilated and the brain not compressed, while the ventricle is dilated, it appears natural to assume that the cause of the latter dilatation is the arrested development (aplasia) of the brain. The condition has been described as a *dropsy ex vacuo*.

In unilateral hydrocephalus the foramen of Monro has been found closed.

An abnormal collection of liquid in the subarachnoid tissue is called **meningeal hydrocephalus**. Of the congenital varieties some are simply due to general failure of development (agenesis, Arts. 630, 633), to local aplasia, or to some disturbance of the growth of the brain: the liquid in the meshes of the subarachnoid tissue fills the space which should have been occupied by the brain. The skull is not dilated.

In another form however the accumulation of liquid is not preceded by cerebral atrophy or aplasia, and then the brain-substance becomes compressed and the skull more or less dilated.

When the brain develops abnormally and its growth is hindered, liquid may collect in the subdural space and so fill out the cranial cavity. This condition is known as **external hydrocephalus** (VIRCHOW).

In Art. 7 we mentioned that when minor deficiencies occur in the bony walls of the skull the cranial contents protrude, and forcing out the dura mater, the cranial aponeurosis, and the scalp take the form of a rounded tumor. Such a tumor is called a **cephalocele** or **hernia cerebri**. Three forms are distinguished according to their contents. The commonest is hydrocephalocele, in which the tumor contains a sacculatation of a ventricle covered with brain-substance. Encephalocele and meningocele are much rarer: in the former brain-substance and pia mater only, and in the latter the pia mater and arachnoid distended with liquid, protrude into the dural sac.

The cause of hydrocephalocele is probably an antecedent hydrocephalus. In encephalocele and meningocele there is probably some local weakness of the membranes or defect in the ossification of the cranium (ACKERMANN); in some cases the condition may be due to adhesions between the meninges and the amnion (ST. HILAIRE).

The commonest seat of cephalocele is at the lower end of the frontal suture (*hernia sincipitalis*), and about the squamous part of the occipital bone (*hernia occipitalis*). More rarely it occurs about the anterior fontanelle, the squamosal suture, the base of the skull, the orbital fissure, etc. It may continue to grow after birth.

References on hydrocephalus and cephalocele:—HUGUENIN, *Ziemssen's Cyclopaedia* XII.; VIRCHOW, *Virch. Arch.* vol. 27; GUNZ, *Jahrb. d. Kinderheilk.* v. (1862); KOLLER and SCHMIDT, *ibid.* VI. (1863); HÄNEL, *ibid.* (new series) I.; AMYOT, *Med. Times* 1, 1869; DICKINSON, *Lancet* 2, 1870; BUTTENWIESER, *D. Arch. f. klin. Med.* X. (1872); PAPP and NEUPAUER, *Jahrb. f. Kinderheilk.* (new series) VII.; MAENNEL, *Jahrb. f. Pädiatrik* 1876; STEFFEN, *Gerhardt's Handb. d. Kinderkr.* v.; VIRCHOW, *Krankh. Geschwülste* I.; S. TALKO, *Virch. Arch.* vol. 50; HARRIS, *Obstetr. Trans.* VI.; HENOCH, *Charité-Annalen* IV.; BIZZOLI, *Bullet. d. scien. med. d. Bologna* 1872; RAAB, *Wien. med. Woch.* 1876; J. F. WEST, *Jahrb. f. Kinderheilk.* IX. (1876); BAUER, *ibid.* XI.; MUHR, *Arch. f. Psych.* VIII.; HEWETT, *St. Geo. Hosp. Rep.* 1873; HEINEKE, *Pitha u. Billroth's Handb.* III.; DEMME, *Jahresber. d. Jenner. Kinderspitals* Bern 1876; SZYMANOWSKI, *Langenbeck's Arch.* VI.; SPRING, *Monographie de la hernie du cerveau* Brussels 1853; G. REALI, *Ueb. d. Behand. d. angeb. Schädel- u. Rückgratsbrüche* In. Diss. Zürich 1874; ACKERMANN, *Die Schädeldeformität bei d. Encephalocele congenita* Halle 1882.

632. Corresponding to internal hydrocephalus we have a congested collection of liquid in the central canal of the cord: this is termed **internal hydromyelia** or hydrorrhachis. The canal is dilated either in parts or throughout its whole length, and the substance of the cord is accordingly thinned out. Partial dilatations are fusiform, cylindrical, or sacculate. Cases occur in which comparatively large cavities lined with cylindrical epithelium are found in the region of the posterior columns, the columns themselves being ill-developed (Arts. 637 and 650).

When the dilatation of the canal is slight the development of the cord may be normal, but where the dilatation is more marked there is

always some thinning of the nerve-substance, and the posterior columns especially are apt to suffer. Extreme localized or cystic dilatation, such as in the cervical region frequently accompanies hydrocephalocele, sometimes leads to actual discontinuity of the cord.

Another variety allied to the last takes the form of a cystic tumor-like growth protruding through the walls of the vertebral canal and appearing under the skin of the back or on the lateral or anterior aspect of the spinal column. This is known as **myelomeningocele** or **spina bifida** (Art. 7).

Lumbo-sacral myelomeningocele is the commonest form. The tumor appears in the mid-dorsal line immediately above the sacrum or on the lumbar spine. It is covered with smooth or shining and sometimes thinned integument, and is of the size of a walnut or a little larger. The inner surface of the cyst is sometimes smooth, sometimes rough with outgrowths from the walls: on the upper and ventral aspect the cord is seen. It is elongated and, it may be, somewhat swollen, or attached by a broad base to the inner surface, or it is lost immediately after it enters, breaking up into a number of strands which run in the wall of the cyst.

In rare cases the cyst at birth is open, or there may be no cyst properly speaking but merely a hole in the skin surrounded by a raised border and leading by a funnel-like passage directly into the central canal of the cord.

The wall of the cyst or sack is formed chiefly of the sacculated dura mater, and the vertebral arches and spinous process are always absent at its neck. Hence the name—sacral spina bifida—sometimes given to the malformation.

Dorsal and cervical myelomeningoceles are much more rare, and usually smaller. The dura bulges slightly through the gap in the series of vertebral arches, while a conical or cylindrical process from the posterior aspect of the cord enters and becomes adherent to the wall of the sack. The process contains both gray and white matter, and sometimes encloses also a saccular dilatation of the central canal.

Lastly there is a form of cystic protrusion occurring in the sacral region and involving chiefly or only the membranes of the cord: it is hence described as **spinal meningocele**. A local accumulation of fluid takes place at the lower part of the subarachnoid space: the dura and the adherent arachnoid are then forced through some normal opening (such as that between two arches, an intervertebral foramen, or the lumbo-sacral hiatus) or through an abnormal one due to absence of an arch or part of a vertebral body, and thus form a protuberance on the posterior, lateral, or anterior aspect of the spine. If the liquid continues to accumulate the cyst may attain a large size. The *filum terminale* and some of the spinal nerves connect it with the cord.

It seems at first natural to suppose that the three varieties of malformation just described are due simply to morbid accumulation of

liquid in the central canal, in other words to hydromyelia combined with a local meningeal dropsy: this view has been taken by many authors (FÖRSTER, AHLFELD, and others). The anatomical characters presented by a myelomeningocele are however inconsistent with the supposition, and make it more probable that during the evolution of the central nervous system the medullary tube was imperfectly differentiated off from the surface or epidermic epiblast (RANKE, VIRCHOW, TOURNEUX, MARTIN, MARCHAND, etc.). This at least explains the fact that the cord so frequently passes out with the sack, and that the central canal sometimes opens freely into its cavity. When the cleft in the integument becomes closed over and the membranes of the cord are developed, liquid collects partly in the subarachnoid space and partly in the lower end of the central canal. It is however a question whether in some cases hydromyelia alone may not lead to myelomeningocele.

Nothing certain is known as to the causation of meningocele. Perhaps here too the malformation depends on the imperfect differentiation of the cord-substance from the epidermis.

References:—VIRCHOW, *Virch. Arch.* vol. 27, *Krankh. Geschwülste* I.; LEYDEN, *Virch. Arch.* vol. 68, *Klinik d. Rückenmarkskrankheiten* I. Berlin 1874; CRUVEILHIER, *Anat. Pathol.* Paris 1824-1842; HILTON, *Lancet* 2, 1860; Discussion, *Med. Times and Gaz.* 2, 1858; RINDFLEISCH, *Virch. Arch.* vols. 19, 27; FÖRSTER, *Missbild. d. Menschen* Jena 1865; BRAUNE, *Die Doppelbildungen und die angeb. Geschwülste d. Kreuzbeinegend* Leipzig 1862; FLEISCHMANN, *Jahrb. f. Kinderheilk.* (new series) v.; J. RANKE, *ibid.* XII. (1878); DARESTE, *Product. artific. d. monstruosités* Paris 1877; TOURNEUX and MARTIN, *Journ. de l'anat.* 1881; W. KOCH, *Mittheil. üb. Fragen d. wiss. Medicin* I. Cassel 1881; AHLFELD, *Die Missbild. d. Menschen* II. Leipzig 1882; MARCHAND, *Arch. f. Gynäk.* XVII. (1881); *Art. Spina bifida*, in *Eulenb. Realencycl.* 1882; DEMME, *Berichte üb. d. Kinderspitale* Berne 1883; ERB, *Ziemssen's Cyclop.* XIII.; HOLMES, *Syst. of surgery* III. London 1883 (with references); HUMPHRY, *Lancet* 1, 1885, *Journ. of Anat. and Physiol.* XIX., XX. (1885-1886); CLELAND, *ibid.* XVII.; Report, *Trans. Clin. Soc.* XVIII. 1885; VON RECKLINGHAUSEN, *Virch. Arch.* vol. 105.

633. Particular parts of the central nervous system are frequently ill-developed, and in consequence remain after birth abnormally small. The cerebrum is naturally the part which has attracted most attention in this respect. When it fails to reach the minimum size met with in healthy persons the condition is spoken of as **micrencephalia**: when the cranium as a whole is likewise abnormally small we have **microcephalia**.

The average weight of the adult male cerebrum is 1375 grammes, that of the female 1245. The minimum weight for the male is 960 grammes, for the female 880; the maximum for the male 1800, and for the female 1600 grammes. The brain of a new-born infant is about 385 grammes, that of a two-year-old child 1173 grammes. The brain-weight of an infant is therefore very large relatively to its body-weight, the pro-

portion being about 14 : 100, while that of an adult is only 2.37 : 100 (VIERORDT).

Micrencephalia is usually apparent even at birth, but it becomes more obvious as the child develops: while the back part of the cranium remains stationary (microcephalia) the face grows apace and the disproportion becomes very marked. This aplasia of the brain is sometimes greater in one part than another, the anterior, lateral, or posterior region being in different cases the most stunted. As a rule however all parts are abnormally small. The gyri and sulci are generally ill-developed and abnormal in their arrangement. The subordinate or secondary sulci are usually the most defective, though cases occur in which some of the principal convolutions and fissures are entirely absent. The statistics of VOGT and JENSEN show that the weight of the brain in microcephalic patients may fall to one-third or one-fourth of the normal. The cerebellum and cerebral axis like the hemispheres are liable to be dwarfed, though they are usually less so than the latter.

C. VOGT thought that in micrencephalia we had an instance of atavism or reversion to an earlier developmental type in the *Primates*. The later researches of AEBY, JENSEN, KLEBS, FLESCHE, VIRCHOW, BINSWANGER, and others have however shown that this view is untenable. Micrencephalia is an arrest or rather failure of development, an *agenesis*, due either to intrinsic causes or to injurious influences exerted on the embryo. It is accordingly very commonly found in association with other morbid alterations in the brain and other organs, and is partly a consequence and partly a concomitant of these.

Thus the micrencephalic patient may also exhibit porencephalia or ventricular hydrocephalus. Fibrous thickenings of the pia mater in some cases indicate antecedent inflammatory disorder. Often too there is some malformation of the extremities due to some injurious intra-uterine pressure; and premature synostosis of the cranial sutures, synchondrosis of the basal bones, and coalescence or cohesion of the hemispheres are also not uncommon. Of these changes some, *e. g.* porencephalia, meningeal inflammation, and premature synostosis, must occasionally be regarded not as mere concomitants of the defective cerebral development but as the primary changes which have led to it.

Less grave results of defective development are—abnormal smallness of particular lobes or gyri, and non-typical arrangement of the gyri associated with diminution (or occasionally increase) of their number. Thus in what has been called **microgyria** the surface of the hemispheres is thrown into a multitude of puckered creases or folds like those of a shirt-frill, the brain as a whole being usually malformed. Very frequently too in brains otherwise normal in size the arrangement of the convolutions is so irregular that the typical furrows and fissures that serve as our landmarks can scarcely be recognized. In rare cases the separa-

tion of the hemispheres is incomplete (TURNER, *Journ. of Anat. and Physiol.* XII. 1878).

Asymmetry of the hemispheres, affecting either the anterior or the posterior regions, is not infrequently observed. Smallness of the corpus callosum, the fornix, the thalami, the corpora striata, corpora albicantia, olivary bodies, corpora quadrigemina, etc. have also been described. The cerebellum may be no larger than a walnut, and in such cases the peduncles also are defective.

Abnormal smallness or shortness of the cord is known as **micromyelia**: the various tracts of the cord may likewise be imperfectly developed.

The causes of such local *ageneses* are sometimes undiscoverable; in other cases they are obviously connected with morbid conditions in other parts. A certain amount of hydromyelia, for example, leads to defective development of the posterior columns. Absence of the central convolutions of the cortex results in the absence or degeneration of the pyramidal tracts. Congenital absence of the cerebellum is accompanied by absence of the superior peduncle and of the red nucleus (FLECHSIG).

The loss of any of the peripheral end-organs (Art. 649) results in partial or total atrophy of the corresponding centres in the central nervous system (GUDDEN).

The posterior columns have frequently been found ill-developed (KAHLER, PICK, JÄDERHOLM, SCHULTZE), and the like is true of some of the fibres in other tracts (KAHLER, PICK, WESTPHAL, FLECHSIG, FÜRSTNER). These forms of aplasia have a special interest, as they are probably the basis of a predisposition to disease of the cord.

Heterotopia is a peculiar variety of malformation, in which masses of gray matter are found in abnormal situations. Such masses, in the form of gray nodules, are now and then met with in the ependyma of the ventricles (VIRCHOW, TÜNGEL, E. WAGNER, MESCHÉDE), and in the subjacent white layer: they measure 1 to 10 mm. across and are sometimes very numerous. They have also been found in the middle of the centrum ovale (VIRCHOW, MESCHÉDE), and somewhat resemble in structure the gray matter of the convolutions. Nodules of gray matter are also described (SIMON) as rising from the surface of the convolutions themselves in the form of little tumors. Heterotopia of gray matter also occurs in the cerebellum (PFLEGER), and lastly these misplaced masses have been found in the white tracts of the cerebral axis and of the cord (PICK, BRAMWELL, OSLER).

Most of those hitherto described contained ganglion-cells, but a few rather resembled the substantia gelatinosa of the cord. In the cord they are doubtless nothing more than isolated fragments of the gray matter, which frequently in the same case itself shows signs of abnormal configuration or arrangement.

Hypertrophy of the brain is rare, though it has been observed in

children and young persons: it may affect the whole or any part of the organ. It is due to excessive developmental growth, probably in the last resort arising from some abnormality in the primary rudiment of the brain. True acquired hypertrophy, not depending on congenital causes, has never been observed.

The brain and the cranium are more or less enlarged according to the extent of the hypertrophy. If the overgrowth takes place after the sutures of the skull have closed the bones in some places may be attenuated or absorbed under the continuous pressure. After death the gyri are usually found to be flattened, the ventricles narrow and appressed, and the brain-substance firm and condensed. We at present know little of the histological characters of the tissue: VIRCHOW states that the principal change is an increase of the neuroglia.

The cord in like manner is sometimes of abnormal size. Partial duplication has been met with in persons who were otherwise normally developed (LENHOSSECK, FÜRSTNER, ZACHER) or suffered from some malformation of the brain.

On microcephalia and malformation of the convolutions:—VIRCHOW, *Gesamm. Abhandl.* 1856; C. VOGT, *Arch. f. Anthropol.* II. (1867); AEBY, *ibid.* VI., VII. (1874), *Ueb. d. Verhältniss d. Mikrocephalie z. Atavismus* Stuttgart 1878, *Virch. Arch.* vol. 77; ROHON, *Arbeit. a. d. zool. Inst. zu Wien* II.; WILLE, *Arch. f. Psych.* x.; FLESCHE, *Verhandl. d. phys.-med. Gesell. zu Würzburg* VIII. (1874), *Festschr. z. Jubil. d. Universität Würzburg* 1882; VIRCHOW, *Berl. klin. Woch.* 1877, *Verhandl. d. Berlin. anthrop. Gesell.* 1878; JENSEN, *Arch. f. Psych.* x.; HADLICH, *ibid.*; SANDER, *ibid.* I. (1870); KLEBS, *Sitzungsber. d. phys.-med. Gesell. zu Würzburg* 1873; SCHUTTEWORTH, *Journ. of mental science* Oct. 1878; BINSWANGER, *Virch. Arch.* vol. 87; RETZIUS, *Hofmann und Schwalbe's Jahresber.* 1878; CHIARI, *Jahrb. f. Kinderheilk.* XIV.

On aplasia of the cerebellum and cord:—MEYNER, *Med. Jahrb. d. Gesell. f. Aerzte* Vienna 1864; PIERRET, *Arch. de physiol.* IV. (1871-72); FISCHER, *Arch. f. Psych.* v.; HUPPERT, *ibid.* VII.; KAHLER and PICK, *Prag. Zeitschr. f. Heilk.* II. (1881), *Berl. klin. Woch.* 1879; JÄDERHOLM, *Nord. med. Arkiv* I.; A. PICK, *Prag. med. Woch.* 1880; FLECHSIG, *Ueb. Systemerkrankungen* Leipzig 1878.

On heterotopia of gray matter, hypertrophy of the brain, and duplication of the cord:—VIRCHOW, *Krankh. Geschwülste* III., *Virch. Arch.* vol. 33; MESCHÉDE, *Allg. Zeitschr. f. Psych.* XXI., *Virch. Arch.* vol. 56; E. WAGNER, *Arch. d. Heilk.* 1861; TÜNGEL, *Virch. Arch.* vol. 16; PICK, *Prag. med. Woch.* 1881. *Arch. f. Psych.* VIII.; MERKEL, *Virch. Arch.* vol. 38; SIMON, *ibid.* vol. 58; SCODA, *Allg. Wien. med. Zeitung* 1859; GELMO, *Jahrb. f. Kinderheilk.* IV. (1860); STEINER and NEUREUTER, *Prag. Vierteljahrsschr.* XX. (1863); PFLÉGER, *Cent. f. med. Wiss.* 1880; BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; LENHOSSECK, *Woch. d. Zeitschr. Wien. Aerzte* 1858; FÜRSTNER and ZACHER, *Arch. f. Psych.* XII.; OSLER, *Journ. of Anat. and Physiol.* XV. 1881 (so-called medullary neuroma).

VIRCHOW (*Gesamm. Abhandl.* 1856) found in a child 3 years old a brain weighing 1911 grammes, in another of 13 the brain weighed 1732. LANDOUZY (*Gaz. méd. de Paris* 1874) describes a brain of 1590 grammes in a boy of 10, and ZIEGLER has recorded one of 1857 grammes in a young woman of 20.

634. All the malformations of the brain above described, when they

are not incompatible with life and growth, give rise to more or less grave disorder of its functions. Where the malformation is great mental development fails, and a condition of **idiocy** is the result. There is however no one variety of malformation which can be assigned as the anatomical basis of idiocy; there is in other words no special 'idiotic brain.' General arrest of development, dropsical dilatation of the ventricles, local defects or imperfections, all may result in idiocy. In other instances idiocy may accompany very slight and apparently unimportant abnormalities, such as heterotopia of gray matter, absence or smallness of the corpora albicantia, corpus callosum, fornix, thalamus, optic nerves, corpus striatum, pineal body, or olivary body, irregularity of the gyri, asymmetry of the hemispheres, etc.: or the brain may be so far as we can see perfectly normal, or hypertrophic through increase of the neuroglia. Lastly, ischæmic and inflammatory destructive processes affecting the cortex sometimes induce idiocy. On the other hand grave malformations such as we have just mentioned, and even others apparently more serious, have existed without giving during life any functional evidence of their presence.

In cretinism as in sporadic idiocy no special and characteristic defect of the brain can be demonstrated.

Cretinism is as we have seen (Art. 623 *a*) a disorder of development occasioned by some unknown miasmatic influence, and manifested in the imperfect growth of the skeleton and the disproportionate size of the soft parts. Idiocy more or less pronounced is a frequent though not invariable symptom, but malformation of the brain is not more general or constant than in idiocy without cretinism.

BENEDIKT some time ago asserted that in **criminals** certain peculiarities of the configuration of the cerebral surface were constantly met with, and inferred that criminals were practically to be regarded as an anthropological variety of the race. Their brains resemble in some points those of lower animals, and were characterized by a tendency of the sulci to run one into the other, so that they were continuous at points where in normal brains they would be bridged over or interrupted by convolutions. This hypothesis is however untenable. Apart from the difficulty of settling the definition of the term criminal, investigation has shown that BENEDIKT'S anomaly of the sulci occurs in persons who have never committed crime or come under the criminal law (BARDELEBEN).

The like holds for the anomalies and malformations of the brain found in certain **insane** and **epileptic patients**. They are none of them peculiar or pathognomonic of nervous or mental disease, inasmuch as they also occur in persons whose mental functions are perfectly normal. All we can say is—that anomalies of brain-structure, both grave and trifling, are more frequent in persons who exhibit mental peculiarities or defects than in those whose minds are normal. Thus heterotopia

of gray matter has been met with chiefly in lunatics, idiots, and epileptics; and in progressive paralysis (of the insane) various malformations of the brain are frequent in addition to the usual cortical changes characteristic of the disease (Art. 656).

Deficiency existing in places where according to our experience the centres governing certain specific functions are usually situate, or through which certain conducting paths usually pass, as a rule implies a like deficiency in the corresponding mental or other function, such as total or partial sensory or motor paralysis, and so on.

References:—VIRCHOW, *Gesamm. Abhandl.* 1856; KLEBS, *Stud. üb. d. Verbreit. d. Cretinismus in Oesterreich* Prague 1877; BENEDIKT, *Anat. Stud. an Verbrechergehirnen* Vienna 1879, *Cent. f. med. Wiss.* 1880; FLESCHE, *Sitzungsber. d. phys.-med. Gesell. zu Würzburg* 1881, *Unters. üb. Verbrechergehirne* Würzburg 1882; BARDELEBEN, *Deut. med. Woch.* 1883; PETRINA, *Zeitschr. f. Heilk.* II.; BINSWANGER, *Virch. Arch.* vol. 87; HARVOUET, *Arch. de physiol.* IV. 1884.

CHAPTER XCIII.

DISORDERS OF CIRCULATION.

635. The quantity of blood contained in the vessels of the cerebrospinal system is subject to very considerable physiological variations. It is greater when the system is functionally active than when it is at rest: the pulsations of the basilar arteries give rise to a pulsatile movement of the convexity of the brain, and its surface likewise rises during expiration and sinks during inspiration. Local hyperæmia of a particular region causes an efflux to other parts of the lymph from the circumvascular channels and of cerebrospinal liquid from the subarachnoid spaces and from the ventricles. When hyperæmia is general space is found for the excess of blood by the efflux of cerebrospinal liquid into the lymphatics of the head, neck, and trunk, and into the venous sinuses of the dura mater.

Morbid **congestion** or arterial hyperæmia of the brain and cord is occasioned when the activity of the heart is greatly and abnormally increased, or when the resistance to dilatation of the afferent arteries or of the arterioles of the meninges and nerve-substance is morbidly diminished. In the latter case the hyperæmia may remain local.

Passive hyperæmia or **engorgement** takes place when the return of venous blood from the cranial cavity and the spinal canal is checked, as it is for instance in certain diseases of the heart and lungs. Local engorgement may be due to intracranial thrombosis, or to tumors, exudations, etc. passing upon the veins.

Venous engorgement of the brain or cord is most apparent in the meninges, whose vessels are more or less distended with blood, and owing to the transparency of the membranes can be followed to their minutest ramifications. The meninges have but few capillaries, and hence the injection of the venules is most marked, though a few of the arterioles are also distended. It must however be kept in mind that the appearances after death are far from representing exactly the conditions that prevailed during life: as soon as death takes place the blood is in a measure free to pass out of the cranium and the vertebral canal, while that which remains tends to sink to the parts that are most dependent.

Hyperæmia of the white matter is recognizable *post mortem* only by the distention of the small veins: on section they allow their contents to

exude as variously-sized drops of blood. A general reddening of the tissue from dilatation of the capillaries is very uncommon, owing to the fact that the coagulation or post-mortem rigidity of the white matter squeezes most of their contents out of the capillaries, while the non-transparent nature of the coagulated white matter prevents the red tint from shining through.

In the gray matter the minuter venules and capillaries may remain filled with blood, the latter giving rise to a diffuse or mottled reddening of the tissue.

Anæmia of the central nervous system is manifested by the emptiness of the arterioles and venules of the pia mater, and the pallor of the gray matter. The white matter on section shows few or no drops of blood on its surface. This anæmia of brain and cord may be part of a general anæmia, or may be due to a morbid congestion of other organs or parts of the body (collateral anæmia). Or again it may result from spasmodic contraction, thickening, or other obstruction in the afferent arteries, or to changes within the cranium and vertebral canal which interfere with the entrance of blood, *e. g.* changes which diminish the space within these bony cavities, such as subarachnoid effusion, dropsy of the ventricles, tumors, hæmorrhages beneath the dura mater, and so on.

Anæmia of the brain and cord is general or local according to the inducing condition. Local anæmia may for instance be caused by closure of a branch of the sylvian artery (middle cerebral), or by the pressure on the cord of a dislocated vertebra or a tumor of the dura mater.

References:—MARSHALL HALL, *The nervous system and its diseases* London 1836; MUNK, *Reichert's Arch.* 1853; REYNOLDS and BASTIAN, *Reynold's System of med.* II. London 1868; LEYDEN, *Ueb. Hirndruck u. Hirnbewegungen*, *Virch. Arch.* vol. 37; F. JOLLY, *Untersuch. üb. d. Gehirndruck u. d. Blutbewegung im Schädel* Würzburg 1871; E. PAGENSTECHER, *Exp. Studien üb. Gehirndruck* Heidelberg 1871; ALTHANN, *Beiträge z. Physiol. u. Pathol. d. Circulation* Dorpat 1871; ACKERMANN, *Virch. Arch.* vol. 15; NOTHNAGEL, *Ziemssen's Cyclopædia* XII.; LANDOIS, *Cent. f. med. Wiss.* 1867; MOSSO, *Kreislauf d. Blütes im Gehirn* Leipzig 1881; MOXON, *Lancet* 1, 1881; ROSS, *Diseases of the nervous system* II. London 1883; ADAMKIEWICZ, *Wiener Sitzungsber.* LXXXVIII. 1883; OBERSTEINER, *Brain* VII. 1884.

636. The brain and spinal cord are especially liable to **hæmorrhage**, both by diapedesis and by rupture (Art. 27). In simple congestive hyperæmia some amount of capillary bleeding is not uncommon, and such bleeding is an almost invariable accompaniment of acute inflammatory disorder of the brain. In both cases the extravasations appear as round or oval specks of the size of a pea or smaller, often mottling the cut surface in a remarkable way. The extravasated blood lies partly in the brain-tissue, partly in the sheaths of the vessels. In the latter

position the small collections of blood are often described as miliary dissecting aneurysms.

In pyæmic encephalitis bacteria are sometimes to be seen in the vessels, and look as if they gave rise to capillary hæmorrhage partly by obstructing and partly by destroying the walls of the vessels. In other cases the capillaries have undergone fatty degeneration.

When the arteries are obliterated by sclerotic thickening of the intima, by thrombosis, or by embolism, the hæmorrhages are not usually very extensive; these changes more frequently give rise to a number of small isolated patches of extravasation.

Extreme venous engorgement, due for example to obstruction of the jugular veins or thrombosis of a sinus in the dura mater, frequently gives rise to capillary and venous hæmorrhages situated chiefly in the pia mater and the ependyma of the ventricles. In the former situation they are sometimes so massive that the subarachnoid and subpial spaces are largely filled with blood. Engorgement within the brain, such as results from large tumors or old extravasations, usually leads to the formation of numerous small circumscribed patches, lying around the capillaries and small veins either in the sheaths of the vessels or in the nerve-substance itself.

Wounds, compressions, contusions, and concussions of the brain and cord due to traumatic violence give rise to bleeding whose extent is of course dependent on the number and magnitude of the ruptured vessels.

Extensive spontaneous hæmorrhage (**apoplexy**) results from the rupture of an artery, and that only takes place when the arterial wall has from degenerative or inflammatory change lost its normal power of resistance (Arts. 297-300). Aneurysmal dilatation (Art. 303) usually though by no means always precedes rupture. Increased pressure within the arteries (so-called 'high tension'), such as generally accompanies the hypertrophied heart and contracted kidney of chronic nephritis or arteriosclerosis, is apt to lead to the rupture of diseased vessels, but not of healthy ones.

Spontaneous arterial hæmorrhage takes place most frequently in and about the region of the basal ganglia and the internal capsule. It is less common about the pons, crura, cerebellum, and centrum ovale. It is least common on the convexity of the hemispheres.

This inequality of distribution depends on the fact that the arteries of the base are subject to a higher blood-pressure than the smaller vessels which pass from the arterial network of the pia mater into the gray matter of the cortex. This is especially true of the branches of the sylvian artery which supply the basal ganglia and the internal capsule.

Arterial hæmorrhage results in disintegration of the nerve-tissue and ganglia over a more or less extensive area, and in compression of the parts surrounding the area. Only in the smallest capillary hæmorrhages can the nerve-tissue escape, and then it is simply compressed by accumu-

lation of blood in the circumvascular sheaths. Rupture of the smallest arteries produces hæmorrhagic foci varying from the size of a pea to that of a hazel-nut; in the case of the larger branches rupture may destroy entire segments of brain-tissue, such as the greater part of the basal ganglia of one side, together with part of the contiguous white substance, or the whole white centre of one occipital lobe.

A recent hæmorrhagic patch forms a soft dark-red coagulated or pulpy mass, containing fragments of disintegrated nerve-tissue. When the hæmorrhage is large the remainder of the brain is anæmic, the convolutions more or less flattened by pressure, and the furrows effaced. Round the chief focus lie a varying number of smaller foci mottling the cut surface, and due to the disturbance of the circulation set up by the primary hæmorrhage. If the rupture takes place in the neighborhood of a ventricle, blood may pass into its cavity and thence through the transverse fissures into the subarachnoid space.

Blood extravasated into the cortex is apt to collect beneath the pia mater and may also penetrate to the subarachnoid space. In hæmorrhage from meningeal arteries these spaces are naturally the main seat of extravasation, the brain-substance being affected only in a secondary manner. When the arachnoid membrane is ruptured we have also subdural accumulations of blood.

As coagulation takes place, the hæmorrhagic mass contracts and the watery portions of the blood are in part removed by means of the blood-vessels and lymphatics. The initial compression of surrounding parts is thus gradually diminished and at length ceases. At the same time the clot changes color and becomes reddish-brown. Presently some of the coloring-matter (hæmoglobin) is absorbed, tinging with yellow the parts around. At length the whole mass disintegrates (Art. 68), the detritus is in course of time absorbed (Arts. 638, 642), and the space so vacated is filled up either by exuded liquid or by the contraction and falling together of its walls. In the latter case a corresponding dilatation of the subarachnoid space or of the ventricles must take place. When the space is filled with liquid we have what is called an **apoplectic cyst**, when the space is effaced by contraction of its walls we have an **apoplectic cicatrix**. In either case there is usually some thickening and induration of the walls (Art. 639), which are stained of a yellow, brownish-red, or brown color, while some of the pigment derived from the extravasated blood remains unabsorbed as brown flakes and granules of ferric hydrate, with perhaps a few particles or crystals of hæmatoidin. The induration is due partly to fibrous hyperplasia of the sheaths of the blood-vessels, partly to proliferation of the neuroglia.

When the hæmorrhage is small and confined to the sheaths of the vessels, and so does not involve any destruction of nerve-tissue, the products of disintegration of the extravasated blood are for the most part

carried off by the circumvascular lymphatics, though granules of pigment frequently lie for a long time embedded in the adventitial sheaths.

Our knowledge of the genesis and history of spontaneous hæmorrhage in the brain is largely due to CHARCOT (*Les maladies des vieillards* Paris 1867, *Diseases of old age* (New Syd. Soc.) London 1881). He affirms that small or **miliary aneurysms** (described by VIRCHOW in *Virch. Arch.* vol. 3; see also BOUCHARD, *Pathology of cerebral hæmorrhage* London 1872) are always present, and sometimes in great numbers, in cases of arterial hæmorrhage. They are due he thinks to periarteritis, which leads to infiltration and thickening of the adventitial and pial sheaths, and to atrophy of the muscular coat. The author finds that CHARCOT'S statement applies only to a certain number of cerebral and spinal hæmorrhages. The aneurysmal dilatation does not always precede rupture: and as to the cause of the dilatation he agrees with ZENKER (*Naturforscherversammlung in Leipzig* 1872), EICHLER (*D. Arch. f. klin. Med.* XXII.), COATS (*Trans. internat. med. congress I.* London 1881), LÖWENFELD (*Arbeiten aus dem pathologischen Institut zu München* 1886), and others, that it may be due to atheromatous degeneration, or even to primary degeneration of the muscularis alone. This last is not always of an amyloid nature, as ROTH maintained (*Corresp. f. Schweizer Aerzte* 1874); at least cases occur in which the muscular fibres are either simply absent or exhibit a fatty or hyaline change which gives no iodine-reaction (PAGET, *Surg. Path.* London 1863). The accumulation of cells and the fibrous thickenings in the sheaths of the vessels described by CHARCOT are doubtless in some instances of a secondary nature. See CHARLEWOOD TURNER, *Trans. Path. Soc.* XXXV. 1884.

The '**miliary dissecting aneurysms**' (first described by KÖLLIKER in 1849) are most frequently met with in cases of acute inflammatory congestion. The term is strictly-speaking incorrect, inasmuch as the blood does not collect between the media and the adventitia (Art. 309), but between the vessel-wall and the pial sheath.

Both ruptured and unruptured aneurysms of the cerebral vessels may be filled up with white or laminated clot and so become obliterated.

637. **Edema** of the brain and cord is characterized chiefly by abnormal moistness of the gray and white matter, so that it has a glistening appearance on section. Owing to the peculiar structure of the central nervous system the dropsical liquid accumulates not so much in the parenchyma of the nerve-tissue itself as in the wide lymph-spaces which it contains. These are chiefly the pial sheaths of the vessels, the ventricles, the central canal of the cord, and the subarachnoid and pial spaces. We thus distinguish œdema of the nerve-tissue from œdema of the pial sheaths of the vessels, of the membranes (*hydrops meningeus*), of the ventricles (*hydrops ventriculorum* or *hydrocephalus internus*), and of the central canal (*hydromyelia*). In dropsy of the sheaths of the vessels the circumvascular lymph-spaces are distended with liquid, so that the vessels appear insulated as they run through the tissue. Sometimes small cysts are thus formed (SCHLESINGER) with a vessel running axially through them.

In œdema of the membranes there is always an increase of the subarachnoid liquid, more rarely of that in the subdural space (*hydrocephalus*

externus). Over the surface of the brain the sulci appear somewhat widened out. This change sometimes extends over the whole brain and cord, sometimes is limited to a particular region: in the latter case the boundary of the dropsical part is indefinite or it is so sharply defined that the distended subarachnoid and pial spaces resemble cysts (cystic or vesicular œdema). These dilatations are met with both on the surface and in connection with the processes of the pia mater which lie inside the ventricles, namely the telæ choroideæ and their plexuses. The latter especially sometimes carry cysts of the size of a bean or larger and filled with clear liquid. The cyst-walls consist of vascular connective tissue covered externally with flat polygonal epithelium and internally with endothelium. The cavity of the cyst is often traversed by vessels and delicate fibrous bands. Small cysts of this kind are of no great importance, but the larger ones may cause serious compression of the brain and lead to disturbance of its functions.

Ventricular dropsy implies the distention and dilatation of one or all the ventricular cavities: hydromyelia leads to cylindrical, fusiform, globular, or more rarely saccular dilatations of the central canal.

The causation of accumulations of liquid within the central nervous structure is not entirely the same as that of dropsy in other organs: to a certain extent they are of a peculiar nature, and to understand them we must somewhat widen our notion of what dropsy implies.

An **œdema of engorgement** may take place over say the whole of the brain whenever the outflow of venous blood from the cranial cavity is impeded. This occurs suddenly when the heart is paralyzed, as in some cases of typhoid (BUHL, KRÄPELIN), when the veins of the dura mater are occluded by thrombosis, etc. Chronic disease of the heart or lungs impeding the circulation will in like manner give rise to chronic œdema. Acute engorgement usually leads to accumulation of liquid in the parenchyma of the brain as well as in the subarachnoid tissue, chronic engorgement usually in the latter only or chiefly.

Local œdema of engorgement is very common round about hæmorrhagic foci, tumors, localized venous thromboses, etc. When by reason of a tumor or of inflammatory change the outflow of blood from the choroid plexuses is impeded, and the outflow of cerebrospinal liquid from the ventricles and central canal is at the same time checked, liquid will accumulate to a greater or less extent in these cavities and distend them. According to LANGHANS fusiform and even saccular dilatations of the central canal are sometimes produced by this cause; they project into the posterior longitudinal fissure of the cord and usually take a downward direction. He also states that clefts or spaces containing effused liquid occasionally appear in the gray matter of the posterior commissure and of the anterior and posterior horns; these may fitly be described as **dropsical lacunæ**.

The so-called **hydræmic dropsy** occurs chiefly in connection with nephritis, and affects the brain-substance as well as the membranes.

Inflammatory œdema is set up within the substance of the brain and cord in the neighborhood of foci of inflammation, sometimes also around tumors and patches of softening. In the membranes it may be the chief symptom of a slight meningitis, though it accompanies almost every form of localized disease of the superficial parts of the central nervous system. In the ventricles and central canal it results from inflammatory changes in the vessels of the plexuses and the ependyma, and is sometimes very extensive. It is acute or chronic according to the affection which induces it. When the inflammatory effusion in the ventricles is abundant the convolutions are compressed against the skull and flattened, while the blood and lymph are gradually squeezed out of the enveloping membranes.

Acute general **congestive œdema** of the brain is said to be commonest in children and as a result of acute congestive hyperæmia. The sudden congestion increases the intra-cranial pressure, and so compresses the capillaries and veins that the outflow of blood from the meninges is hindered: in this way secondary engorgement and œdema are produced (HUGUENIN).

It is not possible to distinguish sharply between congestive and inflammatory œdema: on the contrary it is highly probable (JÜRGENSEN) that so-called congestive œdema often represents merely an early stage of a rapidly fatal inflammation (Arts. 652, 653).

When the brain and cord diminish in size, the space they leave unoccupied is usually filled up by the collection of liquid in the subarachnoid space: this is described as **meningeal dropsy ex vacuo**. Sometimes the ventricles are at the same time dilated. The volume of the brain may diminish rapidly as in extreme anæmia, profuse diarrhœa, infantile marasmus, etc. or slowly and gradually as in senile atrophy. The like happens to a limited extent when parts of the brain or cord lying just beneath the ependyma or pia mater are lost in consequence of some destructive process. When the nerve-substance in the interior of the central organs undergoes atrophy the space vacated is sometimes filled by liquid gathering in the circumvascular channels of the affected region itself. This is especially apt to occur when the atrophy has been preceded by abnormal dilatation of the vessels or distention of the lymphatics within the brain, so that the circumvascular lymph-spaces are already abnormally capacious. If the condition is wide-spread, affecting a considerable number of vessels, the brain on section appears riddled with perforations and the condition is referred to as *état criblé* (Art. 643).

Extensive loss of substance in the interior of the brain or cord, whether due to hæmorrhage, softening, or inflammation, leads (after absorption of the detritus) to the formation of cavities which are generally

filled up in part by clear or turbid liquid: these are described as **cysts**. If they are small and numerous the apparent perforation of the tissue is also described as *état criblé* ('Gruyère cheese condition': see SAVAGE and WHITE, *Trans. Path. Soc.* xxxiv. 1883).

Vesicular œdema or cysts of the pia mater would appear to depend on the presence of closed lymph-spaces, congenital or acquired, in the pia mater and subarachnoid tissue.

An interesting affection of the cord called **syringomyelia** should be mentioned in this connection. The term is applied to a condition in which fissures and cavities occur, chiefly in the posterior gray commissure and about the median plane, and often extending longitudinally over a considerable distance. Not infrequently the excavation extends into the posterior horns, traversing them sometimes transversely sometimes obliquely, or into the posterior columns; very rarely extending as far as the anterior horns, the anterior commissure, or the lateral columns.

These fissures and cavities may occur in any part of the cord, they have even been observed in the medulla oblongata (SCHULTZE). They are always enclosed by a delicate more or less cellular neuroglial tissue, and are in part due to the breaking down of some gliomatous proliferation of this tissue. Their contents are either clear liquid or a kind of hyaline jelly. The proliferation which precedes their excavation starts as a rule in the neuroglia about the central canal, though it may also originate in remoter portions of either gray or white matter. From the facts at present before us it seems likely that the starting-point in most cases is some congenital histological anomaly in the posterior commissure, which interferes with the closure of the central canal and so with the development of the posterior columns. In many cases syringomyelia is thus a consequence of congenital hydromyelia (LEYDEN), and that either because some abstricted remnants of the medullary tube persist behind the central canal, or because malformation of the central canal is associated with histological changes in the parts about it which predispose to abnormal proliferation and subsequent disintegration of tissue (Art. 650). With reference to the supposed abstriction and persistence of parts of the medullary tube it should be mentioned that several observers (SCHÜPPEL, PICK) have recorded instances of duplication and even triplication of the central canal for some part of its length, each tube being lined with cylindrical epithelium.

Various explanations of syringomyelia have been given. SIMON and F. SCHULTZE refer it to the disintegration of proliferous neuroglia. LANGHANS maintains that obstructions to the flow of blood or lymph, such as are caused for example by the growth of tumors, give rise to dilatations and even sacculations of the central canal. Such saccular diverticula extend through the posterior columns and adjacent parts usually in a downward direction, and so form as it were a segment of a second canal behind the central canal. Dropsical lacunæ may also be formed by the collection of gelatinous liquid in the gray commissure

and the posterior horns. The appearances would thus be accounted for. LEYDEN regards syringomyelia as resulting from congenital hydromyelia in the manner described in the text. WESTPHAL takes a like view, which is rendered at least possible by the fact that the central canal even in a fœtus of the fifth month still extends to the posterior margin of the cord.

ZIEGLER agrees with those who think the affection is essentially due to an excavation of proliferous neuroglia. LANGHANS is no doubt right in stating that tumors of the cord and medulla give rise to very remarkable dilatations of the central canal, and it is not hard to believe that actual diverticula are occasionally produced. But these should properly be considered as cases of hydromyelia, and they do not exclude the possibility of an excavation of proliferous tissue; to this latter it would perhaps be well to limit the term syringomyelia. Probably too we shall be right in referring the whole process to a congenital anomaly of development, the proliferation depending on some morbid structure of the neuroglia, accompanying or following upon defective closure of the canal or defective elaboration of the gray or white matter in its neighborhood.

References on syringomyelia and duplication of the central canal:—NONAT, *Archives générales* 1838; GULL, *Guy's Hosp. Reports* VIII. (1862); HALLOPEAU, *Archives générales* 1871-72; VIRCHOW, *Virch. Arch.*, vol. 27; KESTEVEN, *St. Barth. Hosp. Reports* VIII. (1872); WESTPHAL, *Arch. f. Psychiatrie* v. (1874), *Brain* VI. (1883); SIMON, *ibid.*; LEYDEN, *Klinik d. Rückenmarkskr.* II. 1877, *Virch. Arch.* vol. 68; STRÜMPPELL, *Arch. f. Psych.* x.; FRIEDREICH, *Virch. Arch.* vols. 26, 27; GRIMM, *ibid.* vol. 48; LANGHANS, *ibid.* vol. 85; REISINGER, *ibid.* vol. 98; F. SCHULTZE, *ibid.* vol. 87; SCHÜPPEL, *Arch. d. Heilk.* VI. (1864); PICK, *Arch. f. Psych.* VIII.; WITKOWSKI, *Arch. f. Psych.*, XIV. (1883); FÜRSTNER and ZACHER, *ibid.* XIV.; TAYLOR, *Trans. Path. Soc.* XXIX. (1878), XXXV. (1884); WHIPHAM, *ibid.* XXXII. (1881); KRAUSS, *Virch. Arch.* vol. 101; HARRIS, *Brain* VIII. (1886).

On cysts of the meninges, choroid plexus, etc.:—ZENKER, *Virch. Arch.* vol. 12; HAECKEL, *ibid.* vol. 16; LUSCHKA, *Die Adergeflechte d. mensch. Gehirnes* Berlin 1855; ROKITANSKY, *Path. Anat.* III. London 1850; RIPPING, *Cystoide Degen. d. Hirnrinde*, *Allg. Zeitschr. f. Psych.* vols. 30, 32 (1874-65); SCHOPFHAGEN, *Wiener Sitzungsber.* LXXIV. (1876); SCHLESINGER, *Arch. f. Psych.* x.; ARNDT, *Virch. Arch.* vols. 63, 72.

According to BUHL (*Henle's Pfeuffer's Zeitschr. f. rat. Med.* IV. (1858)) the amount of water in the brain in typhoid fever increases up to the beginning of the third week, the increase amounting to 9 or 10 per cent above the normal.

CHAPTER XCIV.

SIMPLE AND DEGENERATIVE ATROPHY.

638. In all **degenerative processes** affecting the central nervous system the nerve-elements are the first to disintegrate and disappear, while the neuroglia frequently persists unchanged or actually increases.

Ganglion-cells atrophy by simple shrinking of their protoplasm without visible change of structure; when they lose their processes they appear as little shrunken specks (Figs. 257, 258, Art. 640) and at length disappear altogether: this is **simple atrophy**.

Pigmented ganglion-cells as they shrink appear to be still more



FIG. 250. DEGENERATION OF CELLS AND FIBRES FROM THE CEREBRAL CORTEX.

(From the border of an encephalitic patch eight days old: the preparation macerated in Müller's fluid and then teased out: $\times 300$.)

- | | |
|--|--|
| a, swollen and hyaline ganglion-cells, with processes already splitting up | a ₂ , cell resolved into oil-globules |
| a ₁ , pale denudeated cell beginning to split into fragments | b, axis-cylinder swollen up and splitting |
| | c, normal ganglion cell |

deeply tinted; indeed it sometimes looks as if the actual amount of pigment were increased during the atrophic process. This form has been called **pigmentary atrophy**.

In acute destruction of the ganglion-cells, such as occurs in the neighborhood of inflamed areas, after sudden compression, anæmic and hæmorrhagic softening, and so on, the cells and their processes frequently swell up (Fig. 250) and become pale and hyaline (a). Some-

times vacuoles appear, and the nuclei partake of the general swelling. After a time the cells split up and dissolve away (a_1), the nuclei at the same time disappearing. **Fatty degeneration** of the cells may also occur (a_2) under the same conditions, but it is more common in cases where chronic or recurrent disorder of the circulation leads to defective nutrition of the cells. In such cases it may be the only change that is perceptible: it may occur in patches or extend over the cortex. Fatty change of this kind is met with in many forms of mental disease.

When the ganglion-cells have once perished, whether from inflammation, anæmia, sudden compression, or other cause, and do not at once dissolve, they sometimes undergo **calcification** (Fig. 251), becoming as it were tightly crammed with particles and spherules of calcareous matter. FRIEDLÄNDER found a calcified ganglion-cell thirteen days after a



FIG. 251. CALCIFIED GANGLION-CELLS AND FIBRES.

(From the brain of a hemiplegic idiot with unilateral hydrocephalus: $\times 300$.)



FIG. 252. DEGENERATION OF THE CORD FROM PRESSURE.

(White matter teased out: $\times 300$.)

- a*, nerve-fibre with coagulated myeline
- b*, axis-cylinder with myeline attached
- c*, naked axis-cylinder, c_1 another much swollen
- d*, free globules of myeline
- e*, free detritus
- f*, granule-spheres (cells crammed with detritus)
- g*, small round-cells (leucocytes)

wound of the part. In chronic diseases the cells sometimes take on a glistening wax-like appearance, a change which has been described as sclerosis of the ganglion-cells.

In the **degeneration of nerve fibres** (at least of the medullated kind) the medullary sheath is the first part to disintegrate. When for example a portion of the brain or cord is destroyed by traumatic violence or by anæmic or inflammatory softening, the disintegrated tissue contains nerve-fibres whose sheath consists of myeline in a peculiar state of coagulation (Fig. 252 *a*), together with naked or sheathless axis-

cylinders (cc_1), free drops or globules of myeline (d), and small spheres (e) of fatty detritus derived from the disintegration of myeline. The axis-cylinders are sometimes unaltered, sometimes greatly swollen (c_1), with such irregular and wavy outlines that they have been described as varicose. Soon they become fragmented and are absorbed; sometimes however globular masses of altered myeline accumulate at certain points of their length and thus give them a varicose appearance (b) from another cause.

The process of degeneration is similar in cases that are chronic or less acute, as in the peripheral parts of nerves that are severed from their centres (Art. 646).

Wherever nerve-fibres thus undergo degeneration it is sooner or later



FIG. 253. DEGENERATING PATCH FROM A CASE OF MULTIPLE SCLEROSIS OF THE BRAIN.

(Prepared by treating with perosmic acid and teasing: $\times 200$.)

a, blood-vessel filled with blood
 b, tunica media
 c, adventitial lymph-sheath
 d, unaltered neuroglia cells
 e, fatty neuroglia cells
 f, binuclear neuroglia cells

g, sclerotic tissue
 h, lymphoid cells and leucocytes
 h₁, cells containing a few oil-globules
 h₂, fat-granule cells
 h₃, pigment-granule cells

accompanied by extravasation of liquid and of white blood-cells from the neighboring vessels. Part of the detritus dissolves in the exudation and is thus absorbed. The undissolved remainder is taken up chiefly by the white blood-cells which thus become myeline-carriers and fat-granule cells (Fig. 252 *f*, Fig. 253 *h₂*). The latter are always present when disintegrative processes are going on. If blood should have escaped from the

vessels during the process, pigment-granule cells (Fig. 253 *b*,) will also be found.

The free detritus and the carrier-cells are in the course of time conveyed into the circumvascular lymph-channels (Fig. 253 *c*) of the affected region and by them removed.

When the degeneration is extensive not only the neighboring lymphatics but also those more remote are crammed with granules and granule-carrying cells. If these reach the meshes of the pia mater or the subarachnoid space they give the tissue a milky and turbid appearance.

Corpora amylacea (Art. 61), which are normally met with in the brain-tissue, are found in increased numbers where degeneration has taken place.

Regeneration of the nerve elements of the brain and cord appears never to occur, at least in man. When ganglion-cells and the nerve-tracts corresponding to them are once destroyed, the functions they performed can only be restored by the substitution of equivalent centres and tracts capable of functionally replacing them.

The above-mentioned form of disintegration of the myeline of nerve-fibres is usually described as fatty degeneration, inasmuch as the myeline-detritus after a time gives the microchemical reactions of fat.

When the tissues of the brain and cord, with their membranes and lymphatics, are found to contain granule-carrying cells, it may in general be regarded as evidence that disintegration of nerve substance has taken place at some place or other. According to JASTROWITZ (*Arch. f. Psych.* II.) this applies only to persons more than seven months old. From the fifth month of gestation to the seventh month after birth such granule-cells occur normally in various parts of the central nervous system, depending on the stage of growth: they appear to be connected with the development of the medullary nerve-sheaths. According to BOLL the material for the formation of these sheaths is brought to the fibres by migratory cells. Formerly their presence was supposed to indicate a morbid change described as **congenital encephalitis**. VIRCHOW has however re-asserted (*Berl. klin. Woch.* 46, 1883) the pathological nature of the granule-cells found in the brain of new-born infants, arguing that the granules give the microchemical reactions of fat but not those of myeline, that they are not constantly found, and that they are accompanied by swelling of the neuroglia-cells and multiplication of nuclei, and that occasionally some degeneration of nerve-tissue is present. The granule-cells are either scattered diffusely or grouped in clusters which form opaque white patches on the grayish-red surface of the foetal brain, and are quite visible by the unaided eye.

Not infrequently the pia mater about the base of the brain exhibits a deep-brown **staining**. It is usually due to an exceptional development of the stellate pigment-cells normally found in the pia mater, and is therefore not pathological. Morbid pigmentation of the membrane is as we have seen sometimes caused by hemorrhagic effusions.

The mode in which the **amyloid concretions** are produced is not certainly known. CECI has recently (*Transunti d. real. accad. dei Lincei* v.) called attention to the fact that they do not always give the iodine-reaction, while they are stained brown or black by perosmic acid, differing in this from ordinary amyloid

substance. In their double refracting power and in their reactions they resemble myeline, and CECI suggests that they may consist of or be derived from that substance.

The question of the regeneration of the tissues of the central nervous system and especially of the cord has frequently been the subject of experimental enquiry. H. MÜLLER experimented on lizards and fishes (*Ueb. Regeneration d. Wirbelsäule u. d. Rückenmarkes* Frankfurt 1864), MASIUS and VANLAIR *Mém. de l'acad. de Belgique* XXI. (1870) on frogs, while BROWN-SÉQUARD (*Gaz. méd.* 1849, '50, '51), EICHHORST and NAUNYN (*Arch. f. exp. Path.* II.), DENTAN (*Rech. sur la régénération de la moëlle épinière* In. Diss. Berne 1875), and SCHIEFFERDECKER (*Virch. Arch.* vol. 67) used dogs. Some of the results were negative, others pointed to functional and histological regeneration of the severed cord. Nevertheless it cannot be considered as proved that this regeneration takes place in mammals.

References on the behavior of ganglion-cells and nerve-fibres in degeneration:—VIRCHOW, *Virch. Arch.* vols. 10, 44, 50; LEYDEN, *Klinik d. Rückenmarkskr.* 1874-76, *Zeitschr. f. klin. Med.* I. (1879); OBERSTEINER, *Wiener med. Jahrb.* III., IV. (1879); JAHN, *Arch. f. Psych.* VIII.; ZENKER, *Arch. f. Ophthalm.* II.; MÜLLER, *Beitr. zur path. Anat. d. Rückenmarkes* Leipzig 1871; CHARCOT, *Maladies du syst. nerv.* Paris 1877-80; *Diseases of the nervous system* (New Syd. Soc.) London 1876-80; MESCHÉDE, *Virch. Arch.* vol. 34; MÖBIUS, *Schmidt's Jahrb.* 190, 193 (a summary of recent memoirs on nervous diseases); WIEGER, *Virch. Arch.* vol. 78 references on hyaline degeneration of cerebral vessels); HADLICH, *ibid.* vol. 46; SALVIOLI, *Rivista clin. di Bologna* 10, 1878; ROTH, *Virch. Arch.* vol. 53; FRIEDLÄNDER, *ibid.* vol. 88. The last three authors refer specially to calcification of ganglion-cells either as an accompaniment of degeneration or as an independent affection. VIRCHOW met with it chiefly as a consequence of concussion of the brain. On senile degenerative changes in the cells of the cortex see KOSTJURIN and HESS, *Wiener med. Jahrb.* 1886.

639. When a large area of nerve-tissue is destroyed the neuroglia is apt at the same time to undergo partial necrosis, or at least to show evidence of fatty degeneration in its tissue-cells (Fig. 253 *e*). In like manner the endothelium of the pia mater and of the blood-vessels may become fatty. When the destruction of tissue is less extensive the nerve-elements alone persist, while the neuroglia with its vessels and their supporting fibrous structures remain intact.

After absorption of the products of disintegration of the nerve-elements the neuroglia of the white matter of the brain has the appearance of a network of anastomosing stellate cells (Fig. 254 *bb*₁). The fibrils of these cells are very fine, and in hardened sections at least have a granular appearance, which is most marked in recent preparations where the degeneration is not advanced. When the absorption of the nerve-tissue is incomplete, the meshes of the connective tissue contain particles of detritus and granule-carrying cells (Fig. 254 *e*).

The white matter of the cord in degeneration resembles that of the brain (Fig. 255 *B*), but the network (*c*) of connective tissue which originally surrounded the parallel nerve-fibres appears much more regular and at the same time stouter. The meshes contain either liquid or the

detritus of the nerve-fibres together with granule-cells (*d*) and a few leucocytes.

The neuroglia of the gray matter, like that of the white, may persist after the nerve-elements have disappeared. The tissue in hardened sections appears granular (Fig. 258) and beset with the nuclei of neuroglia-cells. In the cortex of the brain fibrils make their appearance which at their intersections exhibit small masses of protoplasm with or without nuclei. Here and there cells can be seen giving off processes resembling the fibrils. As degeneration proceeds a delicate granular meshwork (Fig. 260 *a* Art. 642, Fig. 271 Art. 650), with cells placed at some of the intersections, is all that remains. Ultimately this too disappears, so that nothing persists but the blood-vessels (Fig. 260 *b*, Fig. 254 *cc*).

In many cases the persisting neuroglia itself ultimately perishes. In

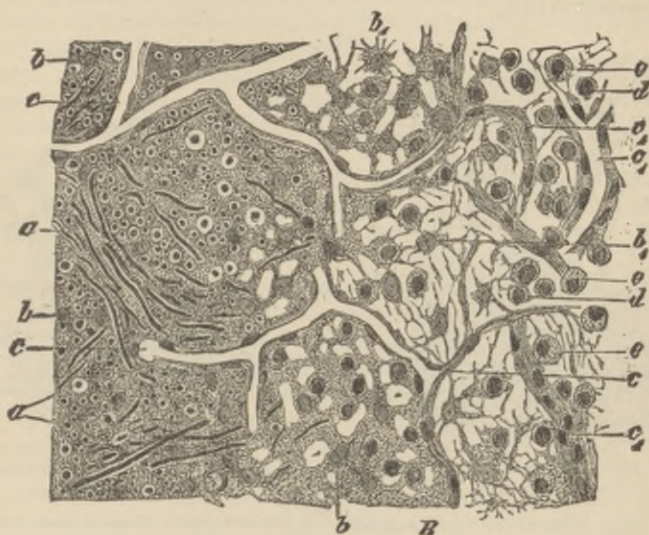


FIG. 254. SECTION THROUGH THE MARGIN OF A PATCH OF SOFTENING IN THE BRAIN.

(Hardened in Müller's fluid, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 250$.)

A normal tissue

- a*, nerve-fibres cut across at various angles
- b*, normal neuroglia-cells
- b*₁, persisting neuroglia-cells
- c*, blood-vessel
- c*₁, blood-vessel with thickened sheath

B degenerate tissue

- d*, extravasated but unaltered white blood-cells
- e*, fat-granule cells which have lost their fat during the treatment of the section with alcohol and clove-oil

others it remains quiescent or undergoes hyperplasia. So far as can be made out the process begins by subdivision and multiplication of the persisting nuclei of the tissue-cells (Fig. 253 *f*, Fig. 254 *B*). This is followed by cell-multiplication and fibrillation, and the resulting new tissue appears like a felted mass of delicate translucent fibrils and nucleated cells, enclosing particles of detritus and liquid (Fig. 253 *g*,

Fig. 256 b). Some of the fibrils are connected with the neuroglia-cells, forming processes as it were; others seem to have no such connection (Fig. 253).

Frequently the walls of the blood-vessels, and especially the adventitial tissue, take part in the hyperplastic process. The vessels then look as if beset and studded with proliferous cells, and the adventitia is thicker and more densely fibrous than usual (Fig. 254 c₁).

So long as a degenerating patch contains detritus of nerve-tissue it appears white and opaque and is of soft consistence. If the disintegration is extreme it may be almost diffuent on section. After absorption of the products of disintegration the tissue becomes gray and translucent. When hyperplasia of the neuroglia ensues a gray gelatinous patch is formed; such patches are occasionally described as instances of **gray degeneration**.

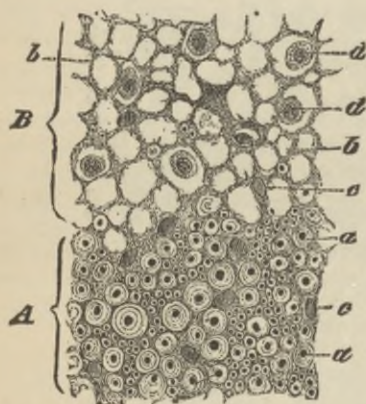


FIG. 255. ASCENDING DEGENERATION OF THE CORD (RECENT).

(Section taken from a cord which had been severely compressed ten weeks before: hardened in Müller's fluid, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 250$.)

A normal white matter
B degenerate white matter

a, normal nerve-fibres
b, neuroglia
c, neuroglia-cells
d, fat-granule cells (fat dissolved out)

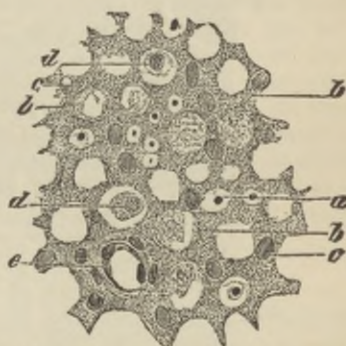


FIG. 256. ASCENDING DEGENERATION OF THE CORD (ADVANCED).

(Section taken from a cord severely compressed eighteen months before: prepared as in Fig. 252: $\times 250$.)

a, section across nerve-fibres
b, hyperplastic neuroglia
c, nuclei of neuroglia-cells
d, fat-granule cells (fat dissolved out)

When the new-formed fibrils are scanty and their meshes wide and filled with liquid, the patch is soft; on section it allows the liquid to escape and retracts below the general surface. If the fibrils are abundant and the resulting felted mass close-meshed, the patch is firm and dense. These two varieties correspond to soft or **gelatinous degeneration** and firm gray degeneration or **sclerosis**. The sclerotic tissue by con-

traction may become tough and cicatricial, but this requires months and probably years.

The behavior of the blood-vessels varies according to the form of the degenerative process. As a rule however in the later stages hyperplasia of the adventitia and thickening of the vessel-walls take place.

The more intimate structure of the neuroglia or supporting framework of the nervous system, and the significance of its several elements, are matters which are still under discussion.

SCHWALBE distinguishes three constituents, namely (1) the epithelium of the ventricles and central canal, (2) the neuroglia, which in life forms a homogeneous cementing substance between the nerve-elements, but after death is resolved by coagulation into delicate reticular fibrils, (3) a 'granular substance' which forms a very close-meshed network and is composed of neuro-keratin (SWALD and KÜHNE). All of these, he says, are derived from epithelial structures. The neuroglia it is true contains flattened (endotheloid) cells, but they are to be regarded as migratory cells which have become modified.

KÖLLIKER, DEITERS, JASTROWITZ, BOLL, LÖWE, GOLGI, FRIEDMANN, and others assign the neuroglia to the connective tissues, and give as its constituents a fibrillar network, a granular matrix or ground-substance, and cells both stellate and simple.

SCHWALBE's account of the neuroglia does not agree with the experience of pathologists. It is a tissue which to some extent is *sui generis*, some of its properties resembling those of no other structure; but it must nevertheless be classed with the connective tissues.

Both gray and white matter contain besides nerve-cells round or oval cells with scanty protoplasm and numerous fine processes either radiating in all directions (stellate cells) or running more or less parallel (Fig. 253 *ef*, Fig. 254 *c*, Fig. 268). These were first described by DEITERS and are called Deiters' cells. The number of the processes and the form of the cells vary much in different parts.

There are also certain rounded or polygonal cells without processes, which are either undeveloped Deiters' cells or migratory cells.

The ground-substance surrounding the cells consists of a finely-granular reticulate structure through which the processes of the cells ramify. It is not yet certain whether all the fibrils that are seen communicate with cells. In the white matter the granular structure is scanty or absent, in the gray matter it is abundant, and the nerve-fibres and ganglion-cells seem as if embedded in it. It is questionable however whether the ground-substance is granular during life. According to GIERKE (*Neurol. Centralbl.* 1883, *Arch. f. mikrosk. Anat.* xxvi. 1885) it is homogeneous and transparent.

SCHULTZE and RUMPF (*Cent. f. med. Wiss.* 1878) have found that in hyperplasia of the neuroglia, where a dense felted mass of fibrils is produced, the so-called neuro-keratin of KÜHNE does not increase in quantity, and the new fibrils react to digestive agents just like fibrous tissue.

The terms gray degeneration and sclerosis have been used as if they were equivalent terms. Strictly speaking *σκληροσ* means hard and dry, and the term sclerosis should be limited to hardening accompanied by loss of moisture (Art. 650).

References on the histology of the central nervous system:—HENLE and MERKEL, *Zeitschr. f. rat. Med.* (3d series) vol. 34; LOCKHART CLARKE, *Phil. Trans.* 1851, '58, '59, '62; DEITERS, *Unters. über Gehirn u. Rückenmark* Brunswick 1865;

MEYNERT, *Bau d. Grosshirnrinde* Neuwied 1869; GERLACH, *Stricker's Man. of Histology* II. (New Syd. Soc.) London 1872; JASTROWITZ, *Arch. f. Psych.* II., III.; BOLL, *ibid.* VII. (1873); LÖWE, *ibid.* VII. (1877); STIEDA, *Zeitschr. f. wiss. Zool.* XVIII., XIX., XX., XXIII., XXV.; RANVIER, *Comptes rendus* LXXVII. (1873), *Histologie du syst. nerv.* Paris 1878, *Arch. de physiol.* XV. 1883 (structure of neuroglia); GOLGI, *Rivista clinica* Nov. 1871, *Arch. ital. de biologie* III., IV.; SCHWALBE, *Handb. d. Augenheilk.* (Gräfe and Sämisch) I., *Lehrb. d. Neurol.* Erlangen 1881; FRIEDMANN, *Jahrbücher f. Psych.* 1883; EWALD and KÜHNE, *Verh. d. nat. med. Vereines zu Heidelberg* I.; DUKE KARL THEODOR of Bavaria, *Virch. Arch.* vol. 69; J. WEISS, *Med. Jahrbücher* 1878; TURNER, *Journ. of Anat. and Physiol.* XIII. 1879 (descriptive summary of recent memoirs); SCHOPFFHAGEN, *Jahrbuch f. Psych.* III. (1881); KLEIN and NOBLE SMITH, *Atlas of Histology* London 1880, *Quain's Anatomy* II. London 1882; HOLLIS, *Journ. of Anat. and Physiol.* XVII., XVIII., XIX.

640. **Simple atrophy.** This term is applied to those changes in the brain and cord which are characterized by dwindling and partial disappearance of the nerve-elements without any marked textural alteration either preceding or following. The atrophy is either general or at least extensive, or it is confined to particular parts of the brain and cord.

Atrophy of the **cerebrum** is the commonest example of the extensive form; the whole or the greater part of the hemispheres diminishing more or less in volume, the gyri becoming narrower, and the sulci with the subarachnoid spaces wider and filled with liquid. Not infrequently the ventricles also are dilated.

Atrophy of the **cerebellum** or of the **medulla** and **cord** is much less common: cases are however recorded in which the cerebellum was so shrunken that its volume was less than half the normal and its gyri were almost filiform. In most instances the atrophy is not uniformly diffused, but is most evident in one or two of the lobes or in particular convolutions. The atrophied parts are usually firmer and denser than the healthy parts.

Atrophy of the pons, of the medulla, and of the cord, is sometimes symmetrical, sometimes unsymmetrical, and may affect the nerve-tracts as well as the ganglion-cells.

The forms of local atrophy most amenable to microscopical investigation are those which are met with in the anterior horns of the cord and in the motor nuclei of the medulla (bulbar nuclei), and which form the anatomical basis of certain nervous diseases variously named by clinical observers.

The anterior horns (Fig. 257) of the cord consist of a tissue whose characteristic elements are large multipolar ganglion-cells (*a*) and numerous tracts of medullated nerve-fibres (*b*), whence the anterior roots (*b*) of the spinal nerves take their origin. Between these elements is a complex texture of stout and slender nerve-fibres (*d*), the whole being embedded in a delicate nucleated neuroglia (*e*).

In simple **atrophy of the anterior horns** (Fig. 258) the ganglion-cells and then the nerve-fibres are lost; so far as can be made out they

simply dwindle and disappear. The ganglion-cells (*a*) lose their processes and shrink up into small pigmented lumps: when these perish nothing remains but a few grains of pigment, and even this may be ultimately removed by absorption. At length all but a very few of the

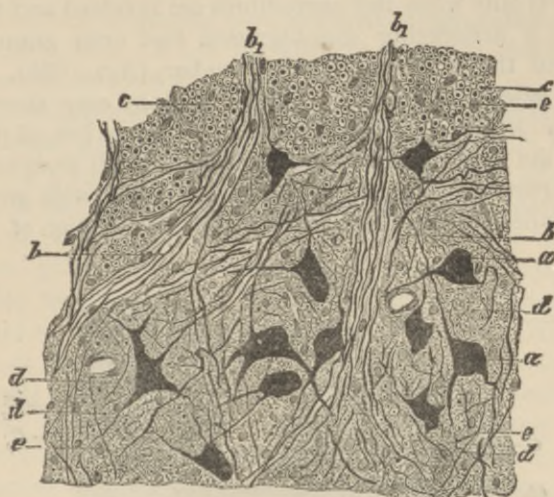


FIG. 257. LEFT ANTERIOR HORN (NORMAL) AT THE LEVEL OF THE FOURTH CERVICAL NERVE.

(Hardened in Müller's fluid and alcohol, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 150$.)

- | | |
|---|--|
| <i>a</i> , multipolar ganglion-cells | <i>c</i> , cross-sections of nerves in the adjacent white matter |
| <i>b</i> , horizontal nerve-tracts within the gray matter | <i>d</i> , nerve-fibres cut across more or less obliquely |
| <i>b</i> ₁ , anterior roots | <i>e</i> , nuclei of neuroglia-cells |

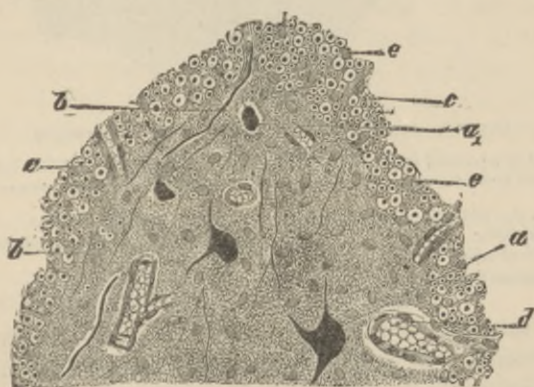


FIG. 258. LEFT ANTERIOR HORN (ATROPHIED) AT THE LEVEL OF THE FOURTH CERVICAL NERVE.

(From a woman aged 40 who died of ascending atrophy of the anterior horns: prepared as above: $\times 150$.)

- | | |
|--|--|
| <i>a</i> , normal ganglion-cells | <i>c</i> , cross-sections of nerves in adjacent white matter |
| <i>a</i> ₁ , atrophied ganglion-cells | <i>d</i> , blood-vessel |
| <i>b</i> , intact nerve-fibres in gray matter | |

cells and fibres (*a a, b*) disappear, and the anterior horn comes to consist chiefly of neuroglia.

Simple uncomplicated atrophy is not accompanied by any change of the connective tissue, and there is no trace of inflammatory mischief; moreover it is only when the nerve-fibres are involved and their medullary sheath is undergoing disintegration that even granule-cells are detected, and these in very small number (Art. 638). Sometimes **secondary sclerosis** follows. Simple atrophy may therefore be described as a primary affection involving simple loss of the nervous elements of the gray matter of the anterior horn; it leads to atrophy of the anterior roots of the spinal nerves, and paralysis with atrophy of the muscles supplied by them. It may attack any portion of the anterior

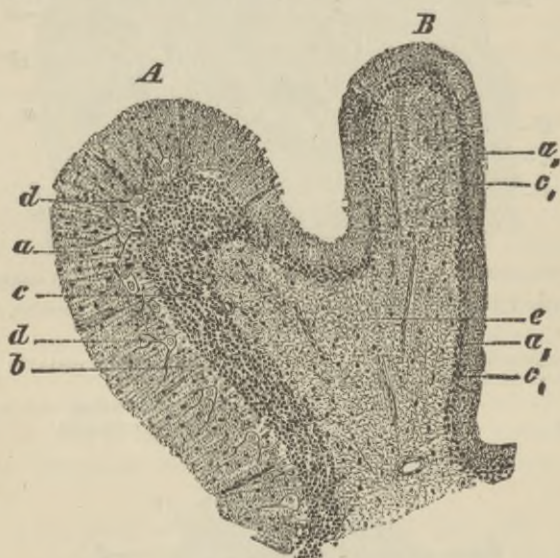


FIG. 259. ATROPHY OF THE CORTEX OF THE CEREBELLUM.

(From a man aged 25 who died in an epileptic fit; section hardened in Müller's fluid and alcohol, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 25$.)

A, normal,

a, normal external layer
 a₁, atrophied external layer
 b, normal intermediate layer

B, atrophied gyrus

c, normal, c₁ atrophied granular layer
 d, Purkinje's cells
 e, medullary (white) centre

columns, but most frequently begins at the upper or the lower extremity and thence extends. In the former case the motor nuclei in the medulla are usually soon involved, while in the ascending forms this is naturally a late symptom. The sensory nuclei in the medulla and the posterior columns of the cord are in general unaffected.

This peculiar affection may thus be characterized as a simple disappearance of the ganglion-cells of the motor centres of the cord and medulla. When it extends over the greater part of the length of the

cord it gives rise to a portion of the group of diseases spoken of as chronic atrophic spinal paralysis (*poliomyelitis anterior chronica*) and progressive muscular atrophy; when it involves the nuclei of the medulla it leads to some of the affections known collectively as chronic progressive bulbar paralysis and Duchenne's paralysis. Descending atrophy of the anterior horns is in general associated with degeneration in the pyramidal tract (Art. 647). When the atrophy begins in the lumbar cord this degeneration does not take place.

A similar disappearance of nerve-cells and nerve-fibres takes place both in the **basal ganglia** and in the **cerebral cortex**. When extensive it leads to a very marked loss of bulk in the parts affected. This loss of bulk is due partly to the entire disappearance, partly to marked dwindling, of the nerve-elements. In the cortex it is sometimes uniformly and widely diffused, sometimes in isolated patches.

The **white matter** like the gray is also liable to atrophy, which is either primary or secondary to atrophy of gray matter. When the bulk of a portion of the brain or cord is markedly diminished, the atrophic process extends to the white matter, and microscopic examination shows that some of the nerve-fibres in the latter have entirely disappeared while others have plainly undergone diminution of their thickness. In the disseminated or patchy form of atrophy the medullary white centre of the cerebrum often contains minute areas within which the tissue has a perforated or cribriform appearance; the nerve-fibres having disappeared a loose meshwork of neuroglia is all that remains. The adventitial lymph-spaces are in general dilated (Art. 637).

Atrophy of the laminæ of the **cerebellum**, when it is at all marked, is chiefly due to thinning of the cortical layers, though the medullary centre also suffers in a less degree. As the cells and nerve-fibres disappear the external (or molecular) layer (Fig. 259 *a*) of the cortex is reduced to a third or fourth (a_1) of its original thickness. The cells of Purkinje (*d*) and their processes disappear entirely, and with them the slender intermediate layer (*b*). Lastly the granular layer (*c*), losing its nerve-cells and fibres, becomes reduced to a mere film (c_1).

Loss of volume alone is not a certain mark of atrophy of the brain. Thus in infants suffering from chronic diarrhoea the brain may shrink so rapidly that the cranial bones overlap one another, but this is due in great measure simply to abstraction of liquid from the brain and its membranes.

Atrophy of the anterior horns of the cord can be certainly demonstrated only by examining a series of sections. The ganglion-cells are by no means uniformly distributed in different segments of the cord, and thus it may happen that a single section of a perfectly normal cord shows very few ganglion-cells, while neighboring sections show them in abundance.

Many authorities speak of pigmentary atrophy of the ganglion-cells as distinct from simple atrophy; but it does not appear that there is ever any real or marked increase of pigment in the cases they describe. As ganglion-cells normally containing pigment become smaller the pigment does not disappear, and they ac-

cordingly seem to have more of it in proportion to their size. Non-pigmented cells scarcely ever exhibit any pigment as they atrophy. It must however be admitted that occasionally after the disappearance of the cells the amount of pigment seems to increase.

Atrophy of the large ganglion-cells of the anterior horns is followed by atrophy (**amyotrophy**) of the corresponding muscles; but all muscular atrophy is not dependent on loss of the ganglion-cells. ERB, SCHULTZE, and others have described cases in which after recent atrophy of the anterior horns of gray matter the anterior nerve-roots were still intact, though the muscles showed signs of degeneration. From this it would appear that the muscles perish more rapidly than the nerve-fibres. Many authors affirm that loss of the anterior ganglion-cells is accompanied by an increase of the neuroglia. This is occasionally the case, but by no means uniformly: very marked atrophy may be unattended by any such increase. It is worth mentioning that after the total disappearance of the nerve-elements from a section of the anterior horns small granular masses remain, interspersed among the cells and fibres of the neuroglia. This would go to show that the granular-looking substance of the gray matter does not belong wholly to the nerve-fibres and ganglion-cell-processes, a view recently re-affirmed by RANVIER (*Arch. de physiol.* I. 1883).

Atrophy of the anterior horns with or without sclerotic change is often regarded as a chronic inflammation and described as *poliomyelitis anterior chronica*. In like manner ischæmic softening is sometimes regarded as a poliomyelitis. The genesis and course of these affections make it obvious that they are non-inflammatory and that such terms are inappropriate.

References on simple atrophy of the anterior horns and bulbar nuclei:—CHARCOT and JOFFROY, *Arch. de physiol.* 1869; PIERRET, *ibid.* II. (1875); CHARCOT and GOMBAULT, *ibid.*; DUCHENNE and JOFFROY, *ibid.* IV. (1870); CHARCOT, *ibid.*, *Diseases of the nervous system* London 1876-80; KESTEVEN, *St. Barth. Hosp. Rep.* XIII. (1878); SCHULTZE, *Virch. Arch.* vol. 75; CORNIL and LÉPINE, *Paralysie gén. spinale ant. subaiguë*, *Gaz. méd. de Paris* 1875; JARISCH, *Viertelj. f. Derm. u. Syph.* VIII. (1881); ERB and SCHULTZE, *Arch. f. Psych.* IX.; VIERORDT, *ibid.* XIV.; GOLDAMMER, *Berl. klin. Woch.* 1876; DÉJÉRINE, *Arch. de physiol.* VI. (1883); see also Art. 647, references on amyotrophic lateral sclerosis.

References on the structure of the cerebellar cortex and cerebellar atrophy:—DENISSENKO, *Arch. f. mikros. Anat.* XIV.; OBERSTEINER, *Allg. Zeitschr. f. Psych.* vol. 27, *Biolog. Centralb.* III. (1883); GOLGI, *Arch. ital. p. l. mal. nerv.* 1874, *Rivista sperim. di freniatria* 1882, 1883; FIEDLER, *Zeitschr. f. rat. Med.* XI. (1861); DUGUET, *Gaz. hebdom.* 1862; MEYNERT, *Med. Jahrb. d. Gesell. d. Aerzte in Wien* 1864; PIERRET, *Arch. de physiol.* IV. (1871-72); E. CLAPTON, *Trans. Path. Soc.* XXII. (1871); OTTO, *Arch. f. Psych.* IV.; FISCHER, *ibid.* V.; HUPPERT, *ibid.* VII.; BISCHOFF, *ibid.* XII.

641. Some of the conditions included under the general term atrophy are directly dependent on **aplasia** or agenesis (Arts. 630 and 633) of parts of the brain and cord. Many atrophies detected only in years of maturity are in fact aplasias dating from the foetal period. Other atrophies affect nervous structures which have from the beginning been ill-developed or ill-organized. The greater number of cases of cerebellar atrophy (Art. 640) unassociated with inflammation or tumor certainly belong to this latter class, as do also those cases of shrinking of the cerebrum in which close examination of the convolutions and their structure

shows that the atrophy coexists with local aplasias, such as partial defects of the gyri, etc. Atrophies of the cord, also, are frequently found associated with anomalies of its development.

When simple atrophy occurs without any visible cause in patients who have a family history of nervous disease, it is natural to suppose that the nerve-elements have had some intrinsic weakness of constitution which led to their premature decay and disappearance: and the same supposition is permissible even in cases where there is no such history.

GUDDEN and his pupils have shown that sensory as well as motor centres undergo atrophy and lose their ganglion-cells if at birth and or in infancy the peripheral end-organs or nerves are destroyed. The explanation is perhaps this—that in the absence of the end-organ the corresponding central organ is not called on to perform its function and so wastes, or at least fails to attain to complete development.

Loss of peripheral end-organs in later life is only to a slight extent followed by similar atrophy. Thus after amputation of the limbs no marked changes take place in the cord, the number of ganglion-cells and nerve-fibres is apparently unaltered. In a few cases the corresponding half of the cord has appeared to become smaller, probably from thinning of the nerve-fibres. At the same time it must be kept in mind that in fifty out of every hundred persons the cord is more or less unsymmetrical (from incomplete decussation of the pyramids), and this makes it difficult to be sure that in a given case asymmetry is due to pathological causes.

Loss of the eye and optic nerve leads after a time in the human subject to atrophy of the corresponding parts of the optic tract. When blindness has lasted for a number of years the atrophy is said (HUGUENIN) to extend up to the occipital lobe.

Senile atrophy of the brain, which is not at all uncommon, seems to be due in the first place to mere outwearing and decay of the nerve-elements, and in part also to diminution of the natural nutritive processes (see KOSTJURIN and HESS, *Wiener med. Jahrb.* 1886). Cerebral atrophy in younger patients reduced and weakened by disease is doubtless due chiefly to disordered nutrition.

Localized atrophy of nerve-cells and fibres within particular circumscribed regions is at times demonstrably induced by atheromatous and hyaline thickening of the vessel-walls (Art. 642), or by occlusion and obliteration of the circumvascular lymph-channels from extravasation of blood or hyaline deposit. As regards the various forms of nervous atrophy met with in persons who have long suffered from disordered circulation, we must assume that the general cause has led to the particular effect. Disease of the heart or of the lungs, chronic inflammation of the meninges (Arts. 655, 656), and intracranial tumors, all act in this way; in the latter case local compression leading to local anæmia (Art. 644) assists the more general causes. Lastly we must recognize

as causes of atrophy the many injurious agencies which reach the central nervous system by way of the blood, and so damage its constituent elements. As examples we may mention lead (VULPIAN, DÉJÉRINE, MONAKOW, POWOW, and others), and alcohol when taken constantly and for a long time.

GUDDEN (*Arch. f. Psych.* II., *Graefe's Arch. f. Ophthalmologie* XX., XXI., XXV., *Naturforscherversammlung in Eisenach* 1882) was the first to show that the extirpation of peripheral or central end-organs in young animals is followed by atrophy of the corresponding central or peripheral end-organs respectively and of the conducting tracts. Thus extirpation of one cerebellar hemisphere induces atrophy of the restiform body and its three nuclei on the same side and the olivary body on the opposite side. Extirpation of one anterior quadrigeminal body leads to blindness and proportionate wasting of the nerve-fibres of the optic tract on the opposite side. This method enables us to determine the central nuclei, the course, and the connections of the various cerebral and spinal nerves, and the connections between the nuclei of the cerebral axis, the cerebrum, and the cord. FOREL (*Arch. f. Psych.* VII.), MAYSER (*ibid.*), GANSER (*ibid.* XIII), FÜRSTNER (*ibid.* XII.), and MONAKOW (*ibid.* XII., XIII.) have applied the method, and thereby greatly increased our knowledge regarding the nuclei and tracts of the cerebral axis. MONAKOW (*Arch. f. Psych.* XII.) showed that extirpation of the visual centre in the occipital cortex in new-born rabbits is followed by atrophy of almost the entire visual tract, *i. e.* the corresponding part of the corona radiata (optic radiations of Gratiolet), the external geniculate body, the lateral (lattice) stratum of the external nucleus of the thalamus, to a less extent the anterior quadrigeminal body of the same side, the chiasma, and the opposite optic nerve. Extirpation of the eyeball leads to atrophy of the same parts, most marked however in the optic nerve of the same side and in the anterior quadrigeminal body of the opposite side. According to HAAB a like atrophy or rather aplasia is met with in cases of anophthalmia.

Our knowledge of the secondary degenerations of the visual tract is however still very defective, and minute investigation of the histological changes involved is much to be desired. Probably the first change is a disintegration of the medullary sheath of the nerve-fibres (Art. 646): the axis-cylinder appears to persist for a time. GUDDEN, SCHMIDT-RIMPLER, PURTSCHER, SAMUELSON, BAUMGARTEN, MARCHAND, and others have shown that atrophy of the optic nerve is after a time accompanied by wasting of the decussating bundles of fibres on the inferior or ventral aspect and of the non-decussating bundles on the dorsal aspect of the optic tract. We do not yet know how far this process of wasting may extend. SAMUELSON followed it up to the external geniculate body: HUGUENIN states that it extends to the occipital lobe. The descending atrophy induced by destruction of the visual centre in the cortex (hemianopsia) has not been fully investigated. LEBER thinks that in adults the trunk of the optic nerve does not atrophy after a cortical lesion, and only after a period of years when it is the optic tract that is destroyed. HOSCH (*Klin. Monatsbl. f. Augenheilk.* XVI.) alone seems to have actually observed atrophy of the optic nerve after destruction of the occipital lobe. It would appear from what we have said above that in the case of the optic nerve we may have an ascending atrophy, but the like has not been observed in the case of other sensory nerves. The only analogue is apparently the atrophy of the posterior columns of the cord observed to follow destruction of the posterior nerve-roots, and we might add the instance of ascending atrophy of the auditory nerve extending to the temporal lobe, which

HUGUENIN describes as having occurred in a patient who had been deaf for many years.

References on ascending atrophy of the visual tract:—LEBER, *Graefe and Saemisch's Handb.* v.; GUDDEN, *Arch. f. Ophthalm.* 1879; HAAB, *Beiträge z. Ophthalm., Festschrift für Horner* Wiesbaden 1881; KELLERMANN, *Beilage z. klin. Monatsbl.* 1879; PURTSCHER, *Graefe's Arch. f. Ophthalm.* XXVI. (1880); SAMUELSON, *Berl. klin. Woch.* 1880; BAUMGARTEN, *Cent. f. med. Wiss.* 1878; MARCHAND, *Graefe's Arch.* XXVIII.; MAUTHNER, *Gehirn und Auge* Wiesbaden 1881; DRESCHFELD, *Brain* IV. (1882).

On hemianopsia and destruction of the cortical visual centre see Art. 625.

DICKINSON (*Journ. of Anat. and Physiol.* III. 1868), DRESCHFELD (*ibid.* XIV. 1880), VULPIAN (*Arch. de physiol.* 1868), LEYDEN (*Klinik d. Rückenmarkskr.* II.), DÉJÉRINE and MAYER (*Gaz. méd. de Paris* 1878), and others have described cases of atrophy of the motor and sensory centres and tracts in the cord after **amputations** of the limbs. Objections may be taken to some of their statements, but it would appear that the posterior roots, posterior horns, and posterior columns may occasionally atrophy: the ganglion-cells and nerve-fibres do not disappear outright but become abnormally small and thin.

It is questionable whether in persons who in adult life have lost a limb the corresponding centres in the cortex ever undergo atrophy. SANDER (*Cent. f. med. Wiss.* 1875), LUYIS (*Gaz. des hôp.* 1876), BOURDON (*Recherches clin. sur les centres mot. des membres* Paris 1877, *Bull. de l'acad. de méd.* XII. 1883), and others have described such cortical atrophies, but it must be remembered that the width of the convolutions varies greatly even in persons otherwise normal. CHARCOT, FERRIER, and others have failed to find unmistakable instances. DAVIDA (*Virch. Arch.* vol. 88) and EDINGER (*ibid.* vol. 89) have found that when limbs are congenitally absent there is atrophy of the spinal nerve-roots, the corresponding gray matter, and the lateral columns of the cord, and in some cases (EDINGER, GOWERS) even of the corresponding cortical centres.

VULPIAN (*Maladies du syst. nerv.* Paris 1879), DÉJÉRINE (*Gaz. méd. de Paris* 1879), MONAKOW (*Arch. f. Psych.* x. 1880), POPOW (*Virch. Arch.* vol. 93), and others state that in paralysis from **lead-poisoning** there is degeneration not only of the muscles and peripheral nerves but also of the ganglion-cells of the cord and brain. It does not appear certain that lead gives rise to any primary atrophy of the central nervous system, though apparently there is no doubt that in lead-poisoning the brain may contain a large proportion of the metal, and that the affection may be accompanied by grave and chronic mental disorders. For reference see ROSS, *Diseases of the nervous system* II. London 1883, and ROBINSON, *Brain*, VIII. 1885.

642. **Ischæmic and hæmorrhagic softening.** The vessels of the brain and cord are peculiarly liable to morbid changes. Sclerosis and atheroma are more common in them than in those of almost any other organ, while the small arteries and capillaries of the central nervous system and its membranes might almost be called the favorite seat of hyaline degeneration. Fatty and calcareous change are exceedingly common, the latter being sometimes so extensive and so great that on section the vessels stand out from the brain-substance as little rigid tubes. Moreover corpuscular matters passing from the heart into the arterial system, and atheromatous detritus or fibrinous coagula from the

ascending aorta, are very readily swept through the cervical into the cerebral arteries.

The consequence is that it is very common for the arteries of the brain or cord to be suddenly or gradually occluded, the accident being followed by grave disturbance of the circulation and nutrition of the corresponding regions.

The arteries of the brain and cord have no arterial anastomoses within the nerve-substance, and thus after the closure of one of them collateral circulation is very slowly and imperfectly established. This is especially the case when the neighboring arteries are already rigid and obstructed by atheromatous or hyaline change in their walls.

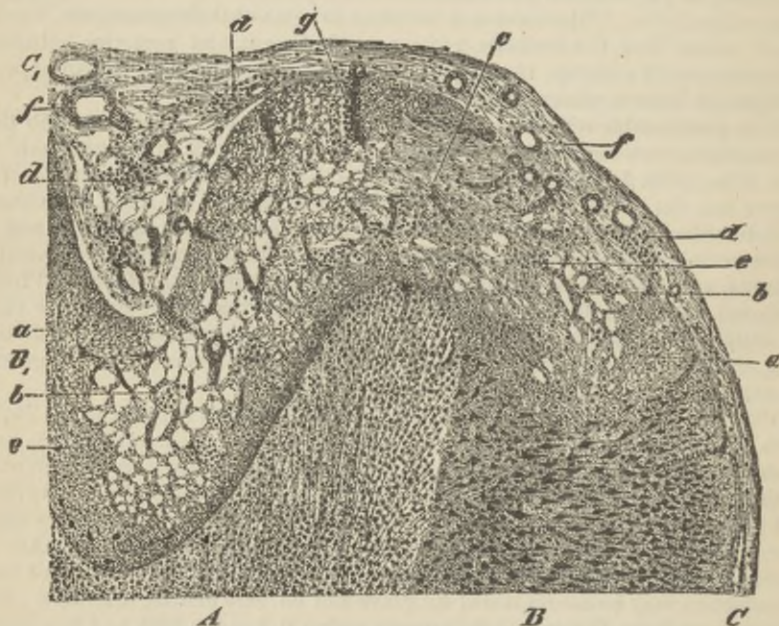


FIG. 260. ISCHÆMIC SOFTENING OF THE CORTEX OF THE BRAIN.

(From the brain of an idiot; hardened in Müller's fluid and alcohol, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 25$.)

A, white centre

B, normal cortex

B₁, softened cortex

C, normal pia mater

C₁, thickened pia mater

a, softened part of the cortex without ganglion-cells, the neuroglia still remaining in places

d, groups of cells in the subpial and subarachnoid spaces

b, part with little but the capillary network remaining

e, patch containing leucocytes, fat-granule cells, and pigment-cells

c, condensed fibrous-looking tissue

f, small blood-vessel

g, groups of cells in the circumvascular spaces

Engorgement, stasis, and hæmorrhage all lead to local anæmia or **ischæmia** of the particular regions affected. Hæmorrhage need not be at all large; even the smallest extravasations, confined it may be to the

pial sheaths of the vessels, have their effect, and other matters, such as products of disintegration, when they collect in these sheaths may by compression render the vessel impermeable to the circulation.

Lastly, compression of the nerve-substance by tumors, exudations, etc. (Art. 644) leads frequently to local anæmia or ischæmia.

When such temporary or permanent ischæmia gives rise to necrosis of the substance of the brain or cord, **softening** of the necrosed region speedily takes place. If the ischæmia is unaccompanied by hæmorrhage the tissue remains pale and at first only becomes softer and more brittle: this process is therefore described as **white softening**.

After a few days the substance of the organ is (owing to the rapid disintegration of the nerve-elements and the escaped liquid from the vessels) transformed into a pulpy mass, containing the products of disintegration described in Art. 638 together with fat-granule cells of every conceivable form.

In the course of weeks the process of liquefaction steadily advances, and at length nothing remains of the nerve-substance but a liquid mass rendered turbid by detritus and fat-granule cells. The blood-vessels usually persist (Fig. 254 *c*, Fig. 260 *b*), and thus the liquid appears as if lodged in the meshes of a delicate network of capillaries. After some months the liquid becomes clear, owing to the absorption of the products of disintegration.

Around the patch of softening the neuroglia proliferates and gives rise to **sclerotic thickening**, though this is seldom very marked. It is most apt to occur when the patch is small, the patient young, and the softening not due to arterial sclerosis. Often after weeks or months no considerable proliferation is discoverable, the softened patch being surrounded by a zone in which the nerve-elements are in process of degeneration and the tissue accordingly more or less interspersed with granule-cells.

The vessels within the softened patch become in part obliterated. Cellular and fibrous hyperplasia sometimes takes place in the pial sheaths both of the collapsed and of the permeable vessels.

When hæmorrhage accompanies the ischæmic softening the products of disintegration of the extravasated blood mingle with those of the nerve-substance and give the patch a red, yellow, rusty, or brown tint. The process is then described as **red** or **yellow softening**. The mass thus contains pigment-granule cells, and after a time flakes of yellow or brown pigment and occasionally crystals of hæmatoidin are deposited in the surrounding tissue.

On ischæmic softening see EISENLOHR (*Arch. f. Psych.* IX. 1878, on acute affections of the medulla and pons), KLEBS (*Prag. med. Woch.* 1879).

On hyaline degeneration of cerebral vessels see WEDL (*Wiener Sitzungsber.* XLIII. 1863), ARNDT (*Virch. Arch.* vol. 49), LUBIMOFF (*ibid.* vol. 57), BENEDIKT (*ibid.* vols. 64, 72), KOLESSNIKOW (*ibid.* vol. 85), NEELSEN (*Arch. d. Heilk.* XVII.

1876), OTTO (*Arch. f. Psych.* XVI., on aneurysms of the vessels of the cord), and references in Art. 636.

643. The size of a patch of softening depends on that of the vascular territory which has been deprived of blood, and consequently varies much in different cases. The smallest patches may be too small for the unaided eye, the larger may involve whole convolutions, important sections of the centrum ovale or of the basal ganglia, or even entire lobes.

The smaller patches after a time take the form of little cavities filled with clear liquid, and when numerous give the tissue a cribriform or sponge-like appearance. When the softening has occurred round a small arterial branch the space left vacant on absorption of the products of disintegration is often filled up by accumulation of liquid in the adventitial lymph-channel belonging to the vessel, which latter then looks as if it ran through a wide lymph-sac resembling that caused by simple localized lymphatic stagnation or engorgement. The condition in which the nerve-tissue is thus as it were riddled with small cavities is commonly described as an *état criblé* (compare also Art. 637).

The contents of large **cysts of disintegration** due to ischaemic softening are seldom quite clear, the absorption of the solid detritus being a very slow process, while at the borders of the softened region the disintegration of nerve-substance usually goes on to some extent for months or years after the initial lesion.

When such large cysts lie just under the pia mater or at least not very deeply, the overlying tissue in general sinks in and leaves a subpial or subarachnoid space which soon fills with liquid. The depressed surface looks opaque and white or tinged with yellow or brown. On section the softened patch is found to contain a milky (or sometimes pigmented) liquid traversed by shreds of tissue which are for the most part collapsed or still permeable vessels and capillaries (Fig. 260 B.).

The membranes overlying an old patch of softening are usually hyperplastic (*C*), the blood-vessels also often showing signs of thickening (*f*). A certain amount of cellular infiltration takes place not only into the walls of the cyst but also into the soft membranes (pia mater and subarachnoid), and this may continue as long as the process of disintegration goes on. Calcareous concretions are not infrequently formed in the thickened membranes, and the ganglion-cells in the parts contiguous to the cyst may also become calcified. When a patch of softening lies near a ventricle the latter usually becomes dilated by the falling away of its walls in the direction of the cyst of disintegration.

Ischaemic softening occurs at all parts of the central nervous system: in the brain the process is named briefly **encephalomalacia**, in the cord it has been called **myelomalacia**.

Softening of the cord affects the gray matter, the white matter, or

both together. It is interesting to observe that the anterior horns are more liable than other regions to undergo anæmic and hæmorrhagic softening: the anterior horn corresponds almost exactly with the vascular territory of one of the arterial twigs entering by the anterior longitudinal fissure, and when the circulation in it is suspended almost all the motor ganglion-cells in the corresponding half of the spinal segment must suffer.

Any part of the basal region of the brain may be the seat of softening, and the disorders of function thus induced are of the most various kinds. Occurring anywhere in the pyramidal (or motor) tract it leads to motor paralysis which is usually unilateral (hemiplegia): in the neighborhood of the bulbar nuclei or the conducting paths leading from them it gives rise to paralysis of one or more of the cranial nerves.

In the cerebrum softening occurs in the territory of the basilar or of the cortical arteries. Destruction of cortical centres thus brought about results in various motor and sensory paralyses. Thus destruction of the angular gyrus and occipital lobe implies loss of vision, destruction of the central convolutions and parietal lobe causes paralysis of the limbs on the opposite side, destruction of the left inferior-frontal convolution in right-handed persons induces motor aphasia, and so on. If the number of patches of cortical softening (Fig. 260) be great, all the functions of the brain may be more or less impaired.

Large and single or small and multiple softening occurring in the corona radiata or internal capsule lead to interruption of the motor tract and consequently to motor paralysis.

Localized softening in the anterior horns of the cord is followed by paralysis of special groups of muscles. Thus in a recent case observed by the author the muscles of one arm were paralyzed, in another one arm and the diaphragm; on examination patches of softening were in each case found in the anterior horn of the middle and lower portions of the cervical cord on the same side. Such ischæmic softenings of the anterior horns are frequently misdescribed by clinical observers as due to anterior poliomyelitis. EHRlich and BRIEGER (*Zeitschr. f. klin. Med.* 1884) found that after temporary ligature of the aorta, by which the lumbar cord was deprived of blood for half an hour, the gray matter and the anterior roots were completely degenerated, the white columns still remaining intact.

644. Softening from compression. When the substance of the brain or cord is in any way subjected to severe compression, degeneration of the compressed tissue sooner or later sets in. Such compression is most frequent in the case of the cord, every encroachment on the narrow spinal canal involving almost of necessity a pressure on the soft tissue which it cannot escape. For example, tuberculous granulations, caseous matter and pus collecting in the epidural space during inflammatory disease of the vertebræ, tumors of the bone, dura mater, or pia mater, hæmorrhagic effusion into the membranes, varicosities or angiomas

overgrowth of the pial vessels, dilatations of the central canal of the cord itself, dislocation of the vertebræ such as occurs in caries of the spine, all give rise to compression of the nerve-substance.

Loosening or rupture of the ligaments connecting the axis and atlas, such as occurs in carious disease of the upper cervical spine or occiput, or a blow on the back of the head or neck, may cause the odontoid process of the axis to press upon the medulla oblongata.

The injurious effect of sudden or gradual compression of the cord, apart from any mechanical damage of the tissues, is doubtless due in great measure to disturbance of the circulation, leading to more or less protracted anæmia of the nerve-substance. When this reaches a certain degree of intensity and duration anæmic necrosis and softening are induced. In like manner if the outflow of blood be hindered by the compression we have hæmorrhage from venous engorgement. The white matter is the first to soften; the gray matter usually persists for a time, its blood-supply being derived not from the periphery but from the vessels of the longitudinal fissures. According to KAHLER six hours after compression the axis-cylinders begin to swell up to such a degree that they sometimes seem to distend and stretch the meshes of the neuroglia. After the second day they begin to disintegrate, often becoming vacuolated in the process.

In the first week or two after compression the substance of the cord is white and opaque owing to the quantity of nerve-detritus which is present. Then it becomes more translucent, and at length gray and gelatinous, as the products of disintegration are absorbed. At the same time hyperplasia of the neuroglia sets in, and continues for some months, until the tissue is very considerably increased in amount and in density (Art. 639, Fig. 256). If the hæmorrhage has taken place during the process of softening the gray sclerotic tissue is more or less visibly pigmented.

Compression of the brain differs in its conditions from that of the cord much as the cranial cavity differs from the spinal canal. Thus if a meningeal tumor slowly encroaches on the space within the cranial cavity room is made for it by an efflux of lymph or cerebrospinal liquid from the brain, the latter so far altering its form as to become indented where the growth presses on it. The brain-substance remains uninjured unless the tumor is of considerable size: in this case it may cause a localized simple or degenerative atrophy. Degeneration is more common in cases of tumor growing within the brain, or of chronic cerebral abscesses, which by pressure on the sound tissue give rise to disturbance of the circulation.

Sudden encroachments are apt to damage the brain-substance, such for instance as are caused by hæmorrhages, or inflammatory exudations into the meninges or ventricles. Even sudden congestive hyperæmia may give rise to dangerous intracranial pressure.

Increased afflux of blood to the brain, inflammatory exudations, and hæmorrhagic effusions determine in the first instance an outflow of cerebrospinal liquid from the cranium into the spinal canal: sometimes indeed the liquid displaced is so abundant that the intervertebral ligaments bulge under its pressure. When however the intracranial pressure reaches a certain point no further displacement can take place, the capillaries of the brain are compressed, the circulation comes to a standstill, and the impaired nutrition of the nerve-elements results in impairment of their functions. If the pressure is not quickly relaxed by re-absorption of the effusion or by efflux of blood, so that the circulation is restored, and death does not at once ensue, extensive degenerative changes may take place in the parts first compressed. In remoter parts the pressure relaxes as the first give way. Thus it is very common to find a zone of softening immediately surrounding an extravasation of blood or an effusion into a ventricle, but not extending to any great distance.

References:—ERB, *Ziemssen's Cyclopædia* XIII.; LEYDEN, *Klinik d. Rückenmarkskrankh.* 1874-76; KAHLER and PICK, *Arch. f. Psych.* x.; CHARCOT, *Diseases of the nervous system* II. London 1880, *Gaz. méd.* 1874; BOUCHARD, *Dict. ency. d. sciences méd.* (second series) VIII.; MICHAUD, *Sur la myélite et la méningite dans les mal. vertébr.* Paris 1871; BERGMANN, *Deutsche Chirurgie* part 30, 1880; KAHLER, *Prag. Zeitschr. f. Heilk.* III.; ADAMKIEWICZ, *Wien. Sitzungsber.* XLVIII. 1883, *Wiener Klinik* VIII., IX. (1884); WERNICKE, *Fortschritte d. Med.* III. 1885.

KAHLER experimented on compression of the cord by injecting melted wax into the spinal canal. Sclerosis resulted only after several months.

645. **Softening from contusion and concussion.** When the substance of the brain or cord is contused or crushed, or even violently shaken, it frequently undergoes complete and rapid necrosis and ultimately disintegrates.

A moderately abundant spontaneous hæmorrhage may have this effect, but among mechanical causes the commonest are dislocation and fracture of the vertebræ, blows or falls on the head (concussion), cuts or stabs penetrating the bony coverings of brain or cord, and projectiles reaching the central nervous tissues. Splinters of bone, such for example as occur in depressed fracture of the skull, should also be included.

The death of the nerve-substance is doubtless due to the direct injury to its elements and the rupture of their connections, and in part to the disturbance of the circulation and consequent failure of nutrition.

When the injury is very extensive it may speedily result in death. Where the contusion is less severe, as in the case of a blow on the head, the part directly injured or even the entire brain is the seat of capillary hæmorrhage, so that on section it appears mottled or speckled with spots of red. Extreme violence may cause immediate disintegration of the tissue, so that it becomes a mere mass of *débris* and blood. Meningeal hæmorrhage is an almost invariable accompaniment.

The changes resulting from traumatic destruction of the nervous tissues, provided septic inflammation is excluded, exhibit the characters partly of anæmic and partly of hæmorrhagic necrosis. Liquefaction and absorption of the products of disintegration ensue, the process not being essentially different from that described in connection with ischæmic necrosis, though the subsequent inflammatory changes are apt to be somewhat more intense than in the latter case (Art. 658). If the traumatic softening is confined to the cortex of the brain, we find some time afterwards defects in the convolutions, which are covered over by a mass consisting of collapsed capillaries, unabsorbed detritus, and granule-cells. Sometimes sclerotic thickening of the underlying brain-tissue takes place.

It is worth remarking that the degenerative changes set up by traumatic violence such as we have just described occasionally go on for years after the initial injury, and that a gradually advancing disintegration of the borders of the softened region takes place, by which in the course of time a very extensive destruction of tissue is effected. Thus for example after a blow on the forehead the whole of the frontal lobe may perish. Probably this progressive destruction depends on some secondary disease of the blood-vessels or obstruction of the lymphatics, which gives rise to permanent disorder of circulation and nutrition.

If the effect of the initial injury is slight there may be no general disintegration of tissue, the damage perhaps not extending beyond the necrosis and calcification of a few ganglion-cells.

The changes in the cord are exactly similar to those in the brain under the same conditions (Art. 659).

The clinical symptoms of concussion of the brain and cord (*commotio cerebri et medullæ spinalis*), namely partial or total loss of consciousness, confusion of mind, muscular weakness, disorder of the functions of the cord, etc., are not dependent on the local damage alone. Even in rapidly fatal cases this damage may be but slight. There is in fact a disturbance of the functions of the entire organ, due doubtless to the mechanical shock which affects detrimentally the whole of the nerve-substance (KOCH, FILEHNE, WITKOWSKI, BERGMANN).

In infants who die soon after birth we often meet with subdural and intrameningeal hæmorrhages, due no doubt to rupture of the venous sinuses or sub-arachnoid veins from displacement and compression of the cranial bones in the act of parturition.

Workmen engaged in bridge-building and exposed to high air-pressure in sunken caissons are sometimes seized with paralysis when they come out suddenly into the free air. LEYDEN (*Arch. f. Psych.* IX.) found in some of them small patches of degeneration in the cord. These he attributes to the rapid escape of gas (oxygen) from the blood, which had under high pressure absorbed it in excess, the bubbles probably forming small emboli in the vessels.

References:—BERGMANN, *Kopfverletzungen*, *Deutsche Chirurgie* part 30, 1880; FISCHER, *Sammlung klin. Vorträge* 10, 27; BRUZELIUS and KEY, *Virchow's Jahresber.* II. (1880); FRONMÜLLER, *Die Rückenmarkszerreissung*, *Memorabilien* 1876; W. MÜLLER, *Path. Anat. u. Physiol. d. Rückenmarks* Leipzig 1871; ERB,

Ziemssen's *Cyclopædia* XIII.; CLEMENS, *Die Erschütterung d. Rückenmarks, Deutsche Klinik* 1863-65; OBERSTRINER, *Wiener med. Jahrb.* 1879; VON RECKLINGHAUSEN, *Virch. Arch.* vol. 30; JOLLY, *Stud. a. d. Inst. f. exp. Path.* Vienna 1870; KRAFFT-EBING, *Die d. Gehirnerschütt. u. Kopfverletzungen hervorgerufenen psych. Krankh.* Erlangen 1868; KOCH and FILEHNE, *Langenbeck's Arch.* XVII. (1874); WITKOWSKI, *Virch. Arch.* vol. 69.

646. **Secondary degeneration of the tracts** (systemic^o degenerations). Destruction of certain parts of the brain and cord is followed by a degeneration of certain corresponding tracts of nerve-fibres, which is called secondary degeneration. It is probably due to the fact that the affected tracts are severed from their 'trophic centres,' or that these latter are destroyed. We have ascending and descending secondary degeneration, according to the direction in which the process advances.

Descending degeneration is commonest in the pyramidal tracts (Art. 626, Fig. 246 *Pvb Psb*), and takes place in all cases in which the motor centres of the cerebral cortex are destroyed, or in which the motor tract as it passes through the corona radiata, the internal capsule, the peduncular region, or the pyramidal columns, is anywhere interrupted. The degeneration extends down to the points at which the motor fibres leave the anterior horns of the cord. In rare cases the ganglion-cells of the anterior horns also are atrophied, and then the motor fibres in the anterior roots of the spinal nerves become degenerate. When the destruction of the cortical centres is incomplete or only superficial it is not usually followed by secondary degeneration. It must however be borne in mind that in insane paralytic patients, in whom extensive superficial atrophy of the motor region of the cortex has resulted from chronic inflammation, we meet with degeneration of the pyramidal tract: this is however probably a secondary disease of the cord rather than a secondary degeneration in the strict sense of the term (Art. 647).

When the primary disease is in the cord, and such that the motor tract is entirely interrupted, the anterior pyramidal tract below the affected section becomes atrophied, but only for a distance of one or two centimetres, a few fibres perhaps showing degenerative change for a greater distance. In the case of the posterior columns of Burdach the degeneration extends downward along some fibres as much as six centimetres. The latter are perhaps fibres which enter with the posterior roots and then pass downwards for a certain distance in the substance of the cord (SCHULTZE).

According to CHARCOT when the anterior portion of the internal capsule is destroyed secondary degeneration appears in a bundle of fibres passing through the middle of the crustal stratum of the crus to the pons and probably ending in some of the nuclei of the medulla.

Ascending degeneration follows upon destruction of the cord or of the posterior root-fibres of the spinal nerves.

If the cord is cut across all the posterior tracts degenerate for a short

distance above the point of section, the columns of Goll (Fig. 246 *fgf*) alone degenerate for a greater distance, namely up to the nucleus of the funiculus gracilis. Destruction of the posterior roots has the like effect. It is thus rendered probable that the columns of Goll have their trophic centre in the spinal ganglion-cells.

If the cord is cut in the upper dorsal region the direct cerebellar tracts (Fig. 246 *Ksb*) above the lesion become degenerate: they pass from the vesicular columns (of Clarke) to the cerebellum. According to SCHULTZE a small region of the lateral column near the periphery also undergoes atrophy.

Secondary degeneration occurs chiefly after ischæmic softening, atrophy from compression, and hæmorrhagic or inflammatory destruction of the tracts and centres indicated. It does not always follow upon sclerosis of the cord or brain, inasmuch as the conducting tracts are apparently not always entirely interrupted in passing through sclerotic patches.

The degeneration takes place simultaneously over the whole extent of the affected tract. It is recognizable under the microscope in the second week after the initial lesion, disintegration of the medullary sheath and axis-cylinder of the nerve-fibres having by that time begun. When it has advanced to a certain point absorption of the products of disintegration begins, and the familiar granule-cells make their appearance. The space vacated by the atrophied fibres is filled up partly by effusion of liquid, partly by hyperplasia of the neuroglia, though it may be months or years before the latter becomes fairly dense and compact (Art. 639, Figs. 255, 256).

So long as the degenerate tracts contain abundance of detritus they are white, opaque, and soft. As absorption goes on they become gray and translucent; when sclerosis takes place they become firm, and at the same time shrink in volume.

In the text we have spoken only of total secondary degeneration of the longitudinal tracts of the brain and cord. Of course particular bundles of fibres may likewise undergo degeneration, and even the short transverse or commissural fibres of the cord. SCHULTZE met with a case of traumatic injury to the sciatic fibres in the lumbar cord, in which only the posterior portions of the columns of Goll were atrophied. Nerve-tracts degenerate from the initial lesion up to the next terminal organ, and apparently in the direction of normal conduction. Some of the fibres of the cord however do not degenerate in either direction after an interrupting lesion (FLECHSIG).

BOUCHARD and SCHIEFFERDECKER found secondary degeneration 14 days after lesion, W. MÜLLER 13 days, and KAHLER and PICK 11 days.

References:—TÜRCK, *Zeitschr. d. Gesell. d. Aerzte in Wien* 1850, *Wiener Sitzungsber.* VI. (1851), XI. (1853); WALLER, *Müller's Arch.* 1852; WESTPHAL, *Arch. f. Psych.* II.; SIMON, *ibid.* V.; LEYDEN, *Deutsche Klinik* 1863, *Klin. d. Rückenmarkskr.* II.; BOUCHARD, *Arch. générales* 1866; GUDDEN, *Arch. f. Psych.* II. (1869); CHARCOT, *Diseases of the nervous system* London 1878-80, *Leçons sur la localis. dans les mal. d. cerveau* I. Paris 1878-80, *Progrès méd.* 1879; FLECHSIG,

Die Leitungsbahnen Leipzig 1876, *Arch. d. Heilk.* XVIII. (1877), *Ueber Systemerkrankungen* Leipzig 1878; SCHULTZE, *Cent. f. med. Wiss.* 1876; *Virch. Arch.* vol. 79, *Arch. f. Psych.* XIII., XIV.; MEYER, *ibid.* XIII.; KAHLER and PICK, *ibid.* x.; BINSWANGER, *ibid.* XI.; SCHIEFFERDECKER, *Virch. Arch.* vol. 67; HAYEM, *Arch. de physiol.* v. (1873); HOMÉN, *Virch. Arch.* vol. 88, *Fortschritte d. Med.* III. (1885); ERB, *Ziemssen's Cyclopædia* XIII.; NEELSEN, *D. Arch. f. klin. Med.* XXIV. (1879); FERRIER, *Localization of cerebral disease* London 1878, *Trans. internat. med. congress* I. London 1881; BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; BARTH, *Arch. d. Heilk.* x.; MÜLLER, *Path. Anat. d. Rückenm.* 1871; ISARTIER, *Des dégén. second. de la moëlle épin. conséc. aux lésions du cerveau* Paris 1878; LÖWENTHAL, *Fortschritte d. Med.* I. (1883); MENDEL, *Neurolog. Centralb.* I. (1882); MARTINOTTI, *Sulle degen. sistem. del midollo spin. second., Collezione ital. di medicina* (3d series) 11 and 12, 1885; LANGLEY, *Brain* VIII. 1886.

647. **Primary sclerosis of the columns of the cord.** Primary sclerosis or gray degeneration is a change extending over entire tracts or columns of the spinal cord: it resembles secondary degeneration in its course and results, differing from it however in the apparent absence of any interrupting lesion of the conducting paths.

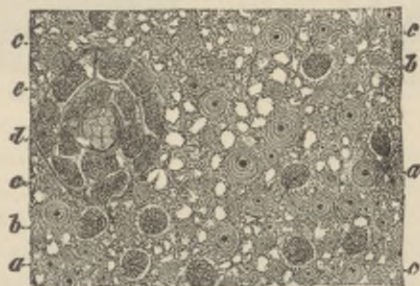


FIG. 261. SCLEROSIS OF THE POSTERIOR WHITE COLUMNS OF THE CORD.

(Section treated with Müller's fluid, hæmatoxylin, carmine, and perosmic acid, and mounted in glycerine: $\times 150$.)

a, section of normal nerve-fibres

b, granule-cells

c, neuroglia with nuclei

d, blood-vessel

e, granule-cells in the lymph-sheath of the vessel d

Its essential characters are degeneration of the nerve-fibres and hyperplasia of the connective tissue (sclerosis), but the relations of these are somewhat different from those observed in secondary degeneration. Disintegration of the nerve-elements and increase of the neuroglia begin almost simultaneously and go on side by side: indeed some have regarded the neuroglial hyperplasia as the primary disorder and the degeneration of nerve substance as secondary to it. There is however no real doubt that the degeneration is the primary and essential feature of the disease.

The medullary sheaths are the first to disintegrate, and then the axis-cylinders; the degenerating tract thus loses in succession a number of its fibres, greater or less according to the duration of the affection

(Fig. 261). Fat-granule cells (*b e*) appear, as in all nerve degenerations, and accumulating chiefly in the lymph-sheaths (*d*) of the vessels are carried off by these channels. While this is going on the cells of the neuroglia (*c*) begin to multiply, and as the nerve elements dwindle and disappear the connective tissue increases and fills their places. Thickening of the vessel-walls also takes place.

Sclerosis is commonest in the posterior columns of the cord, and is the anatomical basis of the disease known as **tabes dorsalis** or locomotor ataxy.

FIG. 262.

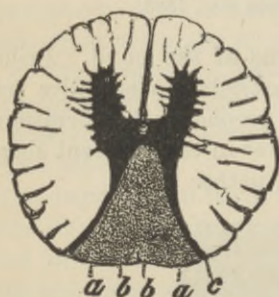


FIG. 263.

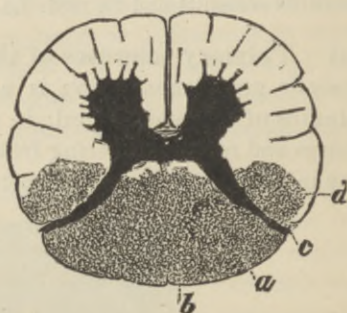


FIG. 264.

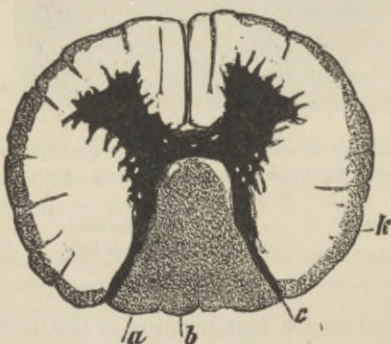


FIG. 262. COMPLETE SCLEROSIS OF POSTERIOR COLUMNS AND ATROPHY OF POSTERIOR ROOTS.

(Section through dorsal region: $\times 5$.)

- a*, cuneate fasciculus
b, column of Goll
c, atrophied posterior root

FIG. 263. SCLEROSIS OF POSTERIOR AND LATERAL COLUMNS.

(Section through upper lumbar region: $\times 5$.)

- a*, cuneate fasciculus
b, column of Goll
c, atrophied posterior root
d, posterior portion of lateral column

FIG. 264. SCLEROSIS OF POSTERIOR COLUMNS AND OF MARGINAL REGION.

(After WESTPHAL: section through cervical region: $\times 5$.)

- a*, cuneate fasciculus
b, column of Goll
k, marginal sclerosis along direct (or lateral) cerebellar tract

In advanced cases the degeneration and sclerosis may extend over the entire section of the posterior columns in the dorsal region of the cord (Fig. 262). In the lumbar region (Fig. 263) the anterior portion of the section is almost always exempt. In the cervical region (Fig. 264) two lateral segments of the anterior portion are spared or but slightly affected. The changes are usually (unless the degeneration is universal) most marked in the lumbar and dorsal regions, though cases occur in which the cervical region is the most affected. The degeneration ascends within the columns to beyond the obex of the calamus scriptorius and ceases about the level of the *striæ acusticæ* (Fig. 248, Art. 629).

When the degeneration of the posterior columns is well-advanced their outer surface assumes a gray or grayish-red tint, and on section the tissue appears quite gray and translucent. At the same time the columns appear somewhat shrunken.

The posterior nerve roots are always more or less atrophic and gray, the atrophy being greatest when the general degeneration is most advanced. The posterior root-fibres within the cord are likewise atrophic; and not alone those which pass forward through the substance of the posterior columns but also those which traverse the posterior root-zones. In rare cases some of the ganglion cells of the gray matter are destroyed.

This degeneration of the posterior columns with the accompanying changes in the posterior roots is usually an independent and uncomplicated malady: but cases occur in which simultaneously or subsequently portions of the lateral columns also undergo degeneration (Fig. 263 *d*).

The portions most apt to be invaded are the posterior (pyramidal tracts) and the marginal (direct cerebellar tracts, Fig. 264 *k*): sometimes the marginal sclerosis extends right round to the anterior columns.

A second form of primary degeneration is that known as **amyotrophic lateral sclerosis**. It is essentially a degeneration of the lateral columns extending over the whole length of the cord, and accompanied by atrophy of the ganglion-cells of the anterior horns and the equivalent gray nuclei in the medulla.

The degeneration of the white matter is marked by atrophy, disintegration, and disappearance of nerve fibres, together with increase of connective tissue, though the sclerotic induration is not usually so extreme as in the corresponding affection of the posterior columns. Only when the disease has lasted a very long time the new fibrous tissue become dense and compact.

In many cases the degeneration is limited to the lateral pyramidal tracts (Fig. 265 *b*): and thus where these tracts have a well-marked contour on section, namely in the cervical region, the disease is also sharply defined; where they are interpenetrated by other systems of fibres and extend forwards, as in the dorsal region, it is difficult to make

out the exact extent of the disease. If the pyramidal tracts have decussated completely at the medulla, the degeneration is confined to the lateral columns (Fig. 265 *b*); but if some of the strands are undecussated then the anterior (or uncrossed) pyramidal tracts are also affected. In other cases again the short tracts in the anterior-lateral columns variously described as principal tracts (FLECHSIG) and anterior root-zones (CHARCOT) undergo a like change. These tracts connect the various segments of the cord with each other and with the medulla, and include root-fibres which run longitudinally for a certain distance within the cord before passing out with the roots.

The direct cerebellar tracts are invariably exempt. In an ascending direction the disease has been traced up to the pons and crura cerebri, but no further. We are thus ignorant of the upper limit of the change, and it is quite possible that it sometimes extends up to the cortex.

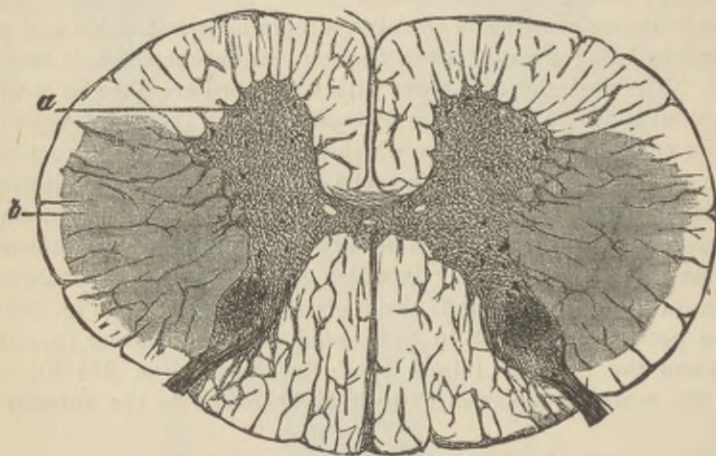


FIG. 265. AMYOTROPHIC LATERAL SCLEROSIS.

(Section through the cervical cord: $\times 10$.)

a, anterior horns, the ganglion-cells of which have almost all disappeared

b, diseased region of the lateral column corresponding to the completely decussated pyramidal tract

In the anterior horns it is chiefly the most anterior ganglion-cells which perish (Fig. 265 *a*); those of the intermedio-lateral tract are scarcely if at all affected; while those of Clarke's columns are quite exempt.

Of the motor nuclei of the cerebral axis those of the hypoglossal, facial, and spinal accessory nerves are the most liable to atrophic change; and to a very much less extent those of the abducens and trigeminal nerves. Details regarding the limits to which the atrophy may extend are unfortunately lacking.

In proportion to the atrophy of the motor ganglion-cells in the cord

and medulla we have of course progressive atrophy of the corresponding motor nerves and muscles.

Amyotrophic lateral sclerosis is from a pathological point of view closely akin to anterior poliomyelitis, or spinal paralysis with wasting of the ganglion-cells in the anterior horns (Arts. 640, 659).

CHARCOT, ERB (*Virch. Arch.* vol. 70), and others incline to the belief that a primary form of sclerosis of the pyramidal tracts exists, unaccompanied by degeneration of the anterior horns, and giving rise to a group of symptoms described by ERB as spastic spinal paralysis, by BERGER as **primary lateral sclerosis**, and by CHARCOT as spasmodic tabes dorsalis. STOFFELA (*Wien. med. Woch.* 21, 1878) describes a case of sclerosis of the lateral columns only, but the anatomical examination was not sufficiently minute to prove that it was a primary lateral sclerosis. The like is true of the older instance given by TÜRCK (*Wiener Sitzungsber.* XXI. 1856). Probably it was a case of amyotrophic lateral sclerosis. See however DRESCHFELD, *Journ. of Anat. and Physiol.* xv. 1881, and the cases and references given by ROSS, *Diseases of the nervous system* II. London 1883. The author's experience induces him to agree with LEYDEN (*Berl. klin. Woch.* 48, 1878), SCHULZ (*D. Arch. f. klin. Med.* XXIII.), WEISS (*Wien. med. Woch.* 1883), and STRÜMPPELL (*Arch. f. Psych.* x.), in their view that the symptoms of spastic spinal paralysis may be caused by disseminated sclerosis, myelitis, degeneration from compression, tumors, spinal meningitis, hydromyelia, etc. The nature of the lateral sclerosis of chronic insane paralytic patients (WESTPHAL, *Virch. Arch.* vol. 40; SCHULTZE, *Arch. f. Psych.* ix.) is still in dispute: FLECHSIG regards it as a secondary degeneration, WESTPHAL as a primary affection.

References on the morbid anatomy of tabes dorsalis:—LEYDEN, *Die graue Degen. d. hint. Rückenmarksstränge* Berlin 1863, *Klinik d. Rückenmarkskr.* II., *D. Zeitschr. f. klin. Med.* 1877, Art. *Tabes dorsalis in Realeycyclop. d. gesamm. Heilkunde*; PIERRET, *Arch. d. physiol.* III. (1870), IV., v., *Les symptomes céphaliques du tabes dorsalis* Paris 1876, *Gaz. méd. de Paris* 1882; FROMMANN, *Unters. üb. norm. u. path. Anat. d. Rückenmarks* Jena 1867; RINDFLEISCH, *Path. Histology* II. London 1873; SOLLY and CLARKE, *St. Thos. Hosp. Reports* 1870; WESTPHAL, *Arch. f. Psych.* v., IX., XII., XVI.; WOLFF, *ibid.* XII.; ADAMKIEWICZ, *ibid.* IX., X. XII., *Trans. internat. med. congress* II. London 1881, *Die Rückenmarksschwindsucht* Vienna 1885; TAKACS, *Cent. f. med. Wiss.* 1878, *Arch. f. Psych.* IX.; CHARCOT, *Diseases of the nervous system* London 1876-80; VULPIAN, *Maladies du système nerveux* Paris 1879; SIMS WOODHEAD, *Journ. of Anat. and Physiol.* XIV. (1882); ERB, *Ziemssen's Cyclopædia* XIII.; FRIEDREICH, *Virch. Arch.* vols. 26, 27, 68, 70; STRÜMPPELL, *Naturforscherversammlung in Salzburg* 1881, *Arch. f. Psych.* XII. (1882) (and *Brain* v. 1882); JÄDERHOLM, *Nord. med. Arkiv.* I.; KÄHLER, *Zeitschr. f. Heilk.* II. (1882); RAYMOND and ARTAUD, *Soc. de biol.* July 1882; ROSS, *Diseases of the nervous system* II. London 1883 (with numerous references); BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884 (for good figures); BUZZARD, *Brain* VI. 1884 (disease of blood-vessels); KRAUS, *Neurolog. Centralb.* 1885; DÉJÉRINE, *Arch. de physiol.* 1884; BABINSKI, *ibid.* 1885; LISSAUER, *Fortschritte d. Med.* III. 1885.

References on amyotrophic lateral sclerosis and bulbar paralysis:—DUCHENNE, *Gaz. hebdom.* 1859, 1861; CHARCOT, *Diseases of the nervous system* II. London 1880; FLECHSIG, *Ueber Systemerkrankungen* Leipzig 1878; BARTH, *Arch. d. Heilk.* XII., XV.; DUMÉNIL, *Gaz. hebdom.* 1867; LEYDEN, *op. cit.*, *Arch. f. Psych.* II., III., VIII.; MAIER and KUSSMAUL, *Virch. Arch.* vol. 61; GOMBAULT, *Arch. de*

physiol. iv.; PICK, *Arch. f. Psych.* viii.; PITRES, *Arch. de physiol.* 1876; LÉPINE, *Gaz. méd. de Paris* 17, 1878; WESTPHAL, *Virch. Arch.* vol. 40; KUSSMAUL, *Sammlung klin. Vorträge* 54; WORMS, *Arch. de physiol.* iv. (1877); CORNIL and LÉPINE, *Gaz. méd. de Paris* 1875; FERRIER, *Lancet* 1, 1881; STADELMANN, *D. Arch. f. klin. Med.* xxxiii.; MOELI, *Arch. f. Psych.* x.; VIERORDT, *ibid.* xiv.; DÉJÉRINE, *Arch. de physiol.* vi. (1883); MINKOWSKI, *D. Arch. f. klin. Med.* xxiv. (1884); ORMEROD, *Brain*, viii. 1886 (a critical digest).

On sclerosis affecting more than one tract ('combined degeneration'):—WESTPHAL, *Virch. Arch.* vols. 39, 40, *Arch. f. Psych.* v., viii., ix. xv. (causation of spastic spinal paralysis); KAHLER and PICK, *ibid.* viii., x.; SCHULTZE, *Virch. Arch.* vol. 79, *Arch. f. Psych.* v.; FRIEDREICH, *Virch. Arch.* vols. 26, 27, 68, 70; STRÜMPELL, *Arch. f. Psych.* xi.; PRÉVOST, *Arch. de physiol.* iv. (1877); WOLFF, *Arch. f. Psych.* xii.; HAMILTON, *New York med. record* xv. (1879); BABESIU, *Virch. Arch.* vol. 76; ORMEROD, *Brain* vii. 1885 (a critical digest of the literature).

648. From what we have said in the last Article it will be seen that both in tabes dorsalis and in amyotrophic lateral sclerosis the morbid change follows the course of certain definite tracts, and the question at once arises whether in these cases we have what with FLECHSIG we may call **primary systemic diseases**. If by a 'system' we mean one definite group of homologous nerve-fibres and their ganglion-cells, and this only, these affections can hardly be described as simply 'systemic,' inasmuch as at least in tabes various systems are involved. Tabes would in that case be properly described as a combined systemic disease (STRÜMPELL). But if we include under the term 'system' a group of fibres and cells all *functionally* related, both tabes and amyotrophic lateral sclerosis are systemic.

The **morbid change in tabes** has been variously interpreted by different authors. LEYDEN regards it as a degenerative process, CYON, FRIEDREICH, and FROMMANN regard it as inflammatory, CHARCOT calls it a parenchymatous inflammation, ERB a chronic myelitis, ADAM-KIEWICZ thinks the essential fact is a chronic degeneration of the connective tissue.

Minute microscopic examination shows however that the process is essentially a degenerative one, having nothing to do with inflammation; and STRÜMPELL accurately expresses the facts when he describes it as a degeneration of functionally related nerve-fibres.

According to PIERRET, CHARCOT, and STRÜMPELL the disease begins with the degeneration of certain strands of fibres running through the middle of Burdach's columns (Fig. 266 *a*), and usually in the lumbar and dorsal regions of the cord. At the same time degenerate fibres appear in the posterior nerve-roots, and along the inner (or median) aspect of Goll's columns in the dorsal and cervical regions there is a sclerotic strip. After a time Burdach's columns in the cervical region are likewise invaded.

We have thus at first patches and strips of degeneration occurring in centripetal fibres which enter the cord through the posterior roots. This

is followed by secondary ascending degeneration of the fibres initially attacked in the lower part of their course. Tabes according to this view then is a localized multiple ascending degeneration primarily affecting a part of the region of the posterior columns, which with its associated secondary degenerations extends in the course of years over nearly the whole of that region.

As to the **cause** of the first onset of the affection—whether it depends on some congenital or acquired weakness of the centripetal tracts, or on disordered nutrition from disturbance of the circulation—it is not easy to decide. The fact that some forms of tabes appear to be inherited or at least congenital (FRIEDREICH) supports the former supposition, while the latter agrees with the observation that very frequently we find almost from the commencement of the disease like disorder of the optic, oculomotor, and trigeminal nerves, while simultaneously with its progress multiple patches of sclerosis appear in other parts of the brain and

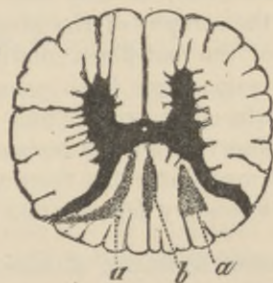


FIG. 266. COMMENCING SCLEROSIS OF THE POSTERIOR COLUMNS.

(After CHARCOT: section from the dorsal region: $\times 5$.)

a, sclerotic patch in the cuneate fasciculus

b, sclerotic patch in the columns of Goll

cord. When simultaneous degeneration of other systems of fibres takes place we can only suppose that the like weakness of organization or disorder of nutrition is affecting them also. At least there is no ground for the theory that the imagined inflammatory process has extended by continuity from the primarily diseased posterior columns to other tracts.

At present we cannot say anything as to the real nature of the exciting cause. Clinical observers mention a great variety of predisposing conditions, such as cold, over-exertion, sexual excess, etc. FOURNIER, ERB, GOWERS, and others have lately laid special stress on **syphilis** as the commonest of all antecedents of tabes. If when the pathogenic agency is extrinsic the sensory tracts alone are affected, we must assume either that they have been congenitally weaker than the others, or that they are normally less able to resist certain forms of injury.

The like difficulties arise in the case of amyotrophic lateral sclerosis. Here also we are driven to conclude that the disease is a result of a

localized degeneration occurring primarily in the region of the motor tract, perhaps also in the motor nuclei, and followed by a secondary degeneration along the course of the pyramidal fibres. This is the more likely inasmuch as the degeneration of the pyramidal tracts is most marked and typical when the degeneration affects chiefly the medulla oblongata; while a like degeneration beginning in the gray matter of the lumbar cord is not as a rule followed by any appreciable change in the pyramidal tracts (Art. 640). In some cases indeed (ZIEGLER) the medulla shows not only atrophy of the ganglion-cells of the gray nuclei but also patches of softening in the white matter of the pyramids: descending secondary degeneration may well start from the latter also.

When portions of the white matter of the anterior root-zones and neighboring lateral regions are affected as well as the pyramidal tracts, we may explain the apparent complication by assuming that fibres belonging to the anterior (uncrossed) pyramidal tracts run through the anterior root-zones (FLECHSIG), as they they sometimes do; while we also bear in mind that the atrophy of the ganglion-cells of the anterior horns involves atrophy of the root-fibres entering and leaving the white substance. Perhaps in some cases fresh primary foci of degeneration appear in the region of the commissural fibres of the anterior columns. And when as has been observed in a few instances the posterior columns are likewise affected, we must infer that there too some isolated patch of degeneration has led to secondary degeneration of the tract.

Many authors (FRIEDREICH, SCHULTZE, KÄHLER, PICK) have asserted that defective development of the conducting columns is frequently the principal cause of primary systemic degeneration. In support of this they point to the fact that certain forms are hereditary (FRIEDREICH, *Virch. Arch.* vols. 68, 70; RÜTMEYER, *ibid.* vol. 91; DRESCHFELD, *Liverpool and Manchester med. and surg. reports* IV. 1876; ORMEROD, *Brain* VII. 1884; EVERETT SMITH, *Boston med. and surg. journ.* 1885; BURY, *Brain*, VIII. 1886, with summary of cases), and that in these cases post-mortem examination has revealed changes explicable only on the supposition of imperfect development of the cord. It cannot be denied that in some cases hereditary conditions play a considerable part. In others, and these the majority, there is no evidence of such conditions, and we must look elsewhere for the causes of the disease. ERB (*D. Arch. f. klin. med.* XXIV. (1879), *Cent. f. med. Wiss.* 1881, *Trans. internat. med. congress* II. 1881, *Berl. klin. Woch.* 32, 1883), FOURNIER (*L'ataxie locomotrice d'origine syphilitique* Paris 1882), GOWERS (*Lancet* 1, 1881), ALTHAUS (*Trans. internat. med. congress* II. 1881) VOIGT and RUMPF (*Berl. klin. Woch.* 1883), EULENBURG (*Virch. Arch.* vol. 99), and others have pointed out the great significance of syphilis in this connection, some going so far as to say that 80 to 90 per cent of tabic patients have suffered from syphilis. Even though other observers like WESTPHAL and BUZZARD have been unable to agree with such high estimates it appears plain that the influence of syphilis in the genesis of the disease is an important one.

ADAMKIEWICZ has carefully investigated the distribution of the blood-vessels in the cord (*Wiener Sitzungsber.* LXXXIV., LXXXV. 1882, XC. 1884) and shows that the degeneration of the posterior columns is coextensive with the vascular territory of the arteries which enter from the posterior circumference and the pos-

terior longitudinal fissure. Even if we cannot suppose that all the vessels entering from these situations become successively diseased, we may at least imagine that the initial or primary lesion is due to disease within the territory of some of them, and that this lesion is the starting-point of secondary degeneration of the corresponding tracts. This at least would explain why the process sometimes does not extend over the whole of the posterior columns and the adjacent gray matter. On the other hand the fact that the disease of the posterior columns so often coexist with like disease of other systems and tracts shows that the degeneration may start in other vascular territories also.

TUCZEK (*Arch. f. Psych.* XIII.) states that in ergotism changes resembling those in tabes appear in the posterior columns: according to LEYDEN this is also the case in pellagra (Art. 369). BRUNELLI (*Trans. internat. med. congress* II. 1881) attributes an affection presenting the symptoms of lateral sclerosis to the use of bread contaminated with *Lathyrus cicera*. If these observations are confirmed in numerous cases they will go to show that certain poisons have a selective action on definite tracts of the central nervous system (ADRIANI, *La pellagra* Perugia 1880; ALTHAUS, *Brit. Med. Journ.* 1, 1884).

The fact that we occasionally meet with thickening of the meninges in tabes does not prove that the disease originally starts in meningitis. The thickening of the pia mater may quite well be a secondary process, though of course it is possible that it may be primary and give rise to the characteristic degenerative changes in the cord.

WESTPHAL (*Virch. Arch.* vols. 39, 40, and *Arch. f. Psych.* XII. 1882) and CLAUS (*Allg. Zeitschr. f. Psych.* XXXVIII. 1881) have shown that in patients suffering from paralytic dementia (general paralysis of the insane) gray degeneration or sclerosis of the posterior columns is very common. The inference is either that such patients are peculiarly liable to tabes, or that the exciting causes, which in the brain produce the changes that are manifested as progressive paralysis, are potent to give rise in the cord to gray degeneration. See STEWART, *Glasgow Med. Journ.* 1886.

DÉJÉRINE (*Soc. de biologie* Feb. 18, 1882, *Arch. de physiol.* 1883, *Comptes rendus* 1883) states, what had already been pointed out by FRIEDREICH and WESTPHAL, that in tabes the peripheral nerves undergo degeneration. He infers that the affection is primarily a peripheral one; but the facts afford no real ground for such a supposition. See also SAKAKY, *Arch. f. Psych.* XV.; OPPENHEIM and SIMMERLING, *Neurol. Centralb.* 11, 1886.

649. **Multiple sclerosis.** This is a peculiar affection of the brain and cord characterized by the formation of a number of gray condensed patches in the nervous tissues. It is either confined to the cord or extends over the whole of the central nervous system.

The patches are some of them superficial, some deep: in the former case they can be recognized by their gray color. Sometimes they are rounded in shape, sometimes elongated and irregular. Their diameter varies from 1 millimetre to 50 or more. On section they look uniformly gray and translucent, occasionally one or two are mottled with white and softer than the others. They are usually sharply-defined against the sound tissue, though now and then a patch is surrounded by an ill-defined zone of a grayish-white or mottled appearance. In general they are firm and dry, but cases occur in which they are softer than the healthy tissue and contain a quantity of liquid that escapes on section.

The dense patches (Fig. 267) consist of a close feltwork of delicate sharply-contoured fibres, beset with a larger or smaller number of nuclei. Within the larger and firmer patches no nerve fibres can be seen; in the smaller and more recent or round the border of the larger ones a few still persist (*a*): they are usually normal in appearance, though sometimes they show signs of degeneration. Fat-granule cells are in some cases entirely absent, though in general a few can be seen.

The vessels (*c*) are at times unaltered, in other cases their walls undergo a hyaline thickening or the adventitial coat is denser than usual. Sometimes too the adventitial lymph-sheaths contain lymphoid and granule-carrying cells, while leucocytes in varying number are scattered through the surrounding nerve-tissue.

Most of the nuclei that are visible belong however to the neuroglia-cells, which have a scanty protoplasm and a large number of glistening processes (Art. 638, Fig. 253). The feltwork is in fact essentially composed of the interlacing processes of these cells.



FIG. 267. SCLEROTIC PATCH IN THE WHITE MATTER OF THE CORD.

(Section treated with Müller's fluid, alcohol, and carmine: $\times 300$.)

- a*, section of nerve-fibres
- b*, neuroglia-cells
- c*, blood-vessels

A few corpora amylacea occur here and there.

The softer and more gelatinous patches have a looser feltwork, with wider meshes and interstices. Those that are mottled with white contain numerous granule-cells and other products of nerve-disintegration. If they lie within the gray matter they sometimes contain also atrophied and shrunken or hyaline and swollen ganglion-cells.

The affection is commonest in the cord, and varies very greatly in its extent. There is nothing special about the manner in which the patches are distributed: they may lie anywhere in the gray matter as well as in the white (Figs. 268, 269, 270). When they interrupt conducting tracts, more or less extensive secondary degeneration of these ensues, but it is surprising to note how frequently the latter change is absent even when the sclerotic patches are pretty large. If the sclerosis should cause

the destruction of ganglion-cells in the anterior horns some of the anterior root-fibres of course become atrophied.

In the brain the chief seats of multiple sclerosis are the white matter near the lateral ventricles, the corpus callosum, the corpora striata, the pons, the crura cerebri, and the dentate nucleus. Often too the optic, olfactory, and trigeminal nerves, and the roots of the spinal nerves, are found diseased. In the case of the brain we now and then find that a large portion of the roof of the lateral ventricle is transformed into gray sclerotic tissue several millimetres thick. Multiple sclerosis of the cortex is comparatively rare.

650. In most cases when the gray patches of multiple sclerosis come under observation the tissue-change is well advanced, and appears to be due to increase of the neuroglia and consequent compression and atrophy of the nerve-elements. This late appearance gives us however no certain knowledge as to the origin and course of the affection. Even when the increase by hyperplasia of the connective tissue is the most obvious fea-

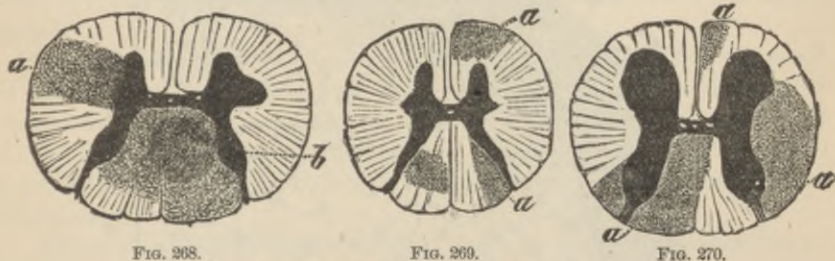


FIG. 268.

FIG. 269.

FIG. 270.

DIAGRAMS OF MULTIPLE SCLEROSIS ($\times 3$).

FIG. 268. CERVICAL REGION.

- a, sclerotic patch in the lateral column and left intermedio-lateral tract
b, patch in the posterior columns

FIG. 269. DORSAL REGION.

- a, disseminated patches

FIG. 270. LUMBAR REGION

- a, disseminated patches

ture in the ultimate result, it does not follow that the change began with such hyperplasia.

In fact there is no doubt that in many cases the disease begins as a degeneration, dependent primarily on a disturbance of nutrition, and first affecting the nerve-elements. Cases sometimes occur in which the typical gray sclerotic patches are accompanied in the brain and cord by others which are mottled with white, or uniformly white and opaque, or even pale-yellow; and these manifest on the one hand all grades of degenerative change, on the other an obvious proliferation and hyperplasia of the neuroglia (Art. 638, Fig. 253). In teased preparations we find not only abundance of nerve-detritus and granule-cells, but also numerous neuroglia-cells whose protoplasm is abundant and nuclei multiplied:

and as we have seen (Arts. 638, 639) there is no doubt that degenerative changes in the nerve-elements may be followed by multiplication of neuroglia-cells and formation of sclerotic patches.

The changes we are considering are certainly often of a non-inflammatory kind, being simply the results of disordered nutrition due to change or impurity in the blood, to thickening or degeneration of the vessel-walls, or to disturbance of the circulation. It is at any rate remarkable how frequently we find morbid changes in the vessel-walls in connection with sclerotic patches. Once however a sclerotic hyperplasia has begun it may extend to contiguous parts without any antecedent degeneration.

Though we are thus able in a number of cases to refer the sclerotic



FIG. 271. GRAY GELATINOUS DEGENERATION OF THE ANTERIOR HORN.

(From the lumbar cord, 18 months after an attack of acute poliomyelitis; prepared with Müller's fluid, hæmatoxylin and carmine, and Canada balsam: $\times 200$.)

- | | |
|--|---|
| A, white matter | B, apex of the anterior horn |
| a, atrophied anterior roots | d, blood-vessels |
| b, branching neuroglia-cells forming a network of fine glistening fibres | e, sclerosis of white matter contiguous to |
| c, round cells without processes | f, dense sclerosis of the margin of the anterior horn |

process to a primary degeneration, it does not follow that this is the invariable rule. Both in the brain and in the cord inflammatory processes may be set up which after they have caused the destruction of a certain amount of nerve-substance come to an end by what we might call sclerotic cicatrization.

When a patch of inflammatory degeneration is formed and the acute changes have ceased, absorption of the detritus and exudation takes place exactly as in the case of ischæmic degeneration or softening. If the

destruction is extensive a permanent defect or hiatus will remain. if it is more limited after the disintegration and absorption of the nerve-elements there is left a tissue consisting of neuroglia (Fig. 271 *B*) and a network of vessels (*d*). This is partly old and persisting tissue, partly new-formed; its essential components are stellate or multipolar cells (*b*) whose processes freely anastomose. After absorption is complete a clear liquid containing a few leucocytes (*c*) lies in the meshes of the tissue. The result is a gray moist gelatinous patch, an example of what is called **gray gelatinous degeneration**.

Such gelatinous patches are usually surrounded by a zone in which the network of neuroglial fibres is much denser (*ef*), and might almost be called a feltwork, and the nerve-elements of the contiguous tissue are as it were embedded in the dense overgrowth which surrounds them (*e*). This change which in gelatinous patches is only marginal becomes in other cases general. Dense hyperplasia of the neuroglia may take place throughout the whole extent of a degenerating patch, and give rise to what is called hard sclerosis, or simply sclerosis (taken in a restricted sense).

Sclerotic patches such as we have described occur chiefly as the result of isolated local inflammations in the cord (Art. 659). Whether the disease known as multiple sclerosis is frequently or indeed at all a result of multiple inflammations is a question still unsettled. The occurrence of a disseminated miliary encephalitis and myelitis is in favor of an affirmative answer.

Although we are thus able in many cases to refer the causation of multiple sclerosis to primary degenerative or inflammatory processes, other cases are met with in which there are no grounds for such an assumption. These are cases both of ordinary multiple sclerosis and of the form which is described as **granular ependymal sclerosis**. The latter is a morbid change of the lining membrane of the cerebral ventricles characterized by the formation of small prominent gray granulations on its surface. In extreme cases these beset the ependyma so closely that it feels rough to the touch. Sometimes the little prominences coalesce and form reticulate or arabesque patterns on the surface.

Histologically the change consists in a new-formation of neuroglia, the fibrous feltwork being exceptionally dense in proportion to the number of cells or nuclei present. The cylindrical epithelium which invests the ventricle sometimes continues to cover the prominences, sometimes falls away and leaves them bare.

Diffuse forms of ependymal and subependymal sclerosis are also met with. If the process extends from the floor of the fourth ventricle to the deeper structures it may cause the destruction of the ganglion-cells in the gray nuclei of the cranial nerves.

We do not yet know the nature of the exciting cause of these affections: the fact that they are frequently associated with chronic meningitis

would suggest that they are of a chronic inflammatory character. In some cases circumvascular collections of cells are found in the subependymal tissue, and in this respect the granulations recall the structure of inflammatory papillomata of the skin (Art. 394).

Not infrequently extensive proliferations take place in the connective tissue about the central canal of the cord; they occur both in patches and as continuous longitudinal growths (Art. 637). As they are met with chiefly in connection with malformations of the canal, or in regions which experience shows to be liable to congenital anomaly, *i. e.* about the posterior columns, it seems fair to suppose that they depend on some congenital anomaly of structure in the tissues. Moreover, these proliferations are sometimes accompanied by sclerotic patches in other parts of the central nervous system, and hence it is not improbable that other multiple scleroses may occasionally be referable to disorders of development.

Many writers speak of all gray degenerations, hard or gelatinous, as scleroses. The etymology of the term (*σκληρος* hard and dry) would limit its application to the former variety. If however we extend the word to cover both varieties, and indeed they are genetically equivalent, we should perhaps speak of them as hard sclerosis and gelatinous sclerosis respectively.

The genesis of multiple sclerosis (called variously disseminated, insular, focal or cerebrospinal sclerosis) is still very differently explained by different writers. Some regard the degeneration of the nerve-elements as the primary lesion, others the hyperplasia of the neuroglia: others again describe the process as a chronic inflammation, or affirm that the overgrowth of fibrous tissue starts from the vessel-walls. In the author's own investigations, undertaken specially to determine these questions, he found that in recent cases the degenerative changes were so marked as to admit of no other supposition than that they were primary, and the multiplication of neuroglia-cells secondary. Cases do occur however where no patches of sclerosis can be found in which this pre-eminence of the degenerative changes is clearly apparent: and it is therefore not easy to disprove the statements of CHARCOT and others who regard the overgrowth of fibrous tissue as the primary cause (by compression) of the degeneration of the nerve-elements. Various facts go to show that forms of cerebrospinal sclerosis occur which are the result of anomalies or disorders of development, and are thus related to the periependymal growths met with in syringomyelia. It is also possible that other forms are due to the formation of multiple foci of inflammation.

References on multiple sclerosis:—LEYDEN, *Deutsche Klinik* xv. 1863 and *Klinik d. Rückenmarkskr.*; RINDFLEISCH, *Virch. Arch.* vol. 26; ZENKER, *Zeitschr. f. rat. Med.* xxiv. (1865), *D. Arch. f. klin. Med.* viii. (1870); CHARCOT, *Diseases of the nervous system* I. London 1876; BOURNEVILLE, *La sclérose en plaques disséminées* Paris 1869; SCHÜLE, *D. Arch. f. klin. Med.* viii.; BUCHWALD, *ibid.* x.; OTTO, *ibid.* x.; JOLLY, *Arch. f. Psych.* iii.; ARNDT, *Virch. Arch.* vols. 64, 68; MOXON, *Guy's Hosp. Reports* xx. (1875); DICKINSON, CHEADLE, DRESCHFELD, *Med. Times and Gaz.* 1, 1878; LEYDEN, *Charité-Annalen* iii., *Arch. f. Psych.* vi. (sclerosis of bulbar nuclei), *Berl. klin. Woch.* 1878; SCHULTZE and RUMPF, *Cent. f. med. Wiss.* 1878; ERB, *Ziemssen's Cyclopædia* xiii.; FROMMANN, *Virch. Arch.* vol. 54, *Normale und path. Anat. d. Nervensystems* Jena 1876, *Die Gewebsveränd. bei*

mult. Sclerose Jena 1879; RIBBERT, *Virch. Arch.* vol. 90; FRIEDMANN, *Jahrb. f. Psych.* IV. (1883); BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884 (for good figures); GOWERS, *Lancet* 1, 1886 (miliary sclerosis of brain).

On ependymal sclerosis and spinal periependymal sclerosis:—ROKITANSKY, *Handb. d. path. Anat.* I. (trans. Syd. Soc. London 1850); VIRCHOW, *Gesamm. Abhandlungen* Frankfurt 1856; WEISS, *Österreich. med. Jahrb.* 1878; MAGNAN and MIERZEJEWSKY, *Arch. de physiol.* 1873; LEYDEN, *Klinik d. Rückenmarkskr.* II.; SCHULTZE, *Virch. Arch.* vols. 70, 87; FRIEDREICH, *ibid.* vol. 26; KAHLER and PICK, *Arch. f. Psych.* VIII.; EICKHOLT, *ibid.* X.; WESTPHAL, *Brain* VI. (1883); *Arch. f. Psych.* XVI. (1885); see also Art. 637.

On multiple and diffuse sclerosis in infants and children:—VON RECKLINGHAUSEN, *Verh. d. geburtshilfl. Gesellsch. zu Berlin* 1863; NEUREUTTER and STEINER, *Prager Vierteljahrsschr. f. pract. Heilk.* XX. (2); HUMPHREYS, *Med. Times and Gaz.* 2, 1877; POLLARD, *Lancet* 2, 1878; HARTDEGEN, *Arch. f. Psych.* XI.; POLLACK, *ibid.* XII.

651. When from simple or degenerative atrophy or inflammatory disturbance of nutrition the nerve-elements belonging to a considerable extent of tissue have perished, a diffuse hyperplasia of the connective tissue often sets in, and in advanced cases gives rise to a continuous in-



FIG. 272. MARGINAL SCLEROSIS OF THE CERVICAL CORD.

(Diagrammatic: $\times 3$.)

a, sclerotic marginal zone

duration, or **diffuse sclerosis** as it is called. This change occurs for instance in simple atrophy of the cerebellar cortex (Art. 640). It is also common in atrophy of the marginal portions of the cord and in atrophy of the cerebral cortex, such as follows grave local disorder of nutrition from chronic inflammation of the pia mater. In the cord we may have a marginal sclerosis of this kind (Fig. 272), exactly resembling in its structure the scleroses we have already described. In the cortex of the cerebrum the induration is seldom great, and it is only on microscopical examination that the stellate neuroglia-cells and their fibrous processes are seen to be more abundant and more obvious than in the normal tissue (Art. 656, Fig. 273). Only when the antecedent atrophy has been very extensive is the hardening of the surface so palpable as to be recognizable by the finger.

This induration is secondary, but there is also a form of primary hyperplasia of the neuroglia which sometimes extends over considerable

portions of the central nervous system. In the general enlargement of the brain known as cerebral hypertrophy (Art. 633) the connective tissue is said to undergo a notable increase, giving the tissue a leathery or rubber-like consistency. This increase is more obvious in some peculiar indurative condition of particular portions of the brain, in which the normal form and aspect remain unchanged while the size is more or less enlarged. A convolution, a lobe, the corpus callosum, or the basal ganglia may thus become indurated *en masse*; or in the white matter ill-defined portions of tissue may be palpably harder than the parts around without any discoloration or other apparent change. Such indurations are all due to increase of the connective tissue: in some of them the brain-substance is transformed into a felted mass of delicate fibres containing a few scattered nerve-cells and nerve-fibres or in some parts none at all.

Diffuse scleroses cannot be sharply distinguished from the new-growths known as gliomata (Art. 662), and must be considered with them. We know nothing as to the causes of the change, though it is at least possible that they are dependent on some disturbance of the histological development of the tissues in which they occur.

References on diffuse sclerosis:—STRÜMPPELL, *Arch. f. Psych.* IX; SIEMENS, *ibid.* X.; F. SCHULTZE, *ibid.* XI.; ZACHER, *ibid.* XIII.; GREIFF, *ibid.* XIV.; ERLER, *Diffuse Hirnsclerose* In. Diss. Tübingen 1881; COTARD, *Hémiatrophie cérébrale* Thèse de Paris 1868; JENDRÁSSIK and MARIE, *Arch. d. physiol.* v. 1885.

CHAPTER XCV.

INFLAMMATORY DISORDERS.

Serous inflammations.

652. Acute inflammatory exudations having a serous character take place into the substance of the brain and cord, into the membranous envelopes, and into the ventricles; and they give rise to grave and even fatal disturbance of the nervous functions.

Acute serous leptomeningitis is an affection in which a sudden congestive hyperæmia is followed by serous effusion into the subarachnoid and pia mater, and into the cerebral ventricles. The quantity of liquid found in the membranes at the time of death varies somewhat in different cases, but it is seldom great. The amount of blood in the congested vessels is also by no means constant. The ventricles are more or less dilated by the effusion (inflammatory internal hydrocephalus); sometimes so greatly that the convolutions are visibly depressed and flattened by pressure against the skull, while the cerebrospinal liquid is to some extent forced out of the subarachnoid spaces. The choroid plexuses are usually hyperæmic: the liquid in the ventricles and subarachnoid spaces is clear or slightly opalescent, and often contains minute flakes of fibrin. It is richer in albumen than the normal cerebrospinal liquid (HUGUENIN) and has floating in it a few pus-corpuscles. A few extravasated leucocytes may be seen in the neighborhood of some of the cortical vessels.

The disorder is commonest in infancy or early childhood, rare in adult life: it not infrequently accompanies the early stages of infective diseases such as measles or scarlatina. Very probably the œdema of the brain and meninges which sometimes supervenes in nephritis is in part at least of inflammatory origin. Perhaps too some of the cases in children are induced by the virus of epidemic cerebrospinal meningitis (Art. 653): frequently however no cause can be certainly assigned, though scrofula, rickets, and syphilis are believed to be predisposing conditions.

If the inflammatory œdema is not fatal it often disappears speedily, though sometimes it issues in a chronic inflammatory condition manifested by thickening of the meninges and permanent and increasing dilatation of the ventricles: this condition is called **chronic hydrocephalus**, and it sometimes comes on gradually and insidiously, that is to say without any markedly acute onset.

Of more common occurrence than these genuine diffuse serous exudations is the **localized inflammatory œdema** of the brain, cord, or membranes which is set up around foci of purulent, granulating, septic, tuberculous, syphilitic, or traumatic inflammation, or around new growths.

When the nervous tissue is the chief seat of œdema it looks moist and glistening, and is softer than in health. There is usually some accompanying circumvascular extravasation of leucocytes, partly in the adventitial sheaths of the vessels, partly in the surrounding tissue.

Purulent inflammations.

653. **Purulent leptomeningitis.** Purulent inflammation of the soft membranes (pia mater and subarachnoid tissue) is preceded first by the hyperæmia which is the first stage of all acute inflammations, then by serous exudation, and lastly by an extremely abundant accumulation of leucocytes in the circumvascular spaces. The veins, engorged and dilated, show streaks and patches of yellow along their course, and these rapidly extend, owing to the continued extravasation and infiltration. The opacity thus occasioned sometimes becomes so dense that the gyri of the brain and the surface of the cord are entirely concealed by it.

In simply purulent meningitis the exudation is composed of pus-corpuscles and extravasated liquid. In the sero-purulent and fibrino-purulent forms the exudation has a turbid muddy appearance, is more liquid, and contains granules, fibres, and (less frequently) hyaline clots of fibrin.

The exudation lies mainly in the clefts and spaces of the pia mater and subarachnoid tissue. The cells covering the trabeculæ of the connective tissue are for the most part cast off and degenerate. The veins and venules are thickly surrounded with leucocytes, and their walls penetrated by them. Sometimes the venous channel is crammed with leucocytes, especially towards its periphery; sometimes it is plugged with hyaline or granular coagula. When the arteries are surrounded by extravasated cells the adventitial coat is seen to be infiltrated with them, and the like is often true of the middle and inner coats.

The cortex of the brain and the cord are sometimes all but unaffected by the meningitis, being perhaps only slightly moister than usual, though it is frequently possible to demonstrate that changes have here and there taken place in the nerve-elements. In the cord, we find swelling and partial disintegration of the axis-cylinders and degeneration in the medullary sheaths and nerve-roots. In the cortex the ganglion-cells become swollen and lose their finer processes.

Often enough the inflammatory change advances along the vessels to the cortex, the pial sheaths especially of the veins becoming filled with leucocytes. Or the change may extend to the nervous tissues in a

more generally diffused manner (Art. 654). The nerves issuing from the brain and cord are frequently infiltrated with cells.

When the inflammation extends through the transverse fissures of the base of the brain to the telæ choroideæ within the ventricles, a purulent or sero-purulent exudation is poured out, the liquid contents of the ventricles are augmented and rendered turbid, and the plexuses swell up and become covered over with pus or fibrino-purulent flakes. The ependyma and underlying brain-substance become moist and sometimes morbidly soft. When the distention of the ventricles is great the brain-substance is compressed, the gyri flattened, and the subarachnoid liquid forced out; the result being that the meningeal structures of the convexity become morbidly dry.

The seat and the extent of the inflammation vary greatly, depending of course on the exciting cause and on the manner in which it reaches the membranes. As to the nature and properties of the exciting causes we know little, but it is probable that micro-organisms are frequently at work, and probably also specifically distinct micro-organisms in different forms of the disease. In many cases micrococci have been found in the inflamed tissues, but it is not likely that they are always of the same kind or the same virulence.

Irritant matters (organic or not) may reach the meninges in the first place by way of the blood-vessels, in which case we might call the meningitis **embolic**.

If it chiefly attacks the convex surface it is described according to its distribution as local or general, unilateral or bilateral, meningitis of the convexity. Affecting the base it is called basal or basilar meningitis, and in the case of the cord spinal meningitis. In basal meningitis the cerebral axis is usually covered with pus, and the subarachnoid cisterns are much distended with the exudation.

Hæmatogenous purulent meningitis occurs in connection with traumatic pyæmia, gangrenous and croupous pneumonia, ulcerative tuberculous phthisis, endocarditis, gangrenous bed-sores, acute rheumatism, purulent pleurisy (empyema), scarlatina, typhoid, inflammation of the umbilicus in infants, etc. It is moreover the essential symptom of the infective disease known as **epidemic cerebrospinal meningitis**. As its name indicates the exudation in this disease extends over cord and brain, though by no means uniformly. When the inflammation is at its height it is usually purulent or fibrino-purulent, seldom hæmorrhagic, though cases rarely occur in which some small hæmorrhages do not appear. If death ensues within the first few days the quantity of exudation poured out is very small: sometimes nothing but a circumvascular infiltration of cells can be made out. In more advanced stages the subarachnoid liquid has a turbid whey-like appearance.

Both brain and cord are always involved, the cellular infiltration spreading from the pia mater along the vessels or directly to the cortex

of the brain and the substance of the cord. In addition to this small patches of inflammation (sometimes hæmorrhagic) are invariably found in the interior of the cerebrum: STRÜMPPELL says they are usually very numerous. The smallest form mere clusters of cells in the pial sheaths of the vessels, the larger ones are quite extensive cellular infiltrations, and are accompanied by softening of the infiltrated region. If the patient survives these patches may become abscesses. Epidemic cerebrospinal meningitis is thus accompanied by encephalitis and myelitis, and even after cessation of and recovery from the meningeal affection **cerebral abscess** may be left as a sequela.

A second group of purulent inflammations are due to **extension** from contiguous parts, either by continuity or by way of the blood-vessels or lymphatics. Thus *ostitis* of a vertebra or of the petrous bone extends directly to the meninges: suppuration of the nose, frontal sinuses, base of the skull, scalp (ulcers, erysipelas, eczema), internal ear, and eye (panophthalmitis) lead to suppuration of the membranes, the various vessels which pass from the bone inwards to the membranes serving as channels of infection. Especially dangerous is puriform softening of thrombi within the veins of the skull or the sinuses of the dura mater. Lastly, purulent inflammation of the brain itself may lead to the like in the meninges. According to some (FISCHER, BILLROTH, HUGUENIN) simple concussion of the brain without any wound of the soft parts or bones occasionally gives rise to purulent meningitis; HUGUENIN and others say the same may occur after sun-stroke.

The inflammation in all these cases will naturally begin where the irritant or exciting cause first acts, that is to say, it begins as a local affection. The wide communication between the several subarachnoid spaces contributes however to the speedy extension and generalization of the process.

Purulent meningitis, especially when it is cerebral, is usually fatal, though in some cases of the epidemic cerebrospinal disease recovery takes place. In the latter event the exudation is in the course of time re-absorbed, but usually certain whitish thickenings of the membranes due to fibrous hyperplasia, and some permanent dilatation of the ventricles, remain as evidence of the attack. Under certain conditions not fully understood the acute inflammation passes into a chronic one, the membranes undergoing cellular infiltration and becoming remarkably thickened. When the inflammation has been mainly confined to the pia mater, it may result in atrophy of the underlying nervous tissues (Art. 656).

STRÜMPPELL and WEIGERT have suggested that in cerebrospinal meningitis the infective virus may perhaps pass from the nose into the interior of the skull. The author is unable to accept the suggestion. Though he is convinced that purulent meningitis does not start from the nose, the phenomena of the epidemic affection appear to exclude that channel of infection. The manner in which the inflam-

matory change is distributed over the various parts of the meninges, the occurrence of numerous foci within the brain and cord, the frequent accompaniment of arthritis in various joints, etc., all indicate that the poison is spread by the channel of the blood-vessels, and thus reaches the central nervous system. The inflammation of the superior nasal meatus is a mere concomitant of the meningitis.

References on cerebrospinal meningitis:--ZIEMSEN, *Ziemssen's Cylopædia* II.; WUNDERLICH, *Arch. d. Heilk.* v., VII.; ZENKER, *D. Arch. f. klin. Med.* I.; STRÜMPPELL, *ibid.* XXX.; LANCEREAUX, *Traité d'anat. pathol.* II.; RADCLIFFE, *Reynolds' Syst. of med.* II. 1868; BURDON-SANDERSON, *Rep. of Med. Off. of Privy Council* 1866.

654. **Purulent encephalitis and myelitis.** In purulent meningitis the underlying nerve-tissue undergoes more or less extensive inflammatory change, and we might therefore very well describe the process as a meningoencephalitis or meningomyelitis. Under certain conditions however the inflammation of the brain or cord becomes the more marked feature, and this affects even the naked-eye appearance of the affected parts. This is especially the case in traumatic inflammations, set up by cuts, blows, stabs, or gun-shot wounds. The tearing and bruising of the tissue by the mechanical violence gives rise to disintegration or necrosis of the nerve elements, while the weapon which causes the injury may penetrate the substance of the brain or cord, or drive before it splinters of bone, or lacerate the blood-vessels and lead to hæmorrhage into the meninges or into the nerve-substance. If the wound becomes septic decomposition of the extravasated blood and of the damaged tissue takes place, and this induces violent purulent or putrid meningitis, encephalitis, or myelitis. The decomposing matters assume a dirty-brown, gray, or greenish color and give off a putrid odor. The actual inflammation begins with swelling of the nerve-substance and the formation of numerous points of hæmorrhage. The change first appears in the part near the injury, but often spreads widely, the hæmorrhagic extravasation extending deeply into the tissue, and also over a considerable area of the cortex beneath the inflamed pia mater. When the vessels are lacerated *ab initio* the swollen nerve-substance is tinged more or less deeply with yellow from the diffusion of the coloring-matter of the extravasated blood.

The hæmorrhagic foci lie always in the immediate neighborhood of small vessels, but as they grow larger they spread beyond the region of the adventitial lymph-sheaths into the nerve-tissue, and when the change is no longer quite recent they appear infiltrated with leucocytes which have left the vessels. This migration of leucocytes is the first stage of the suppurative process, and it steadily increases, until at length the nerve-tissue is as it were inundated by the multitude of extravasated cells, and presently undergoes degeneration and dissolution. When a portion of the tissue is thus liquefied and converted into a yellowish or

grayish or putrid pus-like cream, the encephalitis or myelitis has issued in **abscess**.

In like manner purulent meningeal inflammations due to other causes (*e. g.* suppuration of bone, or septic embolism) sometimes extend to the substance of the brain or cord and lead to abscess. As a rule however the process is not so violent or so rapid.

When irritant matters reach the interior of the brain or cord through the blood-vessels without affecting the meninges on the way, a local inflammation is set up which at first may not extend to the pia mater. If the irritant is one which has the power of setting up suppuration (such as the pyæmic micrococci), and lodges in a capillary or small vein, its first effect is to produce minute hæmorrhagic extravasations. These in the course of a few days become yellowish-white, with perhaps some slight blood-staining in the larger patches, and rapidly assume the appearance of abscesses. The number of extravasated white cells increases steadily, and at length the nerve-tissue breaks down and liquefies.

If at the same time one or more of the arteries have been blocked by embolism the inflammatory changes are accompanied or preceded by those characteristic of anæmic or hæmorrhagic necrosis (Art. 642). The final result is however the same: an abscess is formed, distinguished only from those already described by its possibly larger size.

Both forms of embolic suppuration occur under the same conditions as lead to purulent meningitis, namely pyæmia, endocarditis, suppuration or gangrene of the lung, putrid bronchitis, croupous pneumonia, cerebrospinal meningitis, etc.

Embolitic abscesses arise most commonly in the cerebral hemispheres and cerebellum, rarely in the cerebral axis, and more rarely still in the cord: they are sometimes multiple. They contain as a rule creamy-yellow or pale-greenish pus. The smallest are as large as a pin's head, the larger ones may occupy the greater part of a lobe: most frequently they are from the size of a walnut to that of a hen's egg.

When recent the wall of an abscess has a broken-down appearance, the tissue around being œdematous and often beset with small points of hæmorrhage. If close beneath the pia mater an abscess generally sets up meningitis, and if it breaks into a ventricle a violent inflammation of that region ensues.

Only the very smallest abscesses are capable of absorption and repair by cicatrization. The larger ones, if not fatal by pressure or meningitis, become enclosed in a granulating capsule or membrane and may exist for years in a quiescent state. So early as four weeks after its first appearance an abscess may be walled off from the surrounding tissue by a gray or grayish-red zone: in the course of months the zone grows broader and firmer, measuring from 2 to 5 mm. across. This is simply granulation tissue, which by and by is transformed into cicatricial fibrous tissue. In old abscesses the enclosing membrane is thus

made up of an inner granulating layer of cells and vessels and an outer fibrous layer.

Once encapsuled or 'encysted' in this way, the abscess slowly grows by the accumulation of pus derived from the granulating membrane; this secretion is probably not continuous, and in long-standing abscesses must be very slight. The surrounding brain-tissue is compressed, and sometimes atrophies or even degenerates and breaks down. At any moment moreover inflammatory œdema and fresh cellular infiltration may be set up in the compressed tissue, and these give rise to disturbance of the cerebral functions and often enough lead to a fatal issue. Nor is the danger of perforation into a ventricle or extension to the pia mater by any means removed when the abscess is encapsuled. Cerebellar abscesses may by pressure on the veins of Galen set up dropsy of the ventricles. Recovery from a large abscess is indeed possible only after surgical evacuation of its contents.

References on cerebral abscess:—LEBERT, *Virch. Arch.* vol. 10; SCHOTT, *Würzburg. med. Zeitschr.* II. (1862); BILLROTH, *Arch. d. Heilk.* 1862; HUGUENIN, *Ziemssen's Cyclopaedia* XII.; R. MEYER, *Zur Path. d. Hirnabscesse* In. Diss. Zürich, 1867; MAAS, *Berl. klin. Woch.* 1869; WYSS, *Jahrb. d. Kinderheilk.* IV. (1871); CRUVEILHIER, *Anat. pathologique* part 33; NAUWERCK, *D. Arch. f. klin. med.* XXIX; RETTELHEIM, *ibid.* XXXV. 1835 (abscess after empyema); EISELSBERG, *ibid.* (abscess after sunstroke); TOYNBEE, *Diseases of the ear* London 1868; GULL, *Guy's Hosp. Reports* III. (1857), *Reynolds' Syst. of med.* II. London 1868; HAYEM, *Arch. de physiol.* 1868.

Chronic Meningitis.

655. **Secondary forms of chronic leptomeningitis.** Chronic inflammation of the cranial or vertebral bones, or of the dura mater, are apt sooner or later to extend to the arachnoid, the subarachnoid tissue, and the pia mater. This extension occurs most commonly in tuberculous and syphilitic disease, though it is also met with in other inflammations, such as for instance are set up by mechanical injury to the bones. The idiopathic inflammation known as internal pachymeningitis, which is characterized by the formation of false-membranes and adhesions on the inner surface of the dura mater, sometimes extends to the inner meninges also.

The arachnoid having no vessels of its own is only passively affected by the inflammatory process, and undergoes more or less extensive degenerative changes. In the pia mater on the other hand, and in the vascular portions of the subarachnoid meshwork, inflammatory disturbances of the circulation make their appearance, and lead in the first place to infiltration of the latter tissue and of the arachnoid.

The next stage varies with the character of the inflammation. If it be of tuberculous or syphilitic origin, in course of time the arachnoid, the subarachnoid tissue, and the pia mater become milky and thickened,

partly from cellular infiltration, partly from the new-formation of fibrous tissue. Adhesions are not infrequently formed between the dura mater and the arachnoid. These are usually most dense and abundant in traumatic pachymeningitis; in the idiopathic form they are soft, fibrinous, and vascular.

But secondary chronic inflammations of the inner meninges are still more frequently the result of acute or chronic disease of the brain and cord. Every subpial inflammatory and degenerative process affecting the nerve-substance is capable of inducing meningeal inflammation: and tumors of the brain or cord act in like manner either directly, or through destructive changes in their own substance or in the tissue about them.

The pia mater and the surface of the central nervous organs stand in the closest possible connection, and in all degenerative processes affecting the latter, whether they are inflammatory or not, some of the products of disintegration are apt to reach the pial tissue and the sub-arachnoid spaces, and there give rise to turbidity or (in the case of hæmorrhage) yellow or brown pigmentation. The turbidity is more marked when the disintegrated matters possess irritating properties and excite inflammation. Then abundant extravasation of leucocytes ensues, and in time a more or less extensive fibrous hyperplasia is the result. In many cases the hyperplasia is well marked (Art. 642, Fig. 260), the meninges becoming dense, thick, white, and opaque. Both the sub-arachnoid and the arachnoid tissue take part with the pia mater in this hyperplasia, the trabeculæ of the former becoming thicker and coarser, new trabeculæ being formed, and the characteristic structure of the tissues obscured or altered. Calcareous concretions are common in the thickened membranes; and peculiar-looking cells are aggregated into spherical clusters, then become homogeneous, and lastly calcified, and are surrounded by tiny capsules of cells and new-formed fibrous tissue.

Secondary meningitis of the spinal cord is similar to that of the brain, and follows upon inflammations of the vertebræ or spinal dura mater. In some cases the inflammation also extends to the substance of the cord itself.

656. **Hæmatogenous chronic leptomeningitis.** We have already pointed out (Arts. 652, 653) that acute meningitis of hæmatogenous origin, if not fatal, may issue in recovery by re-absorption of the exudation; but this is frequently accompanied by some thickening of the membranes due to new-formation of fibrous tissue. In certain not fully understood conditions the acute disorder passes into a chronic form, characterized by persistent cellular infiltration, and consequent thickening and opacity of the meninges; chronic internal hydrocephalus is a further sequela.

But there are other forms of chronic leptomeningitis which as to their causation, rise, and progress, differ notably from the foregoing.

We refer to those chronic (more rarely acute or subacute) inflammatory processes which are the most frequent though not invariable antecedent of certain mental disorders, especially that known as paralytic dementia or **progressive paralysis of the insane**. The processes in question and the mental disease as commonly defined are not exactly co-extensive: on the one hand they may be absent in cases where the mental disease exists, and on the other they are met with in cases where the symptoms if any have been other than mental.

The morbid conditions referred to have certainly not the same aetiological or clinical significance in all cases: they may be divided into two groups according to their anatomical characters, in other words according to their situation and the nature of the textural changes they induce.

In the first place we have changes affecting mainly the arachnoid and subarachnoid tissues and giving them a white opaque appearance, the opacity being limited to spots and streaks or more uniformly diffused: it is most apparent over the sulci and the subarachnoid cisterns, and occurs both at the base and on the convexity of the brain. It is still doubtful whether these opacities are always of inflammatory origin. They are histologically due to fibrous thickening, endothelial hyperplasia, or more rarely to cellular infiltration. If we are to reckon them provisionally as due to chronic inflammation, this would probably be best described as **chronic arachnitis** or **external leptomenigitis**. As to their causation they are observed in connection with chronic venous engorgement and with certain morbid states of the blood, as in alcoholism and chronic nephritis.

Of greater importance than the changes just mentioned, which after all can hardly be supposed to induce grave disorder of the nervous functions, are certain chronic affections which involve chiefly the pia mater and underlying nerve-tissue: in their later stages at least they are unmistakably inflammatory, and are therefore appropriately included under the terms **chronic meningoencephalitis** and **meningomyelitis**.

When the morbid process is well advanced the soft membranes, especially the pia mater, are visibly milky and opaque, the change showing best in the sulci along the blood-vessels, and sometimes also on the ridges of the convolutions. It is most common in the anterior parts of the brain, namely the frontal and parietal lobes, the other parts being little or not at all affected. Cases however are described in which the change is most marked in the temporal lobes.

The most striking of the textural changes is undoubtedly the cellular infiltration which pervades the pia mater (Fig. 273 *h*), and to a less degree the subarachnoid tissue (*b*). This is occasionally accompanied by a more or less extensive fibrous hyperplasia of these structures. In later stages accumulations of leucocytes (i_1), and in smaller quantity red blood-cells and brown or yellow pigment (i_2), appear in the adventi-

tial sheaths of the cortical vessels, and sometimes even of those supplying the white matter. But no great accumulations of cells are as a rule met with in the mass of the brain-substance itself. The cellular infiltration is not uniform, varying much even within the tissue of the pia mater. In the cortex comparatively few vessels are surrounded by masses of cells, and in the white matter perhaps one or two at most. Some of the vessels however show hyaline or fibrous thickening of the adventitial coat.

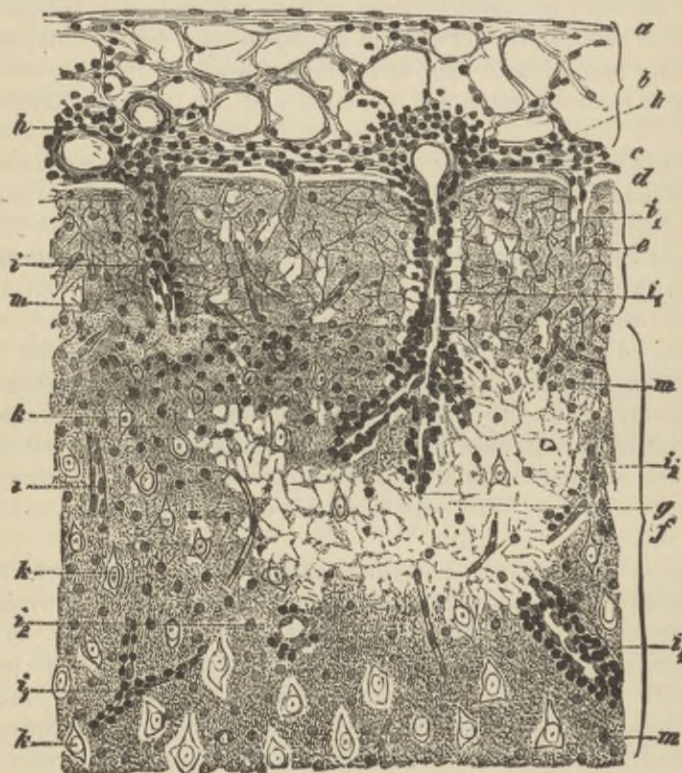


FIG. 273. CHRONIC MENINGOENCEPHALITIS WITH ATROPHY OF THE CORTEX.

(Section hardened with Müller's fluid and alcohol, stained with alum-carminé and ammonia carminé, and mounted in Canada Balsam: $\times 150$.)

- | | |
|---|---|
| a, arachnoid | g, many of these have disappeared, a delicate reticulum remaining |
| b, subarachnoid tissue | h, cellular infiltration of pia mater |
| c, pia mater | i, unaltered blood-vessel |
| d, superficial layer of cortex | i ₁ , pial sheath of vessel filled with leucocytes |
| e, layer of small pyramidal cells; the cells have disappeared, and numerous stellate figures composed of glistening fibres have taken their place | i ₂ , pial sheath filled with blood-cells and pigment |
| f, layer of large pyramidal cells, | k, ganglion-cell (of the third layer) |
| | m, neuroglia-cells |

The nerve-substance of the cortex is probably never entirely normal

in these cases; though it is not always easy to demonstrate the changes that exist. In very chronic cases it is often visibly atrophied, its depth being diminished to a half or a third of the normal: but the atrophy is far from being always uniform over the affected area, being sometimes most marked in particular convolutions or parts thereof. The atrophied areas are usually pale, seldom reddened, and are occasionally somewhat indurated.

As the white matter is at the same time diminished the affected portion of the brain is on the whole perceptibly smaller, and the space left vacant by the shrinking is filled up by liquid collecting in the subarachnoid tissue. Sometimes too the ventricles are dilated and their ependyma beset with granulations (Art. 650). When the atrophy is extreme the brain is sometimes so remarkably shrunken that it weighs less than 1000 grammes. The affection is therefore aptly described as **atrophic meningoencephalitis**.

The outer layers of the gray matter are usually the most altered. In both pyramidal-cell layers (*e f*) the number of cells is diminished, and here and there are patches in which all of them have disappeared (*g*). In sections mounted in Canada balsam the loss of the nerve-elements causes the tissue (normally so densely granular) to look as if it were full of holes and gaps, nothing but a fine scarcely-visible reticulum remaining at certain points. The layer (*e*) of small ganglion-cells (pyramidal cells) shows this in the most marked way: the neuroglia may be hardly apparent (*f*), or it shows as a meshwork of glistening fibres (*e*) interlacing irregularly or disposed in stellate patterns. The points of intersection of the fibres are sometimes occupied by nuclei, and now and then it is possible to demonstrate that the fibres are simply processes of the neuroglia cells. When the cortex is not visibly thinned the atrophy is slight and hardly to be made out in Canada-balsam preparations. Perosmic acid brings out the fact that some of the nerve-cells are breaking down, with or without the formation of fat-granules.

The medullary or white matter of the brain is often in these cases not only shrunken but also interspersed with foci of degeneration.

The cord and pia mater is in like manner subject to cellular infiltration: not infrequently there is also present some degeneration and sclerosis of the pyramidal and of the posterior columns (Arts. 647, 648).

In the disease known as **paralytic dementia** or progressive paralysis, which is characterized by loss of intellectual power, emotional derangement, and illusions, the atrophic form of hæmatogenous chronic meningoencephalitis is an extremely common lesion. It must however be mentioned that not only this form but other chronic inflammations from traumatic injury of the head may lead to progressive paralysis, and that in patients who have died of the latter disease all that is found in some cases is simple non-inflammatory degeneration of the cortex and meninges. It would thus appear that the disordered nutrition and degeneration of the ganglion-cells and nerve-fibres is the essential feature; the

inflammatory infiltration and the increase of the fibrous structures serve to indicate the nature of the process (Art. 657) but do not determine the clinical symptoms.

BAYLE describes progressive paralysis as a chronic arachnitis, CALMEIL as chronic periencephalitis, PERCHAPPE as softening of the brain, TUCZEK as chronic meningitis, MAGNAN as diffuse interstitial meningoencephalitis, MENDEL as diffuse interstitial cortical encephalitis, LUYSS as diffuse interstitial sclerosis. Most writers regard the affection as an inflammation corresponding in general to what we have described as chronic meningoencephalitis. The interpretations given to the various morbid appearances differ widely. Thus MIERZEJEWSKY and VOISIN regard the fibrils and stellate cells, which are often so markedly visible in the atrophied cortex, as fibrinous. MENDEL, LUBIMUFF, SELVILL, and others attribute much importance to the stellate cells, and think that they multiply considerably. This can only occur in a very few cases and to a limited extent. As a rule they are not increased in number, but they are merely more visible in the absence of the nerve-elements. The statements sometimes made as to multiplication of the ganglion-cells cannot be regarded as proven.

It is frequently asserted that in progressive paralysis the pia mater is abnormally adherent to the brain-surface, tearing away the latter as it is stripped off—but the test is of little value. It often fails where there is the most marked change both in pia mater and cortex, and only shows that the brain-substance is abnormally soft: the effect is in part at least due to post-mortem changes. It is better not to try at all to strip off the pia mater, for it renders the brain almost useless for minute examination afterwards.

MIERZEJEWSKY and others have affirmed that in this affection filamentous processes and ramified connective-tissue cells are found attached to the vessels of the cortex when isolated: the description is accurate, but the phenomenon is not characteristic, as it is found in connection with other morbid conditions and even occasionally in healthy brains. SIMON, ARNDT, SCHÜLE, and GREIFF have found in paralytic and other brains patches of clear hyaline substance in the neighborhood of the vessels.

According to TUCZEK (*Neurol. Centralbl.* 1883) in paralytic dementia the medullated nerve-fibres of the cortex are especially apt to be lost, and that chiefly in the island of Reil and Broca's convolution (left inferior-frontal); while the ascending-frontal gyrus, the paracental lobule, the second-temporal gyrus, and the parietal and occipital lobes are usually free from change. The loss of fibres is first apparent in the superficial layers.

In one case of chronic basal meningitis MANZ (*Graefes Arch. f. Ophthalm.* 1883) met with large endothelial growths in the pial sheath of the optic nerve, the nerve itself being atrophied.

On the morbid changes in the brain in progressive paralysis (general paralysis of the insane):—MEYNERT, *Viertelj. f. Psych.* 1868; WESTPHAL, *Arch. f. Psych.* I.; SIMON, *ibid.* II.; GREIFF, *ibid.* XIV.; ZACHER, *ibid.* XIII., XIV.; MESCHEDÉ, *Virch. Arch.* vols. 34, 56; TIGGES, *Allg. Zeitschr. f. Psych.* XX.; SCHÜLE, *ibid.* XXV.; LUBIMUFF, *Virch. Arch.* vol. 55, *Arch. f. Psych.* 1874; MIERZEJEWSKY, *Études sur les lésions cérébrales dans la paralysie générale* Paris 1875, *Arch. de physiol.* 1876; VOISIN, *Traité de la paral. gén. des aliénés* Paris 1879; MENDEL, *Die progr. Paral. d. Irren* Berlin 1880, *Berl. klin. Woch.* 1882, *Neurol. Centralbl.* 1883; SCHULTZE, *Arch. f. Psych.* XI.; SELVILL, *Zur path. Anat. d. Dementia paral.* In. Diss. Zürich 1876; LUYSS, *Gaz. méd.* 33, 1876; KLEBS, *Prag. med. Woch.* 1879; EMMINGHAUS, *Allg. Psychopathologie* Leipzig 1878; TUCZEK, *Dementia paralytica* Berlin 1884; KRÄPELIN, *Arch. f. Psych.* XV. 1884; HARTMANN, *ibid.* XVI. 1885 (mental disorder following injury to the head).

On like changes in the cord:—TÜRCK, *Wiener Sitzungsber.* LI., LII., LVI.; WESTPHAL, *Virch. Arch.* vols. 39, 40; MAGNAN, *Gaz. des hôpitaux* 14, 1876; STEWART, *Glasgow Med. Journ.* 1886.

657. The **ætiology** of hæmatogenous chronic meningoencephalitis is in many respects imperfectly understood. Hereditary predisposition, severe mental labor, exciting or exhausting influences of every kind, etc. have all been observed as antecedent conditions, and in such cases the hypothesis of an infective or toxic exciting cause seems to be excluded: such a cause is conceivable only in cases where the process is associated with diseases like cerebrospinal meningitis, typhoid, erysipelas, articular rheumatism, etc. And even here the secondary affection may well be the result of disordered nutrition rather than of any special extension of the primary disease.

Most cases of chronic meningoencephalitis and meningomyelitis would thus appear to be in their inception mainly dependent on degenerative changes due to excessive functional activity or to disorder of the circulation.

In recent cases of mental disorder presenting the same symptoms as the lesion we are considering, that is to say in what is clinically progressive paralysis, the changes found are frequently degenerative only, little if any evidence of inflammatory disease being discoverable. White turbidity of the pia mater is the chief of these changes, and it is due to an accumulation in the tissue of small globules and granules of fat, fatty and broken-down cells, and occasionally fat-granule cells. This detritus cannot have been wholly produced at the points where it is found by the degeneration merely of the meningeal endothelium or of extravasated cells; it must at least in part be derived from the brain-substance: and as a fact like matters are found in small quantity in the pial sheaths of the cortical vessels, while the vessel-walls themselves show here and there spots of fatty degeneration. It is also of special interest to note that some of the ganglion-cells are likewise fatty.

It often happens that no signs of inflammation appear at the sites of degeneration, though there are often small hæmorrhagic extravasations or pigmentary deposits to indicate that the circulation has been disturbed. It must be remembered that congestive hyperæmia alone, such as frequently accompanies excessive functional activity, is capable of increasing the intracranial pressure, and thus of compressing the capillaries, retarding the circulation, and bringing about local anæmia and engorgement with all their consequences.

But although simple disturbances of circulation and nutrition play an important part in the causation of progressive paralysis, it must not be forgotten that in other parts of the brain or cord, such as the centrum ovale or the columns of gray matter, close examination may reveal collections of leucocytes in the adventitial sheaths of the vessels. These

are sometimes very abundant, and can hardly be regarded as mere accumulations from stasis in the lymphatics, but are almost certainly evidence of inflammation. The occasional combination of multiple sclerosis (like that of recent encephalitis and myelitis) with meningo-encephalitis is of interest as showing that the process is one which in some instances at least is not limited to the cortex, but affects the whole central nervous system. As the disease becomes more advanced, the evidences of inflammation become more numerous, a result probably of the continuous action of the same exciting causes as first induced it.

These observations hold of a number of the cases: in others the inflammatory nature of the lesion is apparent from the commencement. Some acute cases are indeed described in which *post mortem* the hyperæmia and saturation of the brain with liquid effusion were unmistakable.

Chronic leptomeningitis is somewhat frequently associated with exudative pachymeningitis (Art. 664).

The apparent prominence of the neuroglial meshwork with its stellate cells in the atrophied portions of the cortex is at first due simply to the disappearance of the nerve-elements. Later on an actual multiplication and hyperplasia of the neuroglia-cells may take place, as in other atrophies of nerve-tissue.

The occasional combination of meningoencephalitis with degeneration and sclerosis of the posterior columns of the cord would indicate that the latter lesion is secondary, resembling in origin those changes we have already described. The spinal pia mater when it is affected at all is apt to be most thickened over the posterior half of the cord, and this has probably something to do with the locality of the sclerosis. The degeneration of the pyramidal tracts which is sometimes met with in the disease is perhaps dependent on the degeneration of the motor centres in the cortex (FLECHSIG), though this is questioned by WESTPHAL (Art. 647).

Chronic leptomeningitis of the cord alone, apart from the secondary forms dependent on inflammation of the dura mater, vertebræ, or cord-substance, is most commonly a termination of an acute attack. Most writers state that it may also be due to catching cold, and it sometimes follows mechanical injury. It is marked by the presence in the soft membranes of opacities, thickenings, and adhesions to the dura mater, and at times by increase and turbidity of the subarachnoid liquid. Marginal sclerosis, multiple sclerosis, and degenerations of some of the columns are occasionally present in the same case.

Cicatrization and Sclerosis.

658. **Repair of wounds of the brain and cord.** Bruises, cuts, stabs, and gun-shot wounds of the brain are usually fatal from the supervention of purulent meningitis and encephalitis. More rarely

abscesses are formed which are evacuated and healed up by granulation and cicatrization. It is only when the wound is aseptic or is at once protected from septic infection that we can expect healing without sup-puration.

The destructive changes set up by a traumatic lesion vary with its nature. Bruises and contusions are the most dangerous, stabs and punctures the least so.

When the brain is punctured (Fig. 274 *a*), as by a dagger-wound, in the first place hæmorrhage takes place, and the tissue immediately contiguous is thereby destroyed. A patch of anæmic or hæmorrhagic necrotic softening (*b*) is thus produced, the meninges overlying the part being usually infiltrated with blood.

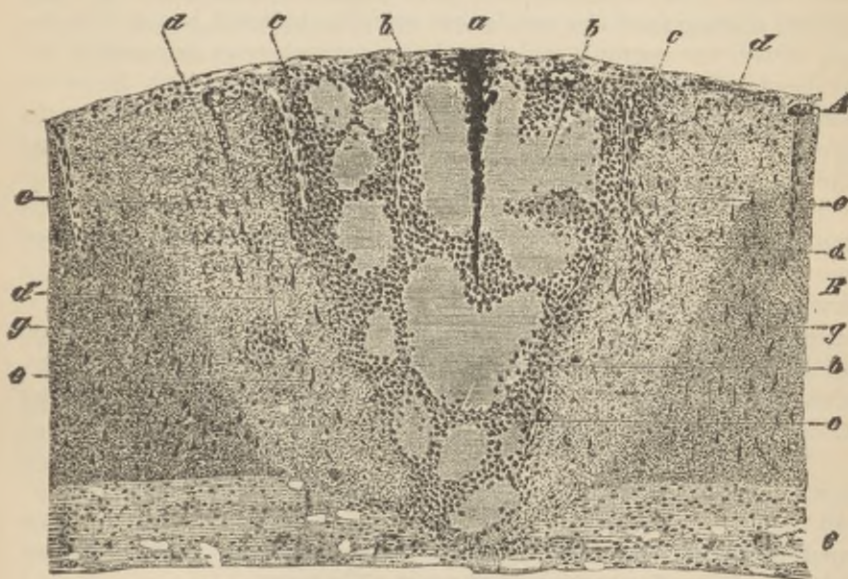


FIG. 274. ENCEPHALITIS EXPERIMENTALLY PRODUCED BY A PUNCTURE.

(From a rabbit's brain 12 days after the injury; section hardened in Müller's liquid, stained with hæmatoxylin and neutral carmine, and mounted in Canada balsam: $\times 25$.)

A, meninges

B, cortex

C, white matter

a, puncture

b, necrotic tissue, granular and denuded

c, zone of inflammatory cellular infiltration

d, zone of degeneration

e, swollen and degenerate ganglion-cells

g, normal cortical substance

At the boundary between living and dead tissue a more or less intense inflammation (*c*) sets in after a few hours, and this by degrees constitutes a zone of demarcation. The inflammatory process advances mainly along the vessels (*c*) entering from the pia mater, and in a few days the inflamed tissue softens and liquefies, while the inflammatory cellular infiltration extends more and more into the necrotic patch (*b*). The

latter also liquefies and is absorbed, though months or years may pass before all the detritus is carried off.

Around the inflamed region the nerve-substance suffers from impaired nutrition, and a considerable portion of it undergoes degeneration (*d*), indicated by swelling, fatty change, fragmentation and disintegration of the ganglion-cells (*e*) and nerve-fibres. The inflammatory zone is thus surrounded by a broad zone of degeneration.

During the first few weeks the inflammatory zone is chiefly made up of vessels, small round-cells, larger formative cells, and fat-granule and pigment-carrying cells. The latter are always very abundant so long as absorption of the products of disintegration and extravasation goes on, the fat-granule cells being visible also in the zone of degeneration. After some weeks or months new fibrous tissue is gradually elaborated, plainly starting from the vessels that enter the inflamed region from the pia mater: the necrotic region is thus more and more surrounded and at length filled up with new-formed fibrous tissue. The fibres are sometimes close-set and wavy, sometimes loose and areolar, and are the product of the fibroblasts derived from the extravasated leucocytes and the connective-tissue cells of the pia mater and the vessel-sheaths.

This cicatrization is a very slow process, and after months or years the scar may still contain multitudes of round-cells. The encapsuled necrotic patch only disappears after the lapse of many months, and the degenerative changes external to the inflamed region persist as long or longer. Rarely does the degeneration result in fibrous hyperplasia and sclerosis, though when this happens the sclerosis is apt to be very extensive. In like manner the fibrous thickening of the wounded pia mater often extends over a large area.

This is the process of repair in comparatively small wounds: it is of course modified if there has been extensive laceration of the brain-tissue. As we mentioned in Art. 645 in speaking of contusions, the development of fibrous tissue is apt to be slight and incomplete, and the process takes the form of progressive **ischæmic softening**.

This account of the repair of the wounds of the brain is based partly on observations made by the author on human injuries, partly on experiments made for him by KAMMERER upon rabbits. The process of healing can be readily followed in punctured wounds made under antiseptic precautions with recently heated needles. The oldest wound examined in a patient was 21 months old, and was due to a knife-stab penetrating the ascending-frontal convolution of a young man. The necrotic patch was not then fully absorbed, and the scar was still surrounded by a broad zone of degeneration, which like the scar contained numerous fat-granule and pigment-carrying cells.

References:—BRUNS, *Die chir. Krankheiten u. Verletz. d. Gehirnes u. s. Umhüllungen* Tübingen 1854; STROMEYER, *Verletz. u. chir. Krankh. d. Kopfes* Freiburg 1864; BERGMANN, *Deutsche Chirurgie* part 30; VIRCHOW, *Virch. Arch.* vol. 50; GLUGE, *Abhandl. z. Physiol. u. Path.* Jena 1841 (experiments on encephalitis); HASSE and KÖLLIKER, *Zeitschr. f. rat. Med.* iv. (1846); JOLLY, *Stud. aus d.*

Inst. f. exp. Path. Vienna 1870; HAYEM, *Etudes sur les diverses formes d'encéphalite* Paris 1868; KLEBS, *Path. Anat. d. Schusswunden* Leipzig 1872; ZIEGLER, *Sitzungsber. d. phys.-med. Gesell. in Würzburg* 1878.

659. Both in the brain and cord we meet with localized or disseminated hæmatogenous inflammation, which like the localized degenerations lead partly to permanent loss of substance, partly to gray degeneration and sclerosis. **Encephalitis** is the name given to the affection of the brain, **myelitis** to that of the cord.

It is in the first place to be kept in mind (Art. 653) that in epidemic cerebrospinal meningitis patches of encephalitis and myelitis are of constant occurrence. In the meningitic processes associated with progressive paralysis inflammatory foci are found in the interior of the brain and cord, and sometimes in the pial sheaths of the nerve-roots. But these deeper inflammations also take place in the absence of meningitis, both in connection with infective disorders and idiopathically.

Thus in typhoid, variola, acute rheumatism, pyæmia, puerperal fevers, ulcerative phthisis, etc. multiple encephalitis is not rare, while in hydrophobia (so-called *lyssa*) patches of inflammation scattered through the whole central nervous system, but chiefly in the base of the brain and the cord, have been described by a number of writers (KOLESSNIKOW, FOREL, GOWERS, WELLER). They are very common in tuberculosis (Art. 660).

Frequently too these patches occur without any apparent exciting cause, and are then attributed vaguely to cold or some such injurious influence. According to certain authorities violent irritation of peripheral nerves is capable of setting up myelitis; though it is more likely that the spinal diseases thus induced are due to ischæmic or hæmorrhagic softening.

The smaller and more recent patches are not visible to the naked eye, being little more than circumvascular cellular infiltrations. When they are somewhat larger they are usually seen as red or pink spots, which are very distinct when in the white matter. Sometimes they contain little extravasations, and under certain conditions the whole patch resembles one of hæmorrhagic softening.

The smaller patches occasionally heal without leaving a trace. In the larger ones there is always some destruction of nerve-tissue, a small cyst (Art. 642), a gray gelatinous patch (Fig. 271, Art. 650), a sclerosis, or a scar remaining after the cessation of the inflammatory disturbance and the absorption of detritus and exudation.

In the brain recent **multiple encephalitis** is found in many acute mental disorders: sometimes the patches are extraordinarily numerous. As to the issue of this form of disease we know little, though it is possible that it terminates in multiple sclerosis. As to the larger myelitic foci and their consequences we are better informed.

In the first place the cord is subject to acute inflammation affecting

chiefly the gray matter, and described as central myelitis or poliomyelitis (*πολιος* gray). **Anterior poliomyelitis** is the commonest form (Figs. 275, 276), the inflammation being limited to one or both anterior horns. More rarely it extends to the posterior horns or to the entire section of the gray columns (Fig. 277).

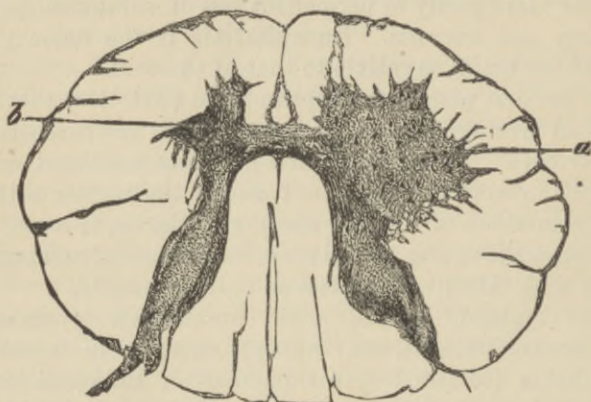


FIG. 275. SCLEROSIS AND SHRINKING OF THE LEFT ANTERIOR HORN.

(Section taken at the level of the fourth cervical nerve from a case of infantile paralysis (acute anterior poliomyelitis) in a child of 3½; hardened in Müller's fluid, stained with neutral carmine, and mounted in Canada balsam: × 7.)

a, normal anterior horn with ganglion cells
b, atrophied and shrunken horn

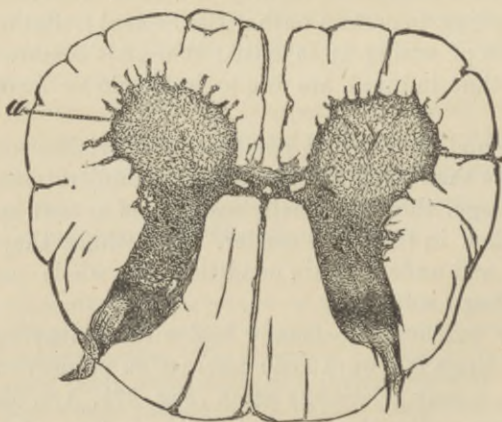


FIG. 276. GELATINOUS DEGENERATION OF BOTH ANTERIOR HORNS.

(Section taken from lumbar region: case of acute anterior poliomyelitis in a man of 40; preparation treated as in last figure: × 6.)

a, anterior horns

The disease chiefly attacks children less than four years old, and hence the clinical name of **infantile spinal paralysis**; it is rare in adults. Its onset is acute, there is usually fever, and soon paralysis, which in

the course of a week passes away to some extent. So far as our knowledge goes the inflammation is hæmorrhagic in character, and gives rise to functional disorder partly by destruction of tissue and partly by pressure. The preference shown for the anterior columns and especially for the inner two-thirds of each appears to be due to the fact that these parts constitute a special vascular territory distinct from the white matter. The length of the affected region varies from about 0.5 to 4 centimetres, though cases occur in which much larger segments of the cord are attacked.

The number of ganglion-cells and nerve-fibres destroyed depends on the severity of the inflammation: sometimes indeed the whole of the nerve-tissue perishes outright.

In the course of weeks or months the exudation and the products of disintegration are absorbed. If the neuroglia as well as the nerve-elements is destroyed a small cyst is formed. If the neuroglia persists and

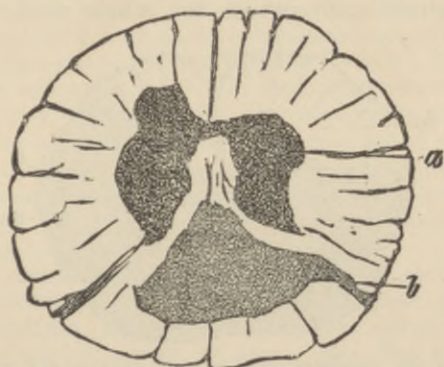


FIG. 277. SCLEROSIS AND SHRINKING OF THE ENTIRE GRAY MATTER.

(Section taken from lower dorsal region of a man of 30 suffering from acute anterior poliomyelitis: preparation treated as in last figure: $\times 6$.)

a, site of gray matter

b, sclerosis of posterior columns

undergoes a moderate hyperplasia, the substance of the anterior horn is transformed into a gray gelatinous mass (Figs. 271, 276), consisting of a loose reticulum containing liquid in its wide meshes. When the hyperplasia is considerable the tissue becomes close-textured, firm, and sclerotic (Fig. 275), consisting of a felted mass of fine fibrils with scattered nuclei. The vessel-walls are in general thickened, the adventitial lymph-spaces are dilated, and contain at least in the earlier stages round-cells and granular cells. When the nerve-elements are not entirely destroyed the sclerotic tissue still encloses a few ganglion-cells (Fig. 278 b) and nerve-fibres.

The anterior roots and the peripheral motor nerves become atrophied when the ganglion-cells are destroyed, and assume a gray wasted appearance. The muscles supplied by them likewise atrophy.

When the inflammation affects the gray matter over its whole cross-section, the horns become after a time strangely warped and distorted, and presently undergo gelatinous degeneration or sclerosis (Fig. 277).

The white columns are frequently affected by secondary extension of inflammation from the gray matter. Sometimes however the white matter is inflamed from the beginning, and we have **leukomyelitis** (*λευκος* white) associated with poliomyelitis. In such cases the whole cross-section of the cord or the greater part of it undergoes destructive inflammation (**transverse myelitis**), and afterwards gelatinous and sclerotic changes (Fig. 278). The disease moreover frequently extends over a considerable segment of the cord. Secondary ascending and descending degeneration of the tracts after a time follows on the local lesion.

Myelitic foci are usually single, though sometimes they are multiple, as in disseminated myelitis. The multiple patches are usually small, and may be scattered throughout the whole cord. When myelitis

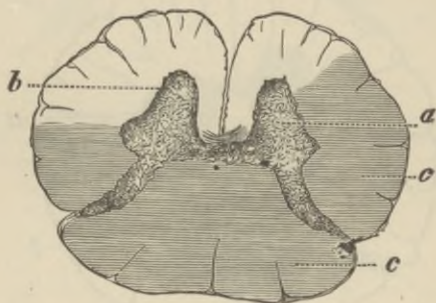


FIG. 278. SCLEROSIS AFTER ACUTE TRANSVERSE MYELITIS.

(Section taken from a man of 40 at the level of the lower dorsal region: hardened in Müller's fluid, stained with carmine, and mounted in Canada balsam: $\times 6$.)

- a, gelatinous change in gray matter
- b, surviving ganglion-cells
- c, atrophied and sclerotic white matter

attacks the region of the bulbar nuclei it gives rise to acute **glossolabio-pharyngeal or bulbar paralysis**.

Under conditions analogous to those which lead to acute poliomyelitis in children we may apparently have an acute inflammation of the cortical gray matter or **acute polioencephalitis** (STRÜMPPELL), the result of which is **infantile cerebral paralysis**. In its later stages it is characterized by loss of substance in the convolutions, resembling the congenital condition known as porencephalia (Art. 630).

BENEDEKT *Virch. Arch.* vol. 64, KOLESSNIKOW (*ibid.* vol. 85), FOREL (*Zeitschr. f. Thiermed.* III.), ALLBUTT (*Trans. Path. Soc.* XXIII. 1872), GOWERS (*ibid.* XXVIII. 1878), ROSS (*ibid.* XXX. 1880), COATS, *Med. chir. Trans.* LXI. 1878), and WELLER (*Arch. f. Psych.* 1879) all agree in stating that in **hydrophobia** circumvascular

extravasations, some of them hæmorrhagic, are found in the central nervous organs. BENEDIKT, KOLESSNIKOW, GOWERS, and WELLER also discovered circumvascular hyaline and granular coagulated masses formed from the extravasated elements of the blood, together with venous thromboses (BENEDIKT), and patches of 'granular' degeneration. FOREL was not able to verify these observations.

LANGHANS (*Virch. Arch.* vol. 64) found in the cord in cases of tetany certain circumvascular patches of cellular infiltration. NAUWERCK in a recent case of chorea minor with endocarditis observed small patches of inflammation situated chiefly in the medulla; these were combined with certain degenerative changes in the brain and cord. Myelitis is said to occur among the Kabyles in North Africa as a result of eating the pulse of *Lathyrus cicera*: see Art. 648, and MARIE (*Progrès médical* 1883), PROUST (*Bulletin de l'acad. d. méd.* XII. 1884).

The number of white blood-cells usually present in the brain (DUKE KARL THEODOR of Bavaria, *Virch. Arch.* vol. 69) is increased in typhoid (POPOFF), but not necessarily owing to inflammation. Sometimes, though rarely, disseminated encephalitis is associated with typhoid.

STUEDENER (*Beit. z. path. Anat. d. Lepra mutilans* 1865), NEUMANN (*Skin diseases*, trans. by PULLAR, London 1871), TSCHIRJEW (*Arch. d. physiol.* 1879), and LANGHANS (*Virch. Arch.* vol. 64) found inflammatory foci in the cord in connection with anæsthetic leprosy. See also STURGE, *Brain* VII. 1885.

ERB and others affirm that in infantile spinal paralysis the inflammatory disturbance extends over the whole of the anterior columns, reaching its greatest intensity only at certain parts, and the wide-spread initial paralysis corresponds with this view of the case. After weeks or months however only circumscribed changes can be demonstrated, the extent of which varies with the extent of the persistent paralysis. When certain muscles only are paralyzed, certain spots only of the anterior horns are found to be degenerate.

References on myelitis:—CHARCOT, *Diseases of the nervous system* London 1880; LEYDEN, *Klinik d. Rückenmarkskr.* 1874-76, *Zeitschr. f. klin. Med.* I., *Arch. f. Psych.* VI.; HAMMOND, *Diseases of the nervous system* London 1876; ERB, *Ziemssen's Cyclop.* XIII.; SCHULTZE, *D. Arch. f. klin. Med.* XX., *Virch. Arch.* vol. 68; DUJARDIN-BEAUMETZ, *De la myélite aiguë* Paris 1872; WESTPHAL, *Arch. f. Psych.* III., IV. (1874); HAYEM, *Arch. de Physiol.* VI. (1874); LAVERAN, *ibid.* VII. (1875); BAUMGARTEN, *Arch. d. Heilk.* XVII.; HAMILTON, *Quart. Journ. of micro. science* 1875; TURNER, and HUMPHREYS, *Trans. Path. Soc.* XXX. 1879 (recent cases of poliomyelitis); DAMASCHINO and ROGER, *Gaz. méd.* 1871 (ditto); BARLOW, *On regressive paralysis* London 1878; ALTHAUS, *Infantile Paralysis* London 1878; ANGEL-MONEY, *Trans. Path. Soc.* XXXV. 1884; DRUMMOND, *Brain* VII. 1885; KRAUS, *Poliomyelitis anter. acuta* In. Diss. Tübingen 1882; SAHLI, *D. Arch. f. klin. Med.* XXXIII.; ETTER, *Corresp. f. Schweiz. Aerzte* 1882 (acute bulbar myelitis); LANGE, *Hosp. Tidende* 1868 (ditto); LEYDEN, *Arch. f. Psych.* VII. (ditto); LICHTHEIM, *D. Arch. f. klin. Med.* XVIII. (ditto); EISENLOHR, *Virch. Arch.* vol. 73; VON VELDEN, *D. Arch. f. klin. Med.* XIX. (disseminated myelitis); ENGELKEN, *Path. d. acuten Myelitis* In. Diss. Zurich 1867 (ditto); DRESCHFELD, *Lancet* 1, 1882 (ditto).

LEYDEN (*Arch. f. Psych.* VIII. 1877, *Charite-Annalen* III.) produced myelitis in dogs by injecting liquor arsenicalis (Fowler's solution) into the lumbar cord, and showed that the affection might terminate in cicatrization, sclerosis, cyst, or in simple rarefaction or loosening of the tissue. He thought that disseminated multiple sclerosis was the result of a disseminated myelitis or encephalitis. Clinically the term myelitis is used in a sense much wider than that to which we have restricted it. Thus poliomyelitis is used to describe conditions which are not

inflammatory, such as ischæmic and hæmorrhagic softening, simple atrophy, and multiple sclerosis of the gray matter. Secondary and primary tract-degenerations, ischæmic and hæmorrhagic softening, degeneration from pressure and contusion of the white matter of the cord or medulla oblongata, are all classed as myelitis. This may be convenient, but the pathologist is bound to be more discriminating. Even if it is not always possible in the post-mortem room to determine with certainty the manner in which a given change, say a patch of sclerosis, was initially induced, this is no reason for declining to classify such changes according to their mode of origin.

The terms acute and chronic progressive bulbar paralysis, anterior poliomyelitis, infantile spinal paralysis, atrophic spinal paralysis, transverse myelitis, leukomyelitis, protopathic and secondary spinal muscular atrophy, spastic spinal paralysis or paraplegia, and so on, are intended to express the character of the clinical symptoms and the seat of the lesion in the several maladies: for the most part however they fail to indicate or at least to indicate correctly the nature of the morbid process.

On acute polioencephalitis:—STRÜMPPELL, *Deut. med. Woch.* 1884, *Jahrb. f. Kinderheilk.* XXII. 1885, *London Med. Record* 1885; GAUDARD, *L'hémiplégie infantile cérébrale* In. Diss. Geneva 1884; RANKE, *München. med. Woch.* 18, 1886; WOLFENDEN, *Practitioner* XXXVII. 1886.

CHAPTER XCVI.

TUBERCULOSIS AND SYPHILIS.

660. **Tuberculosis** of the central nervous organs and their membranes is in most cases embolic in origin, though the disease may also extend by continuity from neighboring tissues, such as the bones.

When the tuberculous virus reaches the brain or cord by way of the blood-vessels a form of tuberculosis is set up which we may call **disseminated tuberculous meningoencephalitis** or **meningomyelitis**. Where the bacilli first lodge their irritative action gives rise to minute inflammatory foci (Fig. 279, *c e f*), which in the subarachnoid and pia mater and in the substance of the brain and cord are distributed chiefly along the course of the small veins, in part also amid the capillaries of the nerve-substance itself. The pial sheaths (*f*) of the vessels are at first the chief seat of the inflammatory infiltration of cells; presently however the process extends also to the adjacent tissues (*e*). In a short time the collections of cells form nodules (*d*) and nodular clusters (*a b*), or more rarely larger continuous patches (*k*).

Disseminated embolic tuberculosis of the brain and cord runs in general a somewhat rapid course, and proves fatal in a few weeks' time. In addition to the nodular eruption there is often wide-spread diffuse inflammatory exudation of a sero-purulent or fibrino-purulent character, the pus infiltrating the meninges and the brain-substance, and often accumulating in the ventricles. It is only in rare cases and these very chronic (Fig. 279) that diffuse exudation fails to accompany an abundant eruption of tubercles.

In the soft membranes the first visible sign of tuberculosis is the appearance of small gray nodules usually lying along the course of congested vessels. By and by they become larger, and the subarachnoid spaces are seen to contain a turbid yellowish-white pus-like exudation. When the choroid plexuses are invaded they too contain gray nodules, and are swollen and infiltrated with a turbid liquid. The ventricles are more or less distended with the like exudation; sometimes they are enormously dilated, and the brain-substance thereby so compressed that the convolutions are flattened and the subarachnoid liquid expressed, leaving the arachnoid surface dry.

The completely-developed tubercles in the nerve-tissue appear as little nodules, gray and translucent, or yellowish-white with a gray periphery.

Quite recent continuous patches of tuberculous infiltration have a reddish tint, like other inflamed parts.

Tubercles may appear in any part of the meningeal or nervous tissue. If growing near a vein they are seen to penetrate not only the adventitia but the inner coats, until the lumen of the vessel appears closely beset and encircled with the accumulated cells. The white blood-cells inside the vessel are often arranged peripherally, and sometimes visibly distend it.

Arteries running through tuberculous foci have first the adventitia

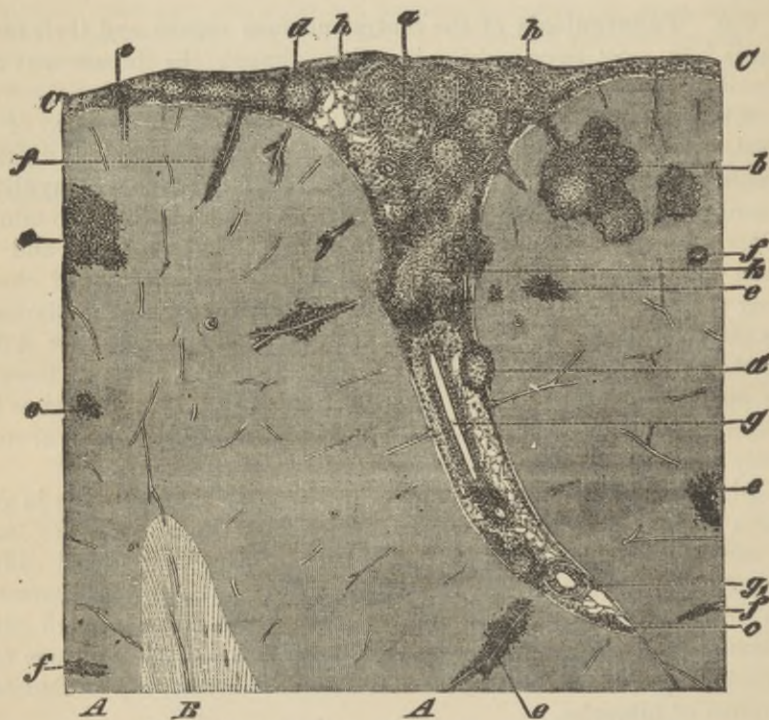


FIG. 279. CHRONIC DISSEMINATED TUBERCULOUS MENINGOENCEPHALITIS.

(Section hardened in Müller's fluid and alcohol, stained with alum-carmin, and mounted in Canada balsam: $\times 10$.)

- | A, cortex | B, white matter | C, meninges |
|---|--|-------------|
| a, dense fibro-cellular mass of tubercle in the subarachnoid tissue | f, cellular infiltration of pial sheath of cortical vessels | |
| b, tuberculous mass in the cortex | g, g ₁ , longitudinal and transverse section of an artery | |
| c, small tubercle in the pia mater | k, diffuse fibro-cellular thickening of the subarachnoid tissue | |
| d, isolated tubercle in the subarachnoid tissue | | |
| e, circumscribed infiltration in the cortex, an early stage of tubercle | | |

invaded and infiltrated with cells; then the media and intima are attacked, especially the latter, which is sometimes so thickened by the infiltrating cells that the lumen of the artery is encroached on and ob-

structed. If then the white blood-cells gather at the diseased spot and form a thrombus the occlusion becomes complete.

Tubercles in the brain or cord very rapidly undergo caseation, and only in chronic cases (Fig. 279) are large formative cells developed in appreciable numbers: in such cases the mature tubercles assume the large-celled coarse-textured appearance of those growing in lymphatic glands (Art. 342). When caseation begins in a tuberculous focus lying near a vessel of moderate size it generally extends to the walls and to the cellular contents of the vessel.

The commonest seat of embolic tuberculosis is about the basal branches of the sylvian artery: the disease is generally bilateral, though often more extensive on one side than on the other, and cases are not wanting in which it is unilateral. When the bacilli reach the arterial branches that pass upwards from the sylvian fissure to the surface of the cerebrum they give rise to more or less extensive meningitis of one or both sides of the convexity.

The territory of the arteries of the median plane of the cerebrum, cerebellum, medulla, and cord may in like manner be infected, and though this does not occur so frequently as in the case of the basal regions it is by no means rare.

When the eruption is abundant the chief mass of tubercle is usually to be found in the soft membranes of the brain and cord; but the nerve-substance hardly ever escapes entirely. The disease of the pia mater extends to the cortex as a diffuse cellular infiltration, leading to destruction of the nerve-elements, often preceded by a remarkable swelling of the axis-cylinders and of the ganglion-cells. In like manner the cranial and spinal nerves are attacked, the cellular infiltration reaching the pial sheaths, and thence spreading along the fibrous septa into the substance of the nerves, and often inducing degeneration of the nerve-fibres.

In addition to this meningeal invasion we frequently meet with tubercles growing directly in the deeper parts of the substance of the brain and cord: even in cases described as tuberculous meningitis the number of encephalitic and myelitic foci is at times very considerable; they are overlooked simply because they are apt to be very small.

If the bacilli lodge in a few branches only of the meningeal or cerebral arteries the first eruption of tubercles is scanty. But as the patient does not usually die at once, the tubercles grow and coalesce into large masses lying beneath the pia mater or in the midst of the nervous tissues. In the subarachnoid spaces and in the pia mater they form flat discoid masses of various sizes, and in the brain-substance rounded nodes, sometimes as large as a walnut or even a hen's egg. These are sometimes described as **solitary tubercles**. Their centres are yellowish-white and caseous, being sometimes firm and dense, sometimes soft and semi-liquid, rarely calcified. Their peripheral parts consist of grayish-red or semi-translucent granulation-tissue, often enclosing typical miliary tubercles,

The larger tubercles are developed from the smaller by the continued growth of new granulosomatous tissue, sometimes containing multitudes of giant-cells, sometimes none at all. It is remarkable that where the inflammatory process is going on the fibrous elements of the brain-tissue often undergo marked hyperplasia, and form thus a coarse fibro-cellular tissue. Tubercle-bacilli can be demonstrated both in the gray granulosomatous zone and in the older portions of the growth.

Solitary tubercles are most frequently observed in the cerebellum and cerebral axis. They act like tumors on the neighboring tissues, giving rise to symptoms of pressure and to disturbance of the circulation both of blood and lymph. The other parts of the central organs may be entirely free from tubercle, though it often happens that tuberculous matter passes from the solitary nodes to the meningeal vessels and gives rise to disseminated and diffuse tuberculous meningitis. It is also of course possible for a fresh infection of the blood to take place, and in consequence a fresh embolic eruption of tubercles.

The situation of tuberculosis of the central nervous organs due to extension of tuberculous disease from contiguous parts is of course dependent on the seat of the primary affection. Tuberculous disease of the vertebræ infects the cord and its membranes, tuberculosis of the petrous bone extends in the first place to the temporal lobes and the basal aspect of the frontal lobe. Nodules appear in the affected regions, and these in time may grow into larger nodes. If the virus gain access to the cerebrospinal lymph-channels it may give rise to disseminated tuberculosis.

Many authorities (VIRCHOW, RINDFLEISCH, BIRCH-HIRSCHFELD, etc.) state that meningeal and cerebral tubercles lie usually in the adventitia of the arteries, and there form clusters of cells derived by multiplication from the endothelium of the lymphatics. They base this statement on the fact that in tuberculous meningitis collections of cells are found in the adventitia of the cortical arteries. This interpretation of the fact is however erroneous. The tubercles are developed from extravasated leucocytes and proliferous connective-tissue cells. The adventitia is affected and takes part in the proliferation only in a secondary way, and what has been described as a tubercle due to periarteritis of a pial vessel is in fact only a fraction of a tubercle growing near the vessel. In other inflammations of the pia mater and cortex we find like cellular infiltrations of the pial sheaths of the vessels, though it must not be overlooked that in tuberculous and syphilitic (Art. 661) inflammations the arteries take part in the cellular hyperplasia to a much greater extent than in other forms of inflammation. The like is true also of the endarteritic processes.

References:—VIRCHOW, *Cellular Pathology* London 1860, *Krankh. Geschwülste* II. Frankfurt 1856; WILKS, *Path. Anat.* London 1875; RINDFLEISCH, *Virch. Arch.* vol. 24, *Path. Histology* II. London 1873; HUGUENIN, *Ziemssen's Cyclop.* XII.; VON CAMPE, *Beitr. z. path. Anat. d. meningit. u. meningo-encephalit. Prozesse* Tübingen 1882.

661. **Cerebrospinal syphilis** usually makes its appearance some years after the disease has become 'constitutional,' that is to say,

simultaneously with the so-called tertiary symptoms: it is rarely an accompaniment of secondary symptoms. The characteristic morbid change is the formation of circumscribed inflammatory foci, or **gummata** as they are called, in the meninges and cortex, very rarely in the interior of the brain or cord. As a rule they lie in the pia mater and subarachnoid tissue of the base of the brain.

The first thing observed in the meninges is a small patch of inflammation, which soon leads to the formation of a gray or grayish-red semi-translucent or gelatinous knot of granulation-tissue (Fig. 280). In the earlier stages the tissue of the knot is extremely cellular (*f*), and contains a number of new-formed capillaries. As the process goes on some of the granulation-tissue becomes-fibro-cellular (*d*₁) and some undergoes

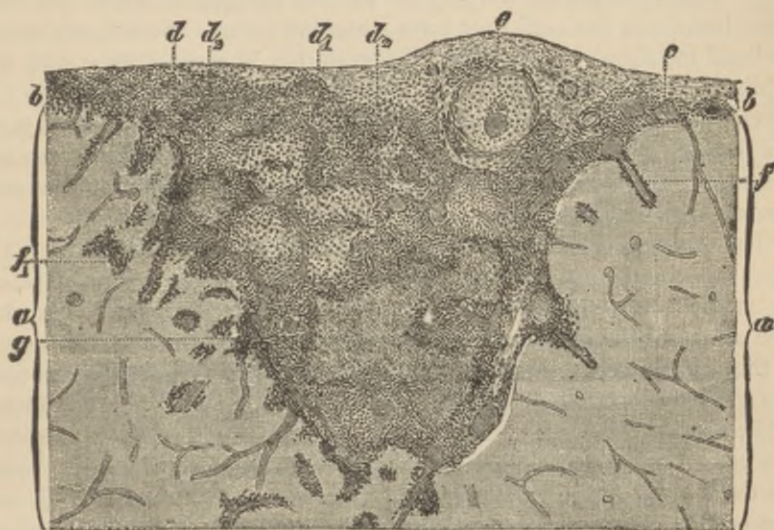


FIG. 280. GUMMATOUS SYPHILITIC MENINGOENCEPHALITIS.

(Section hardened in Müller's fluid and alcohol, stained in alum-carminé, and mounted in Canada balsam: $\times 15$.)

- | | |
|--|--|
| a, cortex | e, artery with thickened intima and infiltrated adventitia |
| b, pia mater | f, cellular infiltration of the pial sheaths of the cortical vessels |
| c, vein surrounded by cellular exudation | g, diffuse infiltration extending into the cortical substance |
| d, recent and cellular, d ₁ fibro-cellular, d ₂ caseous granulation-tissue | |

caseation (*d*₂). The adjacent brain-substance seldom or never remains intact, the inflammation extending into the cortex along the pial sheaths of the vessels (*f*) and also directly (*g*). When arterial branches (*e*) pass through the granulomatous focus they are speedily infected, the adventitia, media, and intima becoming the seat of inflammation leading to cellular infiltration and fibro-cellular hyperplasia of the vessel-walls, according to the stage of the process. The intima (*e*) usually takes part

to a remarkable extent in this hyperplasia, the thickening being often so great that the vessel is much obstructed or even occluded outright. The latter event is most apt to occur when thrombosis accompanies the endarteritis.

Gummatous foci may be either single or multiple. The single foci are sometimes very small; HEUBNER indeed has shown that the specific inflammation may be limited to single spots on the arterial walls, and there lead to the thickening of the intima just described. Larger foci are however more frequent, and are described as nodes or gummata simply. In the earlier stages they are gray or grayish-red and soft, their form depending on the texture of the tissue in which they lie. On the surface of the brain they follow the course of the sulci and take their shape: in the sylvian fissure they are flat and elongated: about the base of the brain and the cord they have irregular forms. Sometimes about the basal meninges the syphilitic inflammation is more diffuse and not nodular. When it extends to the brain-substance and grows in size the diseased patch becomes more and more globular, and at times is as large as a walnut, though the periphery usually remains somewhat irregular. The same holds for the nodes which develop independently in the substance of the brain and cord.

The smaller foci can undoubtedly disappear by re-absorption: the larger ones become partly indurated and partly caseous. The caseation begins with the appearance of yellowish-white opaque spots, measuring from a few millimetres to some centimetres across according to the size of the node itself. When several such spots appear in the same node they give it a mottled appearance, until at length coalescing they form a yellow centre to the mass. Induration generally goes on simultaneously with caseation, though sometimes the latter is absent. It leads to scar-like thickening of the meninges, and to adhesions between the pia and dura mater. The coarse scar-tissue generally encloses caseous patches.

Where syphilitic inflammation is going on the nerve-elements of course perish; the process is frequently associated with ischæmic and hæmorrhagic softening of adjoining parts, consequent on the disturbance of the circulation induced by arteritis and compression. Occasionally these degenerative changes extend widely. Nerves passing through the inflamed region undergo inflammatory infiltration, and thereafter becoming enclosed and beset by coarse fibrous tissue they speedily atrophy and break down. Thus gummatous inflammation of the meninges at the lower end of the cord now and then leads to the enclosure of the greater number of the nerves of the cauda equina in a mass of granulation-tissue: this is presently transformed into a coarse cicatrix, and blended by adhesions with the dura mater forms a compact mass of scar-like tissue enclosing atrophied nerves and caseous patches. The same thing sometimes happens in the case of the cranial nerves.

Some nodes of the brain and cord which have been described as gummatous appear beyond a doubt to have been tuberculous. As the periphery and the neighborhood of these nodes do not always contain tubercles, before the discovery of the tubercle-bacillus it was not always easy to determine the nature of a given caseous mass. VIRCHOW has asserted that tuberculous nodes are rounded, while gummatous ones are irregular; but this criterion does not always hold good.

References:—VIRCHOW, *Virch. Arch.* vol. 15, *Krankhafte Geschwülste* II. 1869; LEON GROS and LANCEREAUX, *Des affections nerv. syph.* Paris 1861; ENGELSTEDT, *Die constitut. Syphilis* Würzburg 1861; WILKS, *Guy's Hosp. Rep.* IX. (1863); WAGNER, *Arch. d. Heilk.* IV. (1863); WESTPHAL, *Allg. Zeitschr. f. Psych.* XX. (1863); JAKSCH, *Prag. med. Woch.* 1864; LANCEREAUX, *Traité de la syphilis* Paris 1866 (trans. New Syd. Soc. II. London 1869); HEUBNER, *Arch. d. Heilk.* XI. (1870), *Die luetische Erkrank. d. Hirnarterien* Leipzig 1874, *Ziemssen's Cyclop.* XII.; GREENFIELD, *Trans. Path. Soc.* XXVIII., XXIX.; CHARCOT and GOMBAULT, *Arch. de physiol.* V. 1873; BRAUS, *Die Hirnsyphilis* Berlin 1873; BRUBERGER, *Virch. Arch.* vol. 60; WILKS and MOXON, *Path. Anat.* London 1875; BROADBENT, *Lancet* 1, 1874; BAUMGARTEN, *Virch. Arch.* vols. 73, 76, 86; VON RINECKER, *Festschrift z. Jubil. d. Würzburg. Universität* 1882; GREIFF, *Arch. f. Psych.* XII.; FOURNIER, *La syph. du cerveau* Paris 1879, *Leçons sur la syph.* (2d edition) Paris 1881; JULLIARD, *Etude critique sur les localis. spin. de la syph.* Paris 1879; WESTPHAL, *Charité-Annalen* I. (1876); GOWERS, *Hill and Cooper's Syphilis* London 1881; BUZZARD, *Lancet* 1, 1873 and *Brain* III. 1880, *Diseases of the nervous system* London 1882; DOWSE, *Syphilis of the brain and spinal cord* London 1881; ROSENTHAL, *D. Arch. f. klin. Med.* XXXVIII. 1886 (with numerous references).

CHAPTER XCVII.

TUMORS AND PARASITES.

662. Of the tumors occurring in the brain and spinal cord the **gliomata** (Art. 145, Fig. 40) claim our first notice. They are commonest in the cerebrum, more rare in the cerebral axis and in the cord: they lie usually close beneath the pia mater. In most cases the outer aspect of the brain-surface remains unaltered, the tumor appearing merely to cause enlargement and discoloration of the affected part, and perhaps some thickening of the meninges. It is seldom that the tumor takes the form of a definite protuberance.

On section the neoplastic mass consists sometimes of tissue not a little resembling pale or hyperæmic gray matter in tint and consistence, more commonly however the glioma is gray, grayish-white, grayish-red, yellow, or gelatinous in appearance, or mottled with all these tints and with spots of opaque white and of extravasated blood (Fig. 281 *b*); its consistence is in parts softer, in parts firmer than that of normal brain-tissue. Frequently it includes numerous vessels distended with blood, and of markedly larger calibre than the ordinary vessels of the part. When the hæmorrhages are numerous and extensive they may so stain and disguise the tissue that it looks like a patch of apoplectic extravasation. If the tissue is partly destroyed either by hæmorrhage or by softening, the growth encloses cavities filled with turbid white or brown semi-liquid detritus.

Cerebral gliomata measure as much as 3 to 8 cm. across, or even more. The surrounding brain-substance is sometimes scarcely marked off from the substance of the tumor, sometimes is quite distinct and even visibly compressed: not infrequently it is softened and may contain cysts of disintegration. The ventricles are as a rule more or less dilated.

In the cord gliomatous tumors usually lie close to the central canal and spread thence posteriorly and externally. They are in general elongated, seldom globular, and may extend over a considerable length of the cord. Externally they give the cord a bulging or thickened appearance. Dilatation of the central canal and excavation of the growth itself are common (syringomyelia, Art. 635).

As we have mentioned in Art. 145 the tumor is made up of branched neuroglia cells, though the number and size of the cells present in dif-

ferent growths is subject to great variation. When they are small and scanty, and their ramifying fibrils numerous and closely felted, the texture is dense and firm: when the cells are large and numerous the tumor rather resembles a sarcoma.

The cells are in general uniformly scattered through the mass, but now and then they appear to lie in small clusters: multinuclear cells are common, especially in the peripheral parts of the growth.

The vessels are frequently much dilated (Fig. 41), and so abundantly developed that the tumor is fitly described as telangiectatic or angiomatic. The vessel-walls are often thickened and hyaline, and there is hyperplasia of the adventitia, the vessels being thus surrounded by a thick envelope of cellular and fibro-cellular tissue. Round the veins there may be accumulations of white blood-cells.

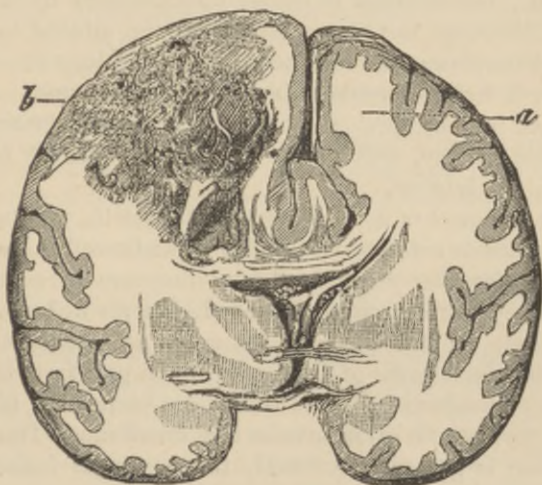


FIG. 281. ANGIOMATOUS GLIOMA.

(Frontal section through the brain.)

a, right hemisphere

b, glioma in left hemisphere

The tumor grows by proliferation of the neuroglia and multiplication of its cells: at least this is as much as can be made out by examination of the growing margin. The nerve-fibres as they are encroached on perish, their axis-cylinders becoming notably swollen before they break down. The ganglion-cells and their nuclei also swell in a remarkable way, and become homogeneous and glassy in appearance. Later on they break down like the nerve-fibres, though it is sometimes surprising how long both elements persist.

When the glioma presses on the pia mater the connective-tissue cells of the latter undergo subdivision and multiplication, and a new-formation of fibrous tissue usually takes place. The gliomatous growth may ultimately extend into the meshes of the fibrous tissue. In ischæmic and

hæmorrhagic softening of the growth the cellular elements perish, partly by necrosis and partly by fatty degeneration. Sometimes peculiar protoplasmic lumps, with or without nuclei, are produced, apparently by coalescence of some of the cells. Stratified corpora amylacea also occur in the tumor-tissue.

Sometimes a mucous liquid forms abundantly in the interstices of a glioma and give it the appearance of loose mucous tissue: such tumors are described as **gliomyxomata**. Still more frequently the connective-tissue cells undergo so marked a proliferation that the tumor becomes a **gliosarcoma**, the neuroglia-cells increase greatly in number and size, and ultimately lose their typical characteristics. In other cases the vascular adventitia becomes abnormally proliferous, and the product of its overgrowth is at length so abundant that the gliomatous structure is overshadowed. Gliosarcoma is chiefly characterized by the multiform character of its cells; but the overgrowth just alluded to results in a spindle-celled neoplasm, the cells being arranged along the course of the blood-vessels: it is therefore described as **angiosarcoma**. Sarcomatous transformation in a cerebral glioma gives the tumor a marrowy or 'encephaloid' consistency, and marks it off more sharply from the surrounding brain-substance.

Sarcoma also occurs as an independent growth, unattended at first by any multiplication of neuroglia-cells. Spindle-celled and multiform-celled varieties are the commonest, and they are in general soft and marrowy. They are commonly rounded, sharply defined, of all sizes, and either single or multiple. So far as we at present know they develop from the pial sheaths of the vessels and in part from the neuroglia. Hæmorrhage and softening of the tumor are frequent. If it lies close beneath the pia mater it often invades that membrane. The surrounding brain-substance is generally softened, the meninges inflamed, and the ventricles dilated.

Small **angiomata** are not uncommon in the brain, though they do not form regular tumors but only small reddish foci, not unlike recent patches of inflammation. They are probably congenital (VIRCHOW), and are of the same nature as vascular nævi. There is simply telangiectasis of the blood-vessels, not cavernous metamorphosis of the tissue (Art. 149). GANGUILLET recently described as **cylindroma** a gelatinous-looking angioma of the lower end of the spinal cord: it was composed of vessels whose adventitia had become hyaline, and was beset with bulging hyaline outgrowths (Art. 163, Fig. 57).

Fibroma of the central nervous organs is rare: it forms rounded nodes, which in the cord and roots of the spinal nerves are sometimes multiple, especially in cases of multiple fibromata (neurofibroma) of the peripheral nerves (Arts. 154, 399, 670).

BIDDER mentions a case of **osteoma** in the corpus striatum; it measured several centimetres in diameter. MESCHÉDE met with a bony

growth in the cerebral hemisphere of an epileptic. BENJAMIN describes a **lipoma** in the cerebrum.

Secondary growths, sarcomatous and carcinomatous, occur in the brain as in other organs: they usually form rounded nodes or nodules.

KLEBS maintains (*Viertelj. f. prakt. Heilk.* 125, 133) that the ganglion-cells take an active part in the production of gliomatous neoplastic cells, and HELLER (*Naturforscherversammlung in Freiburg* 1883) agrees with him. The author has gone over again his preparations of glioma, but is unable to find any ground for altering the view expressed in Art. 145. The ganglion-cells do indeed swell up considerably, and occasionally a binuclear cell can be seen; but that is all. As the tumor develops the ganglion-cells break down, and the clusters of neuroglia-cells afterwards found in their place are evidences merely that the latter have multiplied in their neighborhood.

As we remarked in Art. 651 it is not possible to draw a sharp line between glioma and sclerosis. This is especially true of the gliomatous growths occurring round the central canal of the cord, but it also holds of cerebral glioma. Sometimes part of the neoplastic change will appear to be essentially due to increase and induration of the connective tissue, while close by there is an unmistakable sharply-defined tumor.

Probably the smallest sarcomata of the central nervous organ hitherto described were observed some time ago by the author and Dr. ANDREAE in the cord of a lady who had suffered from some ill-defined disturbance of the innervation of the left arm: two nodules of spindle-celled sarcomata 2 and 3 mm. in diameter respectively were found in the left anterior horn of the cervical cord. The author has met with numerous small fibromatous nodules in the nerve-roots and the cord of a patient suffering from multiple fibroma of the peripheral nerves.

References:—VIRCHOW, *Krankhafte Geschwülste*; SCHÜPPEL, *Arch. d. Heilk.* VIII. 1867 (glioma and gliomyxoma of the cord); K. HOFFMANN, *Zeitschr. f. rat. Med.* XXXIV. 1869 (glioma); NEUMANN, *Virch. Arch.* vol. 61; TH. SIMON, *ibid.* vol. 61; GOLGI, *Cent. f. med. Wiss.* 1875; KLEBS, *loc. cit.*; GANGUILLET, *Beitr. z. Kenntniss d. Rückenmarkstumoren* Berne 1878; PETRINA, *Prager Viertelj.* 133, 134; ROTH, *Arch. de physiol.* 1878 (diffuse glioma of the cord); MESCHEDÉ, *Virch. Arch.* vol. 35; BIDDER, *ibid.* vol. 88; LEBERT, *Traité d'anat. path.* II.; CORNIL and RANVIER, *Man. Path. Hist.* I. London 1882; BENJAMIN, *Virch. Arch.* vol. 14 (lipoma of cerebrum); SCHULTZE, *Arch. f. Psych.* VIII. (periepandyml angiomatous gliosarcoma of the cord); MEYER and BAYER, *Arch. f. Psych.* XII (relation of encephalitis to glioma); GERHARDT, *Festschrift d. Universität Würzburg* 1882 (glioma); OSLER, *Journ. of Anat. and Physiol.* xv. 1881 ('neuroma' of the brain, rather a heterotopia); REISINGER, *Virch. Arch.* vol. 98 (glioma of the cord); GLASER, *Arch. f. Psych.* XVI. (angiosarcoma of the cord); RENAULT, *Gaz. méd. de Paris* 1884 (cerebral glioma); BAIRD, *Les tumeurs du type nerveux*, *Arch. de physiol.* v. 1885.

663. The tumors of the internal meninges, the telæ choroideæ, and the lining membrane of the ventricles are chiefly of the mesoblastic or connective-tissue type; but epithelial or carcinomatous growths are also met with.

In the first place we have a group belonging to the sarcomata which form soft nodes, or less frequently broad flattened growths. Their section is marrowy, grayish-white or grayish-red in tint, sometimes almost

gelatinous. They are commonest about the base of the brain, more rare on its convexity, still rarer in the pia mater of the cord and telæ choroideæ of the ventricles; they are either entirely confined to the meninges or encroach somewhat on the nerve-substance.

So far as investigations have shown they originate partly in the adventitia of the vessels and partly from the (endothelial) cells which cover the fibrous trabeculæ of the arachnoid, subarachnoid, and pia mater. The new-formed cells become highly developed, and resemble the multiform epithelial cells of carcinoma. As they lie in a stroma composed of the meningeal tissues and form dense clusters in its meshes which look exactly like nests of cancer-cells, the tumor has the appearance of a carcinoma and is often so described. It is however strictly speaking an **alveolar sarcoma** (nested sarcoma) in type, and its structure and the grouping of its endothelial cells justify us in classing it with the endotheliomata (Art. 161).

Endothelioma appears to be the commonest growth met with in the soft membranes, but others also occur from time to time which must be classed as ordinary **sarcoma**, **myxosarcoma**, and **myxoma**; the latter is chiefly found in the pia mater of the cord.

The blood-vessels of sarcomatous and myxomatous growths sometimes develop in number and size until they transform these into what we must call **angiosarcoma**, **angiomyxoma**, and **angiomyxosarcoma**. The vessels are wide and thin-walled or narrow and thick-walled, and form networks and complicated coils. The intervascular tissue may be simply fibrous, or mucous, or sarcomatous. If it is scanty the tumor assumes the aspect of a simple **angioma**.

Fibroma, lipoma, and chondroma are rare; but they do occur in the meninges and ventricular plexuses, forming small nodular or lobulated tumors which compress the nervous tissue. Seated at the lower end of the cord they sometimes encircle and compress the nerves of the cauda equina, and lead to their atrophy and degeneration.

Another rare growth in the pia mater consists essentially of a coarse fibrous stroma containing wide cysts or cavities filled with lymph. It looks somewhat like a piece of oedematous tissue, but is distinguished therefrom by the abundant development in it of fibrous tissue, which marks it off sharply from the surrounding structure and forms thick septa between the cysts. It is thus a true neoplasm and might be described as cystic lymphangioma or **cystic fibroma**.

In all these growths, but especially in myxoma and in fibroma, calcification may set in, and alter the vessels or lead to an increase of the so-called **brain-sand**.

Calcareous plates are often formed in the otherwise unaltered pia mater; and in the ventricular plexuses the brain-sand may be so increased that the plexuses are visibly enlarged and turn an opaque white.

In tumors the like occurs, in combination with calcareous degenera-

tion of the vessels. When the accumulation of calcareous matter in the growth is very great we have what is called **psammoma**. The organic basis of brain-sand consists of flattened cells which cohere like the coats of an onion, become homogeneous and lose their nuclei, and then are calcified.

Carcinomata are found in the ventricles, and form soft tumors (Fig. 282 *a*), usually connected with the plexuses and originating in their epithelium or (more rarely) in that of the ependyma. The cancer-cells (Fig. 283 *a*) lying in a fibrous stroma are of the cylindrical or columnar type. By the outgrowth of the vascular stroma into papillæ the tumor sometimes assumes a papillomatous appearance (Fig. 283).

If as not infrequently happens the stroma undergoes partial mucoid degeneration (Fig. 283 *b c c*), the tumor exhibits a very peculiar struc-

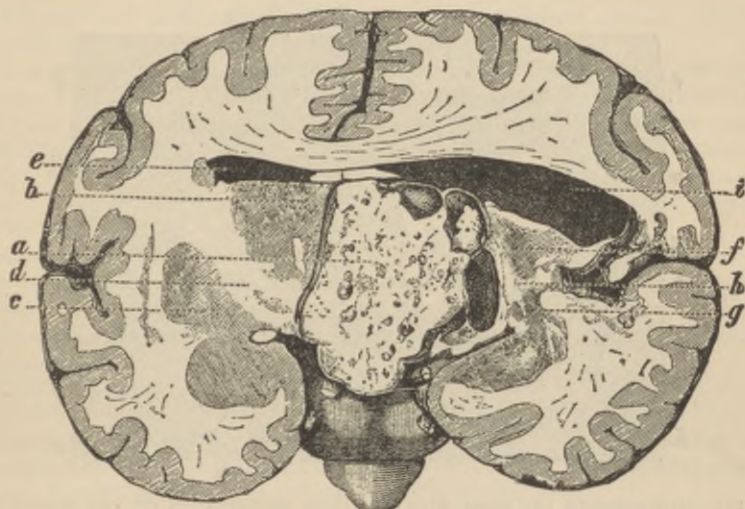


FIG. 282. PAPILLOMATOUS CARCINOMA OF THE CHOROID PLEXUS.

(Frontal section through the third ventricle.)

- | | |
|-----------------------------|-----------------------------------|
| a, tumor with cysts | f, left optic thalamus |
| b, right optic thalamus | g, left lenticular nucleus |
| c, right lenticular nucleus | h, left internal capsule |
| d, right internal capsule | i, dilated left lateral ventricle |
| e, right corpus striatum | |

ture. The papillary outgrowths are transformed into cysts (Fig. 282, Fig. 283 *d*) separated merely by strings of epithelial cells (*e*), so that the epithelium forms a kind of stroma enclosing cysts formed of connective-tissue. **Epithelial pearls**, or concentric globes (*h*), are sometimes formed in the midst of the masses of epithelium, and look wonderfully like those met with in cutaneous cancers (Art. 172), while contrasting sharply with the cylindrical cells of the growth.

The tumor is usually confined to the ventricle, and leads to compression of the brain-substance (Fig. 282 *f g h*) and ventricular dropsy (*i*).

It may however invade the brain-substance, and give rise to secondary nodules (SPAET). It is not certain whether this form of tumor occurs as a primary growth in any other region, but it is quite possible that it may arise say about the anterior or posterior transverse fissure, or at the base of the brain near the infundibulum; it probably develops from aberrant germinal epithelium (Art. 181).

Cholesteatoma, or pearly tumor, is one whose mode of origin is not well understood; it is a growth characterized by the presence in it of white rounded 'pearls' with a nacreous lustre. It occurs chiefly in the dura mater of the base of the brain about the transverse fissures, but it is also found in the interior of the organ. The soft white mass of the growth consists mainly of epithelial scales like those of the epidermis. Most authorities assume its endothelial origin; but it seems more likely



FIG. 288. PAPILOMATOUS CARCINOMA WITH GELATINOUS DEGENERATION OF THE STROMA FROM THE THIRD VENTRICLE.

(Section hardened in Müller's fluid, stained with alum-carmin: $\times 25$.)

- | | |
|---|--|
| a, fibrous stroma with blood-vessels | d, cyst in degenerate stroma, with coagulated contents |
| b, partially mucoid papilla | e f, interpapillary strings and nests of cells |
| c, mucoid papilla coagulated by the hardening fluid | h, epithelial pearls |
| c ₁ , hyaline masses | |

that its 'pearls' are derived from the epidermic epithelium of the medullary tube, and are thus connected by descent with the external surface. Moreover in rare cases (ZIEGLER) minute hairs have been found in the mass; and the situation of the tumor points in the same direction, for the places described are such that at the time of the development of the brain primitive epiblastic cells might well remain unelaborated, and form the rudiment of a neoplasm at a later stage (Art. 181).

Secondary growths of every kind occur in the meninges. It is worth noting that they sometimes spread far and wide in the subarachnoid spaces. Thus a metastatic cancer of the pia mater in the vertebral canal may in course of time encircle the greater part of the cord and infiltrate the cauda equina.

Of **animal parasites** the *Echinococcus* and *Cysticercus* are found in the brain and cord. The former takes the form of single or multiple hydatid vesicles of various size, which compress the nerve-substance and lead to softening. The *Cysticercus*, or measles, is commonest in the meninges of the brain, and appears either in the usual form as a small cyst with its scolex, or as the *Cysticercus racemosus*, a cluster of large lobulated usually sterile vesicles grouped like grapes around a parent cyst (Arts. 243, 245).

We may here make mention of some formations which are not strictly tumors, though in some points resembling them.

Aneurysms of the basilar arteries are very common, and reach a considerable size (see LEBERT, *Berl. klin. Woch.* 1866). **Varices** are developed chiefly in the pial veins of the cord, and sometimes become so large that they form vascular knots like hæmorrhoids, which compress the cord and lead to its degeneration. In the cerebral ventricles are found small nodules seated on the ependyma: they are simply compact **fibrinous deposits** which have become partially organized and contain formative cells and capillaries.

Many of the growths described as cerebral cancer or epithelioma have no claim to the title. EBERTH'S and ARNDT'S epitheliomata of the pia mater were cases of alveolar sarcoma; only those alveolar neoplasms in the development of which the epithelium of the medullary tube is concerned are to be reckoned as carcinomata.

CORNIL and RANVIER state (*Man. Path. Hist.* I. London 1882) that brain-sand arises from buds or off-shoots from the vessels, which are made up of flattened cells and presently become calcareous. They therefore describe the tumors which are characterized by the abundant presence of the sand as **angiolithic sarcomata**. It is doubtful whether all brain-sand is of this kind.

References on tumors:—VIRCHOW, *loc. cit.*; MÜLLER, *Virch. Arch.* vol. 8 (cholesteatoma), vol. 16 (melanoma); ROKITANSKY, *Handb. d. path. Anat.* II. (cholesteatoma, angioma); LEBERT, *Maladies cancéreuses* Paris 1851; PARROT, *Arch. de physiol.* 1869 (lipoma); MORRIS, *Trans. Path. Soc.* XXII. (angioma); WILKS and MOXON, *Path. Anat.* London 1875 (chondroma); ROBIN, *Journ. de l'anat. et de la physiol.* 1869 (endothelioma); J. ARNOLD, *Virch. Arch.* vol. 51 (cystic sarcoma telangiectodes); EBERTH, *ibid.* vol. 49 (endothelioma); ARNDT, *ibid.* vol. 51 (endothelioma); MESCHEDÉ, *ibid.* vol. 35 (osteoma); KLEBS, *loc. cit.*; EPPINGER, *Prager Viertelj.* 1875 (cholesteatoma); SPAET, *Primärer multipler Epithelkrebs d. Gehirns* Munich 1882; RINDFLEISCH, *Path. Hist.* II. London 1873; BERNHARDT, *Beitr. z. Symptom. u. Diagnost. d. Hirngeschwülste* Berlin 1881; GANGUILLET, *loc. cit.* (sarcoma of spinal pia mater); LEYDEN, *Klinik d. Rückenmarkskr.*; ERB, *Ziemssen's Cyclopaedia* XIII.; FALKSON, *Virch. Arch.* vol. 75 (chondrocystosarcoma of choroid plexus); LACHMANN, *Arch. f. Psych.* XIII. (glioma of the filum terminale); DRESCHFELD, *Journ. of Anat. and Physiol.* XIV. 1879 (psammoma); BILLROTH, *Arch. d. Heilk.* III. (myxoma of pia mater of cerebellum); CHIARI, *Prag. med. Woch.* 1883 (cholesteatoma of dorsal cord); LANCEREAUX, *Traité d'anat. path.* II.

On *Cysticercus racemosus*:—VIRCHOW, *Virch. Arch.* vol. 18; HELLER, *Ziemen's Cyclopædia* III.; MARCHAND, *Virch. Arch.* vol. 75, *Breslau. ärztl. Zeitschr.* 1881; ZENKER, *Ueb. d. Cyst. racem. d. Gehirnes* Erlangen 1882, *Henle's Beiträge* Bonn 1882; GRIESINGER, *Arch. d. Heilk.* III. 1862 (with references); FERBER, *ibid.*

On hydatids of the brain see the works of COBBOLD, DAVAINE, etc. (*Arts.* 245-248).

CHAPTER XCVIII.

THE DURA MATER, PINEAL BODY, AND PITUITARY BODY.

664. The **dura mater** is a stout fibrous membrane, closely adherent to the inner surface of the cranium, and dividing into two laminae at the foramen magnum: one of these lines the vertebral canal, the other forms a sack-like investment for the spinal cord, the intervening space containing loose connective tissue, fat, and blood-vessels, in particular the venous plexuses.

Where the dura mater adheres to the bone it serves as its periosteum, and is liable to all the morbid changes that affect the periosteum of other bones. Certain special dangers also arise from its connection with the central nervous system, and these require separate consideration.

In the first place the dura mater is very frequently the seat of an inflammatory process known as **chronic internal pachymeningitis**, the result of various injurious agencies whose exact nature is not fully understood. The inflammation is usually hæmatogenous, and is associated either with inflammation of the pia mater and subarachnoid tissue on the one hand or with disease of the bones on the other. It is commonest in the cerebral dura mater, and may be unilateral and circumscribed, or bilateral and in scattered areas or generally diffused.

The first morbid sign is the appearance of very thin fibrinous deposits on the internal surface of the membrane: these consist of scanty liquid and cellular exudations from the dural vessels. After a time the fibrin becomes organized, or in other words pervaded by living cells and new-formed vessels growing as off-shoots from the inflamed capillaries. A delicate fibrous tissue is thus elaborated, which lines the dura mater as a semi-transparent vascular membrane.

The new-formed vessels have very thin walls and are particularly prone to bleed, the slightest disturbances of the circulation apparently sufficing to set up **hæmorrhage** by rupture or diapedesis. The consequence is that pachymeningitic membranes nearly always contain recent extravasations and pigmented deposits testifying to past hæmorrhage; this peculiarity has led to the affection being described as **hæmorrhagic pachymeningitis**. The extravasations are usually small, but now and then they are so extensive that they separate the false membrane from the dura, and form blood-cysts or **hæmatomata**, which may cause

grave compression of the brain. If the cyst gives way blood will of course escape into the subdural spaces.

Once the inflammation has begun it seldom attains to complete resolution and recovery. The extravasated matters are by degrees reabsorbed, but if they are at all abundant the process is very slow and imperfect, and their continued presence keeps up an irritation that induces renewed inflammation. New exudations and new membranes are thus produced, and at length a dense scar-like tissue results, which contains masses of pigment, fibrinous residues, and calcareous matters. Sometimes after resorption of a hæmorrhagic extravasation a localized collection of liquid appears between the dura and the cicatrized membrane; this has been called **hygroma of the dura mater**, or partial pachymeningitic hydrocephalus. In older denser and more fibrous membranes some of the vessels are gradually occluded by contraction, but other parts remain highly vascular, and fresh hæmorrhages keep up the chronic inflammation.

Pachymeningitic membranes do not usually adhere to the arachnoid; but when this happens the new-formed vessels pass down into the internal meninges.

There is also an **external chronic pachymeningitis** in which the changes are chiefly limited to the cranial surface of the dura mater: they consist of thickening of the membrane and absorption or hyperplasia of the bone. Moreover, the dura mater is frequently inflamed by extension of mischief from contiguous parts. Thus suppuration due to an infected wound of the skull may involve the dura mater (Art. 654); and otitis media or inflammation of the petrous bone or of the vertebræ or the interdural tissue frequently extends to this membrane. When suppuration takes place the dura has a discolored yellowish-white or grayish-yellow appearance: if the suppuration is preceded by hæmorrhage the tint may be grayish-green or brown.

Tuberculosis arises as a concomitant of embolic tuberculous leptomeningitis or of tuberculous bone-disease. The inner surface of the dura is beset with disseminated gray tubercles, while in more advanced stages pachymeningitic membranes containing tubercles, or large granulatous vegetations, or caseous foci are found. The latter are commonest in connection with bone-disease, and then frequently affect both surfaces of the membrane.

In **syphilis** cellular infiltrations and granulations are formed in the dura mater, and lead in time to dense scar-like thickenings, which frequently enclose caseous masses. If the process goes on extensive adhesions are set up with the arachnoid and pia mater.

Most **tumors** of the dura mater are sarcomatous. The spindle-celled forms are the most frequent, but round-celled and multiform-celled types are also found. We also meet with **alveolar sarcomata** and **endotheliomata**, characterized by the formation of cell-nests and re-

ticulated strings of cells (Fig. 284 *cd*) within a fibrous stroma (*a*). These latter take the form of flattened or pedunculated fungoid outgrowths (*fungus duræ matris*), varying from the size of a pea to that of an apple, which grow inwards and indent the surface of the brain or cord. On the outer aspect of the dura they erode and even perforate the bone by continuous pressure and consequent atrophy. They are commonest within the cranium, being indeed rare in the spinal canal. The pedicle sends out root-like processes of cells into the substance of the dura mater, from which the growth evidently originates. The endothelium of the lymphatic vessels furnishes the characteristic clusters and strings of cells, and the latter are often excavated (*d*) in a way that immediately suggests the parent vessel. This appearance is visible chiefly in the recent parts of the growth, the older parts showing merely



FIG. 284. ENDOTHELIOMA OF THE DURA MATER.

(Hardened in Müller's fluid, stained with hæmatoxylin, and mounted in Canada balsam : $\times 35$.)

- | | |
|---|---|
| <i>a</i> , fibrous stroma | <i>d</i> , tubular tract of endothelial cells |
| <i>b</i> , group of round-cells | <i>e</i> , fatty degeneration of a cellular mass |
| <i>c</i> , nests and strings of cells derived from the endothelium of the lymphatic vessels | <i>f</i> , mass of endothelial cells, on the right side passing gradually into the fibrous stroma |

a diffuse cell-growth which passes gradually into the structure of the fibrous tissue. When tumors of the dura mater become very vascular they may assume some of the characters of **angioma**; if the vessels calcify and give rise to an abundant production of brain-sand the growth becomes a **psammoma**.

Fibroma is on the whole rare, but it may occur in any part of the dura mater, forming rounded tumors; **lipoma** is very rare.

Enchondroma is not infrequently met with in the form of small gelatinous nodules about the back of the sella turcica and basilar portion of the occipital bone; the tumor originates in residual unossified frag-

ments of the cartilaginous synchondrosis between this bone and the sphenoid.

Osteoma occurs chiefly in the cerebral dura mater, and most frequently about the falx cerebri. The growth appears as a plate of bone of irregular form with spinous and ridge-like processes.

Of secondary or **metastatic growths** in the dura mater carcinoma is the most usual.

References on pachymeningitis:—VIRCHOW, *Würzburg. Verhandl.* 1856; SCHUBERG, *Virch. Arch.* vol. 16; KREMIANSKY, *ibid.* vol. 42; WEBER, *Arch. d. Heilk.* I. 1860 (hæmatoma); LANCEREAUX, *Arch. générales de méd.* 1862-63, *Traité d'anat. path.* II.; WILKS, *Med. Times and Gaz.* 1, 1868; RINDFLEISCH, *Path. Hist.* II. London 1873; SPERLING, *Cent. f. med. Wiss.* 29, 1871; PAULUS, *Verkalkung und Verköcherung d. Hæmatomes d. Dura Mater* Erlangen 1875; HUGUENIN, *Ziemszen's Cyclop.* XII.

On tumors of the dura mater:—ROKITANSKY, *Lehrb. d. path. Anat.* II.; ROBIN, *Recherches anat. sur l'épithéliome des séreuses, Journ. de l'anat.* 1869; LEBERT, *Virch. Arch.* vol. 3; ARNOLD, *ibid.* vol. 52; RUSTIZKY, *ibid.* vol. 52; BIZZOZERO and BOZZOLO, *Wiener med. Jahrb.* 1874; SCHÜPPEL, *Arch. d. Heilk.* X. (1869); VIRCHOW, *Die Entwicklung d. Schädelgrundes* 1857 (echondrosis of the basi-occipital); LUSCHKA, *Virch. Arch.* vol. 11 (ditto); ZENKER, *ibid.* vol. 12 (ditto); LANCEREAUX, *Traité d'anat. path.* II.

665. The hypophysis cerebri or **pituitary body** is seated in the sella turcica, and is composed of two lobes: the anterior consists of a fibrous stroma enclosing numerous round and oval follicles filled with epithelial cells, the posterior of vascular connective tissue containing cell-like clusters of fat-granules. At the junction of the two lobes the tissue is very vascular, and contains cavities lined with ciliated columnar epithelium (WEICHELBAUM).

Cystic degeneration and hyperplastic overgrowth of the anterior lobe are not uncommon, the cysts usually containing colloid masses. This transformation is called **adenoma** of the pituitary body (WEIGERT), and the growth sometimes reaches the size of a hen's egg. It of course protrudes more or less from the sella turcica, presses on the adjoining brain-substance, or into the ventricles (ZENKER), and sometimes leads to atrophy of the underlying bone.

According to WEICHELBAUM the ciliated cavities are very apt to undergo cystic change, the cysts containing homogeneous or granular matter secreted by the epithelium.

After adenoma the commonest growths are **carcinoma** and **sarcoma** (KLEBS), which also take the form of nodose swellings. WEICHELBAUM has described a pair of small lipomata in the posterior lobe, and WEIGERT a teratoma.

The pituitary body may be inflamed in connection with disease of the neighboring parts: tubercles and gummata are however rare in this situation (WEIGERT).

The **pineal body** consists of fibrous tissue enclosing a number of more or less spherical follicles, each containing a reticulate structure of epithelial cells, a number of rounded cells with slender processes (TOLDT), and a quantity of brain-sand.

The most frequent pathological changes observed in this organ are—abnormal increase of the quantity of brain-sand (psammoma), hyperplastic enlargement (so-called glioma), and cystic degeneration (hydrops cysticus); it may participate in inflammations of the adjacent structures. The author once found in it a tumor as large as a pigeon's egg, consisting essentially of blood-clot (hæmatoma).

References on the pituitary body: VIRCHOW, *Die krankhaften Geschwülste*; ZENKER, *Virch. Arch.* vol. 13; WAGNER, *Arch. d. Heilk.* 1862; WEIGERT, *Virch. Arch.* vol. 65; WEICHSELBAUM, *ibid.* vol. 75; RIBBERT, *ibid.* vol. 90; KLEBS, *Viertelj. f. prakt. Heilk.* 125; BECK, *Zeitschr. f. Heilk.* iv. 1883 (teratoma); BERNHARDT, *Beiträge z. Sympt. u. Diagnostik d. Hirngeschwülste* Berlin 1881.

THE PHYSICAL BODY consists of three parts, viz. a head, a trunk, and a tail. The head is the most important part, and is the seat of the mind. The trunk is the middle part, and is the seat of the emotions. The tail is the least important part, and is the seat of the instincts. The physical body is the result of the combination of the three parts. The head is the most important part, and is the seat of the mind. The trunk is the middle part, and is the seat of the emotions. The tail is the least important part, and is the seat of the instincts. The physical body is the result of the combination of the three parts.

SECTION XII.

PERIPHERAL NERVOUS SYSTEM.

CHAPTER XCIX.

STRUCTURE OF PERIPHERAL NERVES.

666. The peripheral nervous system is composed of **nerves** and **ganglia**, together with certain **terminal organs**. The nerves consist essentially of medullated and non-medullated fibres: in the ganglia there are similar nerve-fibres and associated ganglion-cells.

A **medullated fibre** is a long cylindrical structure, the axis being occupied by the so-called **axis-cylinder**. During life the latter is homogeneous and enclosed in a sheath of myeline (**medullary sheath**), and this again in a delicate fibrous envelope—the primitive sheath, neurilemma, or **sheath of Schwann**. The medullary sheath is interrupted at intervals by the **nodes of Ranvier**: at these points the axis-cylinder is covered only by the sheath of Schwann, and chiefly through them is its nutrition kept up. Each nerve-fibre is thus subdivided into segments of 1 to 2 mm. in length; each segment has about its middle a nucleus lying close to the sheath of Schwann, and on the inner side of the sheath close to the nucleus is a thin layer of protoplasm. External to the sheath of Schwann is a fibrillar sheath (AXEL KEY and RETZIUS), which also contains nuclei and a scanty protoplasm.

The **non-medullated fibres** possess an axis-cylinder with a primitive sheath containing nuclei at intervals.

Both kinds of fibres unite to form nerves of various degrees of thickness: the nerves from the brain and cord consist chiefly of medullated fibres, those of the sympathetic system chiefly of non-medullated fibres.

The smaller nerves consist of a single bundle of nerve fibres, the larger nerves of a certain number of bundles.

Each bundle (Figs. 286, 288 *c*) is surrounded by a fibrous envelope or **perineurium**: in a large trunk several such bundles are enclosed in a perineurium (Fig. 288 *a*), each of them being surrounded by an **epineurium** (*b*) of loose connective tissue, often containing fat-cells. Septa pass from the perineurium between the bundles (Fig. 286), and subdividing into finer fibres surround the individual nerve-fibres with an **endoneurium**. The blood-vessels of the nerve-trunk run in these fibrous envelopes. At the peripheral ends the axis-cylinders break up into primitive fibrils, and these terminate in the various peripheral end-organs.

In the course of some of the nerves (especially of the sympathetic)

are one or more clustered groups of ganglion-cells: when these are large enough to be easily visible they are called **ganglia**. The cells and fibres of such a ganglion lie in a fibrous stroma whose elements are in direct continuity with the fibrous structures of the corresponding nerve.

The **morbid changes** occurring in the nerves affect partly the nervous elements, partly the fibrous framework. In many respects the changes correspond to those affecting the central nervous system, but they also offer remarkable peculiarities of their own.

CHAPTER C.

ATROPHY AND DEGENERATION.

667. The degenerative processes which lead to **atrophy** and disappearance of the peripheral nerve-fibres and ganglion-cells correspond in their general course with the like processes in the brain and cord.

In the first place fibres and cells may gradually dwindle and waste away without undergoing any appreciable change of structure. More frequently however the destruction is speedier and accompanied with the various evidences of disintegration so often observed in the central organs.

In the **medullated fibres** there appears first a turbidity and then a splitting up of the medullary sheath, leading to the formation of large and then of smaller fragments and droplets of myeline, until the whole sheath is reduced to globules or particles. The axis-cylinder and its primitive fibrils may in like manner break up into small fragments (Fig. 285 *c*), or swell up and become liquefied; though it must be remembered that the axis shows itself more resistant towards many kinds of injury than the medullary sheath.

The sheath of Schwann usually remains intact, and even the so-called nerve-corpuscles or nuclei of the several segments persist also (Fig. 285 *d d, d₂*). When the medullary sheaths break up, extravasated leucocytes pick up the products of disintegration and form fat-granule cells which lie within the primitive sheaths or in the fibrous envelopes. Sometimes the cells of the connective tissue also become fatty.

The single or clustered ganglion-cells occurring in the course of the nerves perish by swelling and liquefaction, by fatty change, or by simple atrophy.

A medullated nerve which has lost its medullary sheath shrinks in volume and looks gray and translucent: if it is at the same time vascular its tint is grayish-red.

The exact manner and extent of the degeneration of the nerve-elements depends on the nature of the injurious or destructive agent which is at work; though in all degenerative processes there is one feature which is constant, namely the prompt extension of the change over all the portion of the nerve to the distal side of any point at which the axis-cylinder is completely interrupted.

Such an interruption is most quickly and most completely effected by **section of the nerve**, and thus in the investigation of peripheral degeneration such intentional or unintentional section plays the chief part. At the cut surfaces of a nerve there quickly appears a button-like protrusion and swelling of a gray or grayish-red tint, together with some gelatinous exudation. In a day or two the segments of the peripheral portion become less refractive, and turbid, and by the third day the medullary and primitive sheaths are deeply indented at the nodes. On the fourth to the sixth day the medulla breaks up into large drops of myeline, and in a few days more there is nothing of it left but droplets and granules of detritus which are ultimately absorbed.

The axis-cylinder speedily becomes almost or altogether invisible, and perishes partly by swelling and vacuolation, partly by breaking up into fragments.

In simple uncomplicated section of the nerve the proximal or central end degenerates for a small distance only from the wound, the change stopping at the first or second node of Ranvier. Only when the nerve-end is bruised or otherwise inflamed do some of the bundles degenerate for a greater distance. In such a case the primitive sheath of the degenerate fibres contains a large number of extravasated leucocytes which in simple section are seldom or never very abundant.

Severe crushing or pinching and abiding compression (as from a tumor or a shrinking cicatrix) of a nerve have an effect similar to section, the latter leading to anæmic necrosis or degeneration of the compressed portion. The difference is chiefly in the fact that the interruption is not at once complete, but affects the several strands or bundles in succession.

Disease of the anterior horns of the cord and of the motor roots leading to destruction of motor ganglion-cells or nerve-fibres are, like other interruptions of the conducting tracts, followed by peripheral degeneration: but it must be kept in mind that when the destruction of the ganglion-cells is more gradual the corresponding atrophy of fibres is not so rapid, the medullary sheath wastes by degrees (Fig. 285 *b*), and within one and the same bundle we may find fibres that are sound, others partially atrophied (*b c*), and others totally destroyed (*d, d₂*).

A second frequent cause of degeneration of the nerves is primary and secondary **neuritis**, due to traumatic or infective inflammation of the connective-tissue framework (Art. 669), which leads to disturbance of the circulation and nutrition of the nerve or to direct compression of it. Sometimes too hæmorrhages give rise to injurious pressure on the nerve-fibres.

Lastly, motor nerves atrophy when their **muscles** are long **disused** (FISCHER), the atrophy being however confined to the peripheral parts: there is no ascending atrophy of such nerves to any extent comparable with the descending atrophy.

Occasionally we meet with local or multiple peripheral degenerations of which we cannot with certainty discover the cause. Thus the **vagus** is subject to degenerative changes without any apparent compression, inflammation, or other injury. BLASCHKO describes a wide-spread fatty degeneration of Auerbach's and Meissner's plexuses in the intestines. The **multiple neuritis** of some authors (Art. 669) is in fact of the nature of degenerative atrophy.

In such isolated degenerations we must assume that some disorder of the circulation (due *e. g.* to change in the vessels or change in the blood) is at work. Thus **lead-poisoning** gives rise not only to degeneration of the muscular nerves (LANGEREAUX, GOMBAULT, FRIEDLÄNDER, etc.) but also to change in the intestinal plexuses. When the nerve-changes are acute and accompanied by febrile disturbance it is probable that

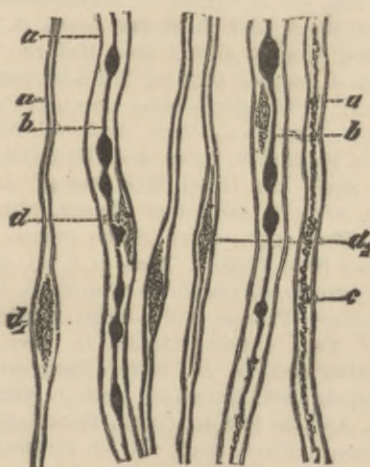


FIG. 285. ATROPHY OF MOTOR NERVES IN ANTERIOR POLIOMYELITIS.

(Treated with Müller's fluid and perosmic acid, and teased out in glycerine: $\times 200$.)

- | | |
|---|--|
| a, sheath of Schwann | d, uninuclear, |
| b, axis-cylinder with adherent drops of myeline | d ₁ , multinuclear, |
| c, axis-cylinder breaking up | d ₂ , bipolar cell within the sheath of Schwann |

infection of some kind is in question. R. MAIER showed experimentally that in chronic lead-poisoning the submucous and myenteric ganglion-cells become turbid, lose their nuclei, break into fragments, and disappear, while the connective tissue about them is simultaneously increased.

According to KEY, RETZIUS, S. MAYER, and KORYBUTT-DASZKIEWICZ, degenerative and regenerative changes take place normally in peripheral nerves; and many filaments hitherto assigned to the fibrous sheaths or the fibres of Remak are simply degenerate or nascent nerve-fibres.

The drops of myeline in degenerate nerves are stained black by perosmic acid

while the granular matters are unstained: S. MAYER infers from this that the nerve-substance breaks up into fatty and albuminoid component elements.

As to the exact fate of the axis-cylinder of the peripheral end of a cut nerve there is still some uncertainty, notwithstanding the numerous investigations that have been made: there is no question as to the medullary sheath. WALLER, EULENBURG, LANDOIS, HJELT, RANVIER, BENECKE, COSSY and DÉJÉRINE, TIZZONI, LEEGARD, VANLAIR, FALKENHEIM, and others state that the axis-cylinder degenerates; SCHIFF, PHILIPPEAU, KORYBUT-DASZKIEWICZ, ERB, CHARCOT, WOLBERG, and others maintain that it persists intact. In the text we have adopted the former account. After loss of the ganglion-cells in the anterior horns of the cord the axis-cylinders of the motor fibres, and after section of a peripheral nerve those of all the fibres, degenerate.

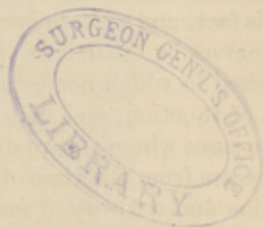
References on degeneration and regeneration of nerves after section:—WALLER, *Müller's Arch.* 1852, *Comptes rendus* 1851-52; SCHIFF, *ibid.* 1854; PHILIPPEAU and VULPIAN, *ibid.* 1859; HJELT, *Virch. Arch.* vol. 19; REMAK, *ibid.* vol. 23; EINSIEDEL, *Ueb. Nervenregener. nach Ausschneidung eines Nervenstückes* Giessen 1864; LAVERAN, *Rech. exp. sur la régénér. d. nerfs* Strasburg 1867; EULENBURG and LANDOIS, *Berl. klin. Woch.* 1864-65; ROBIN, *Journ. d. l'anat.* 1868; NEUMANN, *Arch. d. Heilk.* IX. (1868); ERB, *D. Arch. f. klin. Med.* IV., V.; HERZ, *Virch. Arch.* vol. 46; VULPIAN, *Arch. d. physiol.* 1873-74; WEIR-MITCHELL, *Injuries of nerves* London 1872; LÉTIÉVANT, *Traité des sections nerveuses* Paris 1873; LEEGARD, *D. Arch. f. klin. Med.* XXVI.; BENECKE, *Virch. Arch.* vol. 55; RANVIER, *Leçons sur l'histologie du syst. nerv.* Paris 1878; COSSY and DÉJÉRINE, *Arch. de physiol.* 1875; ENGELMANN, *Pflüger's Arch.* XIII. (1876); BAKOWIECKI, *Arch. f. mikrosk. Anat.* XIII. (1876); COLOSANTI, *Arch. f. Anat. und Physiol.* 1878; GLUCK, *Virch. Arch.* vol. 72, *Arch. f. klin. Chir.* XXV., XXVI.; SANTI SIRENA, *Ricerche sperim. sulla reprod. d. nervi* Palermo 1880; TIZZONI, *Arch. p. l. sci. med.* III. (1878), *Cent. f. med. Wiss.* 1878, *Sulla patolog. d. tessuto nervoso* Turin 1878; S. MAYER, *Degen. und Regen. d. Nervenfasern* Prague, 1881; HOGGAN, *Trans. Path. Soc.* XXXI. (1880), *Journ. d. l'anat.* XVIII. (1882); GESSLER, *D. Arch. f. klin. Med.* XXXIII. (motor-nerve changes after section), *Die motor. Endplatte u. ihre Bedeut. f. d. periphere Lähmung* Leipzig 1885; NEUMANN, *Arch. f. mikrosk. Anat.* XIII. (1880), XVIII. (1885); VANLAIR, *Arch. de biol.* III. (1882); EICHHORST, *Eulenburg's Realencyclop. d. gesam. Heilkunde*, *Virch. Arch.* vol. 59; PEYERANI, *Biol. Centralb.* III. (1883); FALKENHEIM, *Zur Lehre von d. Nervennaht* In. Diss. Königsberg 1881; TILLMANN, *Arch. f. klin. Chir.* XXVII.; BASCH, *ibid.*; WOLBERG, *Deut. Zeitschr. f. Chir.* XVIII., XIX. (1883); NICAISE, *Internat. encyclop. of surgery* III. London 1883; P. BRUNS, *Mitth. a. d. chir. Klinik* II. Tübingen 1884; CATTANI, *Arch. p. l. sci. med.* VIII. 1885 (nerve-stretching); HAYEM and GILBERT, *Modification du syst. nerv. chez un amputé*, *Arch. de physiol.* III. (1884).

The memoirs of VANLAIR, FALKENHEIM, TILLMANN and WOLBERG include not only experimental researches of their own, but also summaries of published cases, and criticisms on previous methods of experiment: the subject of nerve-suture is also dealt with. WOLBERG's paper is the most comprehensive on all points bearing on the main subject.

On nerve-degeneration from lead-poisoning and from undetermined causes:—LANCEREUX, *Gaz. méd. de Paris* 1862, 1871; GOMBAULT, *Arch. de physiol.* V. (1873); DÉJÉRINE, *Gaz. méd. de Paris* 1879; ZENKER, *Zeitschr. f. klin. Med.* I. (1880); WESTPHAL, *Arch. f. Psych.* IV. (1873), VI. (1875); REMAK, *ibid.* VI. (1875); VULPIAN, *Mal. du syst. nerveux* Paris 1879; FRIEDLÄNDER, *Virch. Arch.* vol. 75; POPOW, *ibid.* vol. 93; R. MAIER, *ibid.* vol. 90; KUSSMAUL and MAIER, *D. Arch. f. klin. Med.* IX. (1872); EISENLOHR, *ibid.* XXVI.; BLASCHKO, *Virch. Arch.* vol. 94; DUMÉNIL, *Gaz. hebdom.* 1864; SCHULTZE, *Arch. f. Psych.* XIV.; MONAKOW, *ibid.*

x.; MÖRITZ, *Journ. of Anat. and Physiol.* 1880; BIRDALL, *Amer. Journ. of neurology* 1882; NAUNYN, *Ziemssen's Cyclop.* xvii.

On atrophy from disuse:—FISCHER, *Deut. Zeitschr. f. Chir.* viii. (1877); SIEGMUND MAYER, *Prag. med. Woch.* 1878.



CHAPTER CI.

REGENERATION OF NERVES.

668. **Union of severed nerves.** It has long been known that nerves which have been cut through, and whose function has been thereby completely abolished, are capable of repair, and in the course of weeks or months recover their conducting power. Recent surgery has utilized this fact, and seeks to bring about the speedier union and recovery of severed nerves by **suture** of their ends. Over fifty cases have already been published in which nerve-suture has resulted in more or less perfect restoration of function, and that not only when the wounds were recent but in some cases where suture did not take place till after the lapse of months or years from the time of injury.

The union and recovery of severed nerves has been often observed in animals as well as in men, and in recent years a large number of experiments have been made to throw light on the fact and on the histological process by which it is brought about. Unfortunately we do not yet fully understand all the steps of this process: opinions differ as to the fate of the peripheral end of a severed nerve (Art. 667), and it is therefore scarcely surprising that authorities are not agreed as to the details of **regeneration**. Hardly two of the multitude of writers on the subject take exactly the same view, and we are therefore unable to give an account of it which shall be wholly satisfactory.

When the functional continuity of a nerve is interrupted by section, crushing, compression, etc. various things may happen. The nerve-fibres only may be injured, the nerve remaining still macroscopically continuous; or it may be completely severed, the ends retracting some small distance apart, or becoming so widely separated that there is no possibility of their reuniting naturally. The regenerative process can be best followed in the second case, which is that most frequently observed experimentally, the parted nerve-ends being reunited by the intercalation of a new-formed piece of nerve.

The wound that severs a nerve is immediately followed by an inflammation, which leads to swelling of the cut ends, and the deposit of exudation between them. In the subsequent week or two granulations and cicatricial tissue are formed, while the central and peripheral ends undergo the changes referred to in Art. 667.

The regeneration of the nerve-fibres begins a few days after the

operation (RANVIER) in the central end: RANVIER says at the very extremity of this end, VANLAIR at a distance of 1.5 to 2 cm. from it. EICHHORST observed the beginning of regeneration in the nerve of a rabbit on the fourteenth day after injury.

The first change is a swelling of some of the axis-cylinders in the outer parts (VANLAIR) of the nerve-bundles of the central end, and this is followed by subdivision of each into from two to five new axis-cylinders (RANVIER). The new cylinders grow in length, and form within the old sheath of Schwann whole bundles of new nerve-fibres (Fig. 286 *e*), which usually distend the lumen of the sheath and compress any persisting remnants of the older fibres (*f*). According to VANLAIR they sometimes burst the old sheath, and then either grow out amid the tissue

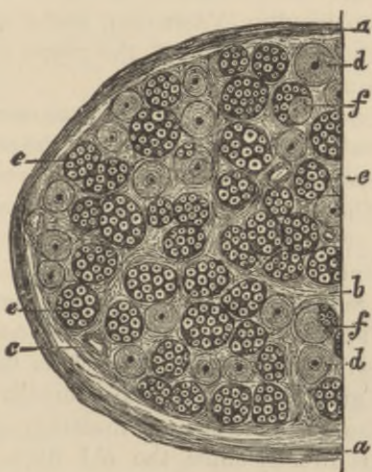


FIG. 286. CENTRAL END OF A NERVE-BUNDLE IN PROCESS OF REGENERATION.

(From the median nerve 4 months after severance by a stab; hardened in Müller's fluid, stained with neutral carmine, and mounted in Canada balsam: $\times 200$.)

- | | |
|------------------------------|--|
| a, perineurium | e, bundle of new-formed nerve-fibres |
| b, endoneurium | f, new-formed nerve-fibres compressing an old fibre within the same sheath |
| c, blood-vessel | |
| d, old unaltered nerve-fibre | |

of the endoneurium, or penetrate the perineurium of the bundles into the epineurium.

In this way at the extremity of the central end a large number of new fibres are developed. They consist at first of new-formed axis-cylinders surrounded by a protoplasmic nucleated sheath (VANLAIR), and presently they receive a homogeneous envelope of connective-tissue (*e*) formed at the expense of the protoplasmic sheath, and a thin medullary sheath which grows between the latter and the axis-cylinder. The perineurium of the bundles giving way and the new fibres thus dispersing as it were in the epineurium, the characteristic grouping of the nerve-fibres in

bundles is lost; the new fibres are more uniformly spread through the connective tissue, and the usually fatty epineural envelope assumes a striated fibrous appearance.

In this manner the re-formed and growing nerve enters the soft mass of granulations and cicatricial tissue that intervenes between the severed ends. When it reaches the peripheral end, some of whose fibres have meanwhile perished, certain of the new fibres enter the empty primitive sheaths (RANVIER), but the greater number penetrate the epineurium (VANLAIR) and perineurium and advance towards the peripheral end-organs. Others miss the peripheral end and run either alongside it or on a course of their own to the surface: many fibres too which leave the old track disappear and are lost in the tissues (VANLAIR). In the peripheral half of the intercalated cicatrix the nerve-fibres begin to gather once more into bundles (VANLAIR), and a perineurium forming round these, the whole thickness of the nerve by degrees assumes a nearly normal appearance.

These changes require weeks or months to complete: according to EICHHORST the fibres of the central end reach the cicatrix about the end of the first month, and in some three months the reunion is established.

It appears from the foregoing that the peripheral end does not itself regenerate, but is provided with nerve-fibres from the central end. VANLAIR describes the process as **neurotization**. It probably takes place in all cases of regeneration after severance, both when the nerve is actually cut through and when only the nerve-fibres and not the fibrous structures are interrupted. The difference is that in the former case the new fibres must grow through a certain amount of cicatricial tissue, while in the latter there is little or no granulation, and the axis-cylinders as they lengthen can directly enter the old fibres. Some authorities (GLUCK, WOLBERG, LANGENFELDT) state definitely that under favorable conditions very rapid union of the severed ends is possible, the function of the nerve being recovered in a very few days.

Even when the peripheral is so remote from the central end that direct union by nerve-tissue is out of the question, some attempt is still made at regeneration. The central end grows out (Fig. 286), but the axis-cylinders do not reach the peripheral end, and lose themselves in the cicatrix.

The so-called **amputational neuromata** (Art. 154) are of this nature; they are club-shaped enlargements of the severed nerve-ends occasionally met with in stumps which have healed after amputation. As they contain new nerve-fibres as well as connective-tissue they are doubtless due to an abortive attempt at regeneration in the nerve-stumps: when they include sensory fibres which are compressed or irritated by the cicatrix they are the source of very considerable pain. Similar traumatic neuromata now and then occur in the course of nerves which have been injured but not severed.

The statements of authors concerning the new-formation of the axis-cylinder in divided nerves are very discordant. WALLER, SCHIFF, RINDFLEISCH, CORNIL, RANVIER, EICHHORST, and others assert that it is due to longitudinal subdivision and growth in length of the old axis-cylinders. PHILIPPEAU, VULPIAN, REMAK, LEEGARD, NEUMANN, DOBBERT, DASZKIEWICZ, and others regard the new cylinder as derived from the peripheral end; LEEGARD believing that it arises from the nuclei of the neurilemma, REMAK from the uninjured and surviving cylinders, DASZKIEWICZ from the surviving segments of the old and partially degenerate cylinders, NEUMANN and DOBBERT from a protoplasmic mass produced by a chemical transformation of the medullary sheath and axis-cylinder. NASSE, GÜNTHER, SCHÖN and STEINRÜCK assert that the new cylinders grow from the old fibres of both ends: LEUT, EINSIEDEL, WEIR-MITCHELL, BENECKE, and GLUCK, from the primitive sheaths of both ends; LAVERAN and HERZ refer their origin to the white blood-cells, HJELT and WOLBERG to the cells of the perineurium.

As the text shows we incline to the view of those who derive the new nerve-fibres from the old nerves of the central end. The subdivision of the axis-cylinder is the essential part of the process, though it is perhaps not impossible that a new-formation of nerve-fibres may start from the cells or nerve-corpules or nuclei on the sides of the sheaths of Schwann. At any rate it is remarkable how frequently in degenerating nerves we find these cells (Fig. 285 *dd*,) swollen up and containing several nuclei: sometimes indeed they give off processes which much resemble axis-cylinders (*d*₂). Until we have more information on the subject however it is more probable that these cells form merely the sheaths for the new axis-cylinders. CATTANI asserts that new axis-cylinders are formed within the nucleated protoplasmic mass which he has observed filling the primitive sheath of degenerating nerves.

The hypothesis that nerve-fibres may grow from granulation-cells or from the connective-tissue cells of the perineurium, endoneurium, or epineurium, is contrary to all histogenetic analogy. The nerves throughout their length are originally outgrowths from the central nervous system (BALFOUR, HENSEN, HIS, KÖLLIKER, etc.), and it is extremely unlikely that in later life they can arise from indifferent connective-tissue cells: this would be at variance with all our experience on the subject of the regeneration of specific tissues. The authors who have made the assertion do not advance any convincing arguments in its favor.

Those who believe that after section of a nerve the axis-cylinders of the peripheral end remain intact assume that the ends of the severed cylinders reunite by the intercalation of a new piece of tissue. WOLBERG describes this as taking place by the growth of strings of spindle-cells from the epineurium. When the reunion does not take place till the medullary sheath disintegrates he speaks of the process as regeneration in the strict sense of the term. If reunion takes place before the sheath disappears he speaks of it as union by first intention, and distinguishes a mediate and an immediate variety. In the former the union is brought about by means of new-formed intercalary fibres, in the latter by direct adhesion of the severed ends of the cylinders and primitive sheaths. The existence of the mediate variety he claims to have experimentally proved. Such a union by first intention is very doubtful: GLUCK's and WOLBERG's experiments do not appear to prove it, and it is probable that mistakes have arisen from the rapid restoration of function that sometimes takes place by means of abnormal nervous anastomoses and supplementary fibres. The secondary or mediate union by means of intercalary fibres appears impossible, the cylinders of the peripheral end being already degenerate: and for the same reason the statements of GLUCK and others that a piece of nerve cut from one animal may become united to the two ends of a severed nerve in another must be regarded as resting on error.

CHAPTER CII.

INFLAMMATION OF PERIPHERAL NERVES AND GANGLIA.

669. **Neuritis**, or the inflammation of nerves, is characterized anatomically by the presence of an exudation in their fibrous framework. If the exudation is chiefly liquid and the blood-vessels are still filled, the inflamed nerve looks red, and swollen, and abnormally moist: if the exudation is cellular (Fig. 287) and the hyperæmia has disappeared there are no apparent signs of the affection, though any hæmorrhage that has taken place may be indicated by reddish or brownish-yellow discoloration.

In simple nerves the migrated leucocytes lie chiefly in the thicker trabeculæ of the endoneurium (Fig. 287 *d*) through which the vessels

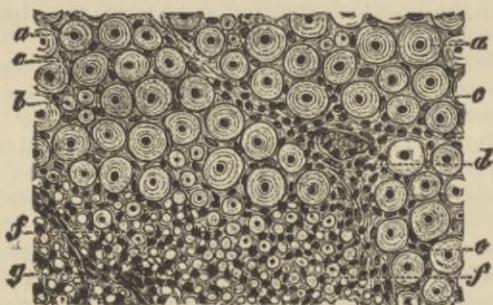


FIG. 287. CHRONIC NEURITIS.

(Hardened in Müller's fluid and alcohol, stained with hæmatoxylin and carmine, and mounted in Canada balsam: $\times 150$.)

- | | |
|---|---|
| <i>a</i> , normal thick nerve-fibre | <i>e</i> , leucocytes between the nerve-fibres |
| <i>b</i> , normal fine nerve-fibre | <i>f</i> , thickened endoneurium with small spaces void of nerve-fibres and a few thin fibres still persisting. |
| <i>c</i> , endoneurium | <i>g</i> , longitudinal section of a blood-vessel |
| <i>d</i> , blood-vessel, and trabeculæ of endoneurium infiltrated with leucocytes | |

run, though they may also pass in between the individual nerve-fibres (*c e*).

In compound nerves (Fig. 288) the exudation frequently lies almost entirely in the epineurium. The perineurium of the bundles and of the nerve generally is usually much less densely infiltrated.

Slight inflammations resolve without leaving any trace: severer attacks result in degeneration of some of the nerve-fibres. If the in-

inflammation is suppurative or gangrenous the nerve rapidly breaks down and perishes, becoming of a dirty yellowish-white, gray, or grayish-green. The connective-tissue elements are however less vulnerable and long resist dissolution.

If the affection is chronic, degeneration of the nerve-fibres ultimately sets in, with the breaking up of some of the medullary sheaths. The axis-cylinders persist for a long time, though they too at length perish; and thus a certain number of the fibres disappear outright, the sheaths of Schwann collapsing (*f*). Wherever an axis-cylinder decays degeneration takes place all down the peripheral portion of that fibre (Art. 667). As the medullary sheaths break down the tissue of the nerve is beset with drops of myeline and granule-carrying cells.

In process of time the chronic inflammation leads to thickening and condensation of the connective tissue, and this with the atrophy of the nerve-elements gives the nerve by degrees the appearance of a fibrous cord. Whether the nerve as a whole is thicker or thinner than in health depends on the proportion between the fibrous hyperplasia and the nervous atrophy. Both in simple and in compound nerves the inflammation may and sometimes does extend over the whole cross-section. In compound nerves the separation of the bundles becomes less distinct, though it is not obliterated even when the atrophy and fibrous changes are very advanced. When the process has been accompanied by hæmorrhage the altered tissue is frequently pigmented.

Chronic neuritis accompanied by great fibrous hyperplasia has been called by VIRCHOW **proliferous neuritis**: if it extends upwards or downwards we speak of it as ascending or descending neuritis respectively.

One of the commonest causes of neuritis is mechanical injury (cutting, bruising, etc.) by a wound or blow: the inflammation results in fibrous hyperplasia, but if it becomes septic suppuration or gangrene may set in.

Moreover the inflammatory process sometimes extends to a nerve from the adjacent tissues; thus nerves running through a wound may undergo granulation or even suppuration without having received any direct injury, and the like extension takes place in the case of other inflammations.

For example, it is extremely common for cerebrospinal nerves traversing an inflamed meninges to be themselves invaded by the inflammatory infiltration. And inflammations of the bones lead to indirect degeneration by compression or to direct inflammation of the nerves that traverse them. This also happens to nerves lying in the neighborhood of chronically inflamed or tuberculous lymphatic glands. It is not uncommon for instance for caseous glands in the neck, beside the trachea, or at the root of the lung, to press upon contiguous nerves, like the vagus and its branches, to irritate them into inflammation, and so to

bring about their degeneration. In the pelvis inflammations of the bladder or of the internal generative organs are apt to extend to the cellular connective tissue and so to the rich nerve-plexuses of that region.

These forms of neuritis are consecutive or secondary, but other forms occur in which the irritant inducing the inflammation is brought to the nerve directly by way of the blood or lymph. These irritants are so far as we know chiefly of an infective nature: thus in typhus (BERNHARDT), small-pox (JOFFROY), typhoid (NOTHNAGEL, LEYDEN, EISENLOHR), and diphtheria (OERTEL, CHARCOT, BUHL, DÉJÉRINE) we meet with simple or multiple neuritis, which we can only regard as direct results of the general infection.

Recently BAEZL and SCHEUBE have shown that the epidemic disease of India and Japan known as **beriberi** or **kakke** is characterized by the appearance of multiple neuritis: it has therefore been designated (BAEZL) as **panneuritis epidemica**.

It does not appear that there is any affection in Europe exactly corresponding to the Japanese *kakke*, but a form of multiple neuritis (LEYDEN) has more than once been described under the names of polyneuritis (PIERSON) and neuritis disseminata (ROTH). Whether this has any analogy to the infective disease, as PIERSON suspects, is still a very open question. Cold is spoken of by many as a cause of multiple neuritis, but probably in most cases some kind of infection or poison is at work. ROTH has shown that a purulent inflammation (as in parotitis) which involves a nerve-trunk may be the starting point of multiple neuritis.

Tuberculous and syphilitic inflammation affect chiefly the intracranial portions of cranial nerves and the spinal nerve-roots in connection with meningeal tuberculosis and syphilis respectively.

Little is known of tuberculosis or syphilis of the peripheral nerves. Foci of some size are most frequently observed in the optic nerve, and give rise to extensive tuberculous destruction. Elsewhere nerves are seldom involved except by extension of tuberculous inflammation from diseased glands.

Leprous inflammation is especially apt to attack the nerves, the disease being in fact chiefly characterized by its thus involving the peripheral nervous system: a particular form of leprosy is distinguished as *lepra nervorum anæsthetica*, or *lepra mutilans* (Arts. 131, 206, 392, 659, and HOGGAN, *Arch. d. physiol.* 1882). The settlement of the lepra-bacilli excites an intense inflammation, accompanied by cellular infiltration and followed by degeneration of the nerve-fibres and hyperplasia of the fibrous tissue. Fusiform thickenings and tuberosities of considerable firmness and size are thus produced in the course of the several nerves. The diseased tissue contains lepra-bacilli, some lying free and others being enclosed in cells.

We know little concerning the inflammations of the ganglia: they apparently occur under the same conditions as those of the nerves, and like them they are characterized by cellular infiltration, fibrous hyperplasia, and degenerative atrophy of the nerve-elements.

In severe cystitis and pyelonephritis and in inflammation of the internal generative organs in women paralysis of the lower limbs is sometimes a symptom. REMAK (*Med. Central-Zeitung* 1860) and LEYDEN (*Sammlung klin. Vorträge* 2, 1870) explain this as due to a progressive or wandering neuritis, which has been called *neuritis disseminata migrans* (LEYDEN). The experimental researches of WEIR-MITCHELL (*Injuries of nerves* London 1872), TIESLER (*Ueb. Neuritis* In. Diss. Königsberg 1869), FEINBERG (*Berl. klin. Woch.* 1871), KLEMM (*Ueb. neuritis migrans* In. Diss. Strasburg 1874), NIEDICK (*Arch. f. exp. Path.* VII. 1877), ROSEN-BACH (*ibid.* VIII.), and TREUB (*ibid.* X.) fail to confirm this explanation. It is much more likely that in the affections named the pelvic plexuses are compressed or directly inflamed by extension from the inflammation of the cellular connective tissue (pelvic cellulitis). See discussion by ADAMS and others (*Lancet* 2; 1880).

On multiple neuritis:—DUMÉNIL, *Gaz. hebdom.* 1864, 1866; LEYDEN, *Ueb. Re. flexlähmung, Samml. klin. Vorträge* 2, 1870, *Charité-Annalen* v., *Arch. f. Psych.* VI., *Zeitschr. f. klin. Med.* I. 1880; CASPARI, *ibid.* v.; GRAINGER STEWART, *Edin. Med. Journ.* 1881; EICHHORST, *Virch. Arch.* vol. 69; JOFFROY, *Arch. de physiol.* 1879; EISENLOHR, *D. Arch. f. klin. Med.* XXVI.; MARCHAND, *Virch. Arch.* vol. 81; ERB, *Ziemssen's Cyclop.* XIII.; NOTHNAGEL, *Samml. klin. Vorträge* 103, trans. New. Syd. Soc. London 1877; PIERSON, *Ueb. Polyneuritis acuta, ibid.* 229; GEP-PERT, *Multiple Neuritis, Charité-Annalen* 1883; STRÜMPPELL, *Arch. f. Psych.* XIV. (*Neurolog. Centralb.* 1884); MÜLLER, *ibid.*; VIERORDT, *ibid.*; ROTH, *Neuritis dissem. acutissima, Corresp. f. Schweizer Aerzte* 1883; DUBOIS, *Multiple Neuritis, ibid.*; BÄELZ, *Kakke oder Beriberi Yokohama* 1882, *Zeitschr. f. klin. Med.* IV. 1882; SCHEUBE, *Virch. Arch.* vol. 95, *D. Arch. f. klin. Med.* XXXI., XXXII., *Die japanische Kakke* Leipzig 1882; HIRSCH, *Handb. d. hist. geog. Path.* (2d edition), trans. by CREIGHTON (New Syd. Soc.) II. London 1885 (beriberi, with full references); CASPARI, *Zeitschr. f. klin. Med.* 1883; DÉJÉRINE, *Arch. de physiol.* 1884; WEBBER, *Archives of medicine* 1884; OPPENHEIM, *D. Arch. f. klin. Med.* XXXVI. 1885; BUZZARD, *Paralysis from peripheral neuritis* London 1886.

On neuritis in infective diseases:—BERNHARDT, *Arch. f. Psych.* IV.; JOFFROY, *loc. cit.*; NOTHNAGEL, *D. Arch. f. klin. Med.* IX. (1872); EISENLOHR, *Arch. f. Psych.* VI.; CORMACK, *Clinical Studies* London 1876; MURCHISON, *Continued fevers* London 1884; CHARCOT, *Diseases of the nervous system* II. London 1880; BUHL, *Zeitschr. f. Biol.* III.; OERTEL, *D. Arch. f. klin. Med.* VIII.; DÉJÉRINE, *Arch. d. physiol.* v. 1878; BUZZARD, *Lancet* 1, 1879, and *op. cit.*; PITRES and VAILLARD, *Rev. de médecine* 1885; ROSS, *Diseases of the nervous system* II. London 1883 (with many references); P. KIDD, *Med. chir. Trans.* LXVI. 1883 (diphtherial paralysis).

On neuritis in herpes zoster see Art. 383; DUBLER, *Neuritis bei Herpes zoster* In. Diss. Basle 1884.

CHAPTER CIII.

TUMORS.

670. Most of the **tumors** which occur in the nerves and their ganglia are developed from connective tissue, and consist essentially of some modification of that tissue, the nerve-elements forming little or no part of their structure.

The fibrous hyperplasia usually starts from the perineurium of the nerves or nerve-bundles, but occasionally from the epineurium or endo-

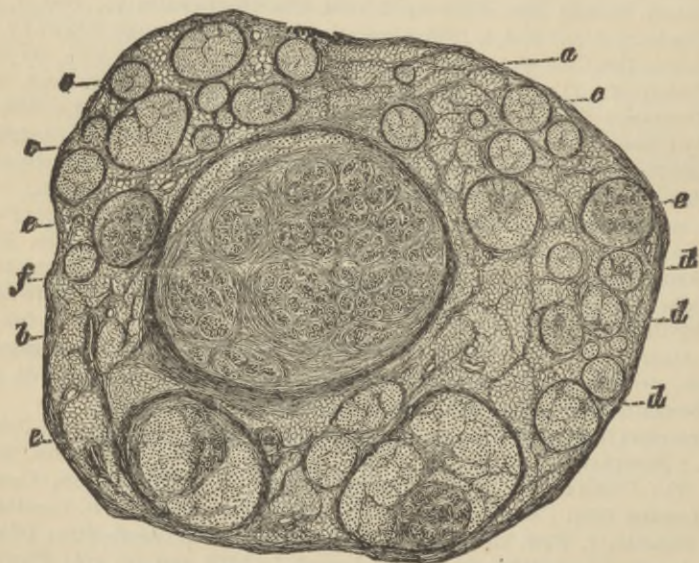


FIG. 288. MULTIPLE FIBROMA OF A NERVE OF THE SCIATIC PLEXUS.

(Hardened in Müller's fluid, stained with carmine, and mounted in Canada balsam: $\times 10$.)

- | | |
|---|--|
| a, general perineurium | e, more advanced fibroma within a nerve-bundle containing atrophied fibres |
| b, epineurium containing numerous fat-cells | f, large fibroma-nodule within a bundle whose perineurium is thickened |
| c, nerve-bundle enclosed in a special perineurium | |
| d, commencing fibroma in the endoneurium | |

neurium (Fig. 288 *d e f*). The nerves are embedded or pervaded by the new tissue, according to its starting-point, and by gradual compression become atrophied and break down. If there is any accompanying

nervous hyperplasia it probably takes place by the longitudinal subdivision and growth of pre-existing fibres: the new-formed fibres are at first naked, but some of them receive a medullary sheath in course of time.

The commonest neoplasm affecting the nerves is **fibroma** (Fig. 288): there are two forms—the soft and cellular, and the firm and fibrous. Tumors really deserving the name of **neuroma**, *i. e.* consisting essentially of new-formed nerve-fibres, are rare; and still rarer, if they exist at all, are tumors containing new-formed ganglion-cells, though these are described under the name of cellular or **ganglionic neuroma**.

Fibromata incorrectly described as neuromata are solitary or multiple, and in the latter case are congenital or at least appear soon after birth. Obviously the foundation of these structures is laid during foetal life; sometimes their heredity can be demonstrated. They occur in nerve-trunks and on their finest twigs and branches, forming fusiform, nodular, or very elongated thickenings of the nerve or nerves. Sometimes a nerve is found thickened over its whole extent, with perhaps occasional fusiform swellings.

The spinal nerves are the most frequent seat of these growths, though they also occur on the cranial nerves. Sometimes all the nerves are simultaneously affected, even the finest branches showing thickenings and knotty swellings. Thus all the branches of the vagus in the lungs and stomach, or those of the sympathetic in the liver, have been described as covered with fibromata, but these cases are very rare. Not infrequently however we find the smaller cutaneous nerves beset with small round or flat usually soft tumors, some being buried in the skin, others protruding. These growths are known as **fibroma molluscum** (VON RECKLINGHAUSEN, Art. 399). The cutaneous nodules are often in great numbers and extend over the territory of a particular nerve or over the whole body; they are sometimes accompanied by neurofibromata of the internal organs. Sometimes too between the nodules extensive hyperplasia of the subcutaneous and cutaneous fibrous tissue takes place, and large soft masses and folds are thus produced and known as **pachydermatocele**, elephantiasis molluscum, elephantiasis mollis or neuro-matous elephantiasis (Art. 399). The smallest growths may only be visible with a lens, the largest are sometimes the size of a kidney or larger.

The fusiform or nodose thickening of a nerve is often due to a single tumor; but a nerve-trunk sometimes includes several nodules in its cross-section, some lying in all or most of its bundles (Fig. 288). A central node will give rise to a fibrous tumor surrounded by nerve-bundles and a perineurium: when the fibroma starts in one of the outside bundles it at length appears as if seated on the nerve-trunk.

At times most of the nodes are confined to a single nerve. Other nodes, and these occasionally very large, consist of a plexus of many nerves united into a mass by hyperplastic fibrous tissue. The nerves are all

thickened, nodular, fusiform, convoluted, twisted, or otherwise distorted (Fig. 289), so that a coil of ravelled and varicose cords is formed, the whole being held together by fibrous tissue. Such a growth is described as a **plexiform neurofibroma**. According to P. BRUNS the cords contain numerous nerve-fibres, and it is therefore probable that new-formed nerve-fibres as well as fibrous tissue take part in its construction.

Of the other connective-tissue growths sarcoma, myxoma, and lipoma occur in connection with the nerves. The external forms they assume are similar to those of fibroma, but they are never multiple.



FIG. 289. PLEXIFORM NEUROFIBROMA OF THE SACRUM.

(Natural size: from a drawing by P. BRUNS.)

a, convoluted strands laid bare by dissection
b, as they appear covered with fibrous tissue

On neurofibroma:—VIRCHOW, *Krankhafte Geschwülste* III. (1863); HITCHCOCK, *Amer. Journ. med. sci.* 1862; CZERNY, *Arch. f. klin. Chir.* XVII. 1874; P. BRUNS, *Virch. Arch.* vol. 50; VON RECKLINGHAUSEN, *Ueb. mult. Fibrome d. Haut* Berlin 1882; KÖBNER, *Virch. Arch.* vol. 93; LAHMANN, *ibid.* vol. 101; NICAISE, *Internat. ency. of surgery* III. London 1883; PRUDDEN, *Amer. Journ. med. sci.* 1880 (with cases); COURVOISIER, *Die Neurome* Basle 1886 (with numerous references); CHAVASSE, *Med. chir. Trans.* LXIX. 1886. Tumors (fibroma, fibrosarcoma, neurofibroma) occur more frequently on the auditory than on other cranial nerves; see VIRCHOW, (*op. cit.*), and AXEL KEY (*Särskildt af Nordiskt med. Arkiv* XI. 1879).

INDEX OF AUTHORS CITED.

(The numbers refer to the articles.)

- Abelin 10
 Ackermann 7: 495, 497, 498, 631, 635
 Acland 623 *b*
 Adami 520, 530
 Adamkiewicz 628, 630, 644, 647
 Adams 11: 530, 669, 648
 Addison 96: 261: 565
 Adriani 648
 Aeby 625, 633
 Afanassiew 490: 530, 623 *b*
 Ahlfeld 1, 5, 9, 12, 13, 179: 630, 632
 Albertoni 623 *a*
 Albrecht 206
 Alexander 479
 Allbutt 659
 Althann 635
 Althaus 648, 659
 Amburger 604
 Ammann 623 *b*
 Amozan 397
 Amyot 631
 Anderson 18
 Andreae 607, 662
 Andral 94
 Angel-Money 659
 Anger 152
 Appert 96
 Argatzinski 528
 Arloing 206
 Armauer-Hansen 117, 131, 185, 206
 Arndt 63: 316: 637, 642, 650, 656, 663
 Arnold 13, 27, 74, 84, 86, 89, 97: 296,
 332, 342, 501: 550, 579, 584, 600, 613,
 663, 664
 Arnott 437
 Arnstein 152: 262, 437, 438
 Artaud 647
 Asch 575
 Assmus 271
 Atkinson 542
 Auerbach 255
 Aufrecht 85, 108, 127, 206: 391, 459,
 498: 535, 539, 543, 552, 613, 620
 Auspitz 128: 388, 392
 Auerbeck 565

 Babes 542, 543, 550, 602, 605, 613, 618
 Babesiu 399: 647
 Babinski 647
 Baelz 620, 669
 v. Baer 11

 Baillarger 623 *a*
 Baillie 118
 Baker-Brown 10
 Bakowiecki 667
 Balfour 74, 75, 86, 89: 348: 516, 668
 Ballard 206
 Balmer 613
 Balzer 591
 Bambeke 10
 Bamberger 272, 279, 495: 523, 639
 Bancroft 235
 Barbieri 54
 Bard 662
 Bardeleben 634
 v. Bärensprung 327, 383, 500: 607
 Barker 315, 437, 438
 Barlow 327: 565, 659
 Bartels 533, 534, 536, 539, 591
 Barth 235: 623, 646, 647
 Barwell 308
 Bary (de) 216, 220
 Basch 388: 667
 Bastian 604, 625, 635
 Bateman 400
 Bauchet 623
 Bauer 52: 490, 631

 Baumgarten 8, 108, 127: 255, 295, 314,
 342: 612, 613, 625, 641, 659, 661
 Baumgärtner 623 *a*
 Bäumlner 128: 327, 441: 625
 Bayer 533, 594, 662
 Bayle 118: 656
 Bazin 412
 Beale 532
 Bechterew 626
 Beck 619, 623, 665
 v. Becker 61
 Beckmann 528, 551, 623
 Beer 539
 Beger 578
 Behrend 359, 392, 412
 Beigel 397
 Bekmann 391
 Beloussow 498
 Bence-Jones 52
 Benedikt 634, 642, 659
 Beneke 272, 278, 286, 492, 510: 532, 667,
 668
 Benjamin 662
 Bennett (Hughes) 260

(The numbers refer to the articles.)

- Berger 578, 621, 625, 647
 Bergmann 191, 197, 201: 342, 479: 644, 645, 658
 Bernhardt 663, 665, 669
 Beschorner 575
 Besnier 322
 Beumer 517, 522
 Bezold 221
 Bichat 266
 Bidder 485: 662
 Biedert 612
 Biefel 573
 Bienstock 479
 Bierhoff 471
 Biermer 261: 539, 582, 594, 604
 Bilharz 231, 239
 Billard 433, 439
 Billroth 86, 109, 149, 156, 159, 161, 163, 171, 183, 184, 185, 209: 321, 324, 334, 344, 346, 438: 568, 653, 654, 663
 Binswanger 630, 633, 634, 646
 Binz 52: 490
 Birch-Hirschfeld 69, 204, 206, 209: 262, 295, 320, 327, 328, 358, 391, 457, 490, 495, 500, 502, 515: 607, 660
 Bircher 623 *a*
 Birdsall 667
 Bischoff 625, 640
 Bizzoli 631
 Bizzozero 35, 81, 108, 114, 156: 252, 260, 261, 263, 317, 319, 400: 664
 Blaschko 667
 Blix 10
 Block 222: 504
 Boas 262: 530
 Boddaert 601
 Bochdalek 439
 Böck 400
 Bockhart 564
 Bögehold 177: 622
 Böhm 13: 457, 470: 530
 Bohme 358
 Bohn 383, 433, 434, 439
 Bokai 564
 Boll 177: 626, 628, 638, 639
 Bollinger 125, 127, 133, 134, 135, 197, 206, 221, 247: 262, 400, 433, 436: 574, 618, 620
 Boser 196
 Boström 153: 518, 522, 530, 534, 556
 Böttcher 79, 99, 108: 260, 460, 491: 530
 Bouchard 304: 542, 626, 644, 646
 Bouchardat 612
 Boucher 623 *b*
 Bouillaud 625
 Bouley 201
 Bourdon 641
 Bourneville 650
 Bowman 94
 Bozzolo 232: 664
 Braidwood 204
 Bramwell (Byrom) 261: 626, 633, 646, 650
 Brauell 206
 Brault 490: 523, 534, 536, 539, 540, 551, 595
 Braun 249: 516, 622
 Braune 13, 632
 Braus 661
 Brefeld 186, 212, 215, 217, 219, 223
 Brehmer 612
 Brenner 460
 Bresgen 567
 Bretonneau 425
 Brieger 191, 192, 197, 201, 204: 479, 498: 576, 623, 643
 Bright 278, 383, 498: 539, 551, 555
 Brinton 460
 Bristowe 153: 295, 495: 577, 620
 Broadbent 661
 Broca 625
 Brodowski 109, 153: 391, 490: 556
 Brookhouse 479
 Brosin 556
 Brown-Séguard 589, 638
 Bruberger 661
 Brücke 94: 253, 453
 Brückner 551
 Brunelli 648
 Bruns 154: 399, 434: 569, 575, 621, 623 *a*, 658, 667, 670
 Bruylants 605
 Bruzelli 645
 Buchholtz 190
 Buchner 186, 190, 193, 201, 209, 211
 Buchwald 523, 539, 650
 Bückling 495
 Budd 453, 460, 498, 500
 Budge 94
 Bugnion 231
 Buhl 9, 11, 120, 206: 271, 272, 279, 436, 458: 539, 582, 587, 595, 600, 601, 603, 604, 606, 613, 637, 669
 Buob 621
 Burckhardt 436
 Burger 362: 565
 Burkhard 84
 Burkhardt 282: 533
 Burow 61: 575
 Bury 648
 Busch 18. 88
 Butlin 165: 402: 575
 Buttenwieser 631
 Buzzard 647, 648, 661, 669
 Cadet 261
 Caillé 500
 Calmeil 656
 v. Campe 660
 Canalis 623 *a*
 Capitain 542
 Carl 498
 Carré 589
 Carswell 613
 Carter 201, 207, 222: 531
 Carville 625
 Caspar 457
 Caspari 669

(The numbers refer to the articles)

- Caton 96
 Catiano 262
 Cattani 667, 668
 Cavafy 623 a
 Cayley 31
 Ceci 193
 Cervato 575
 Challand 513
 Chamberland 188
 Champneys 517
 Chantreuil 623
 Charcot 28: 260, 302, 303, 304, 383, 498:
 526, 531, 536, 539, 579, 589, 625, 626,
 627, 628, 636, 638, 641, 644, 646, 647,
 648, 650, 659, 661, 667, 669
 Charrin 542
 Chauveau 42, 125, 127, 231
 Chavasse 561, 670
 Cheadle 650
 Cheyne (Watson) 201, 204: 361: 564
 Chiari 179: 391, 396, 404, 415: 565, 574,
 595, 619, 623, 630, 633, 663
 Chotinsky 551
 Christison 259: 539
 Christoph 145
 Church 302, 358
 Chvostek 500
 Cienkowski 223
 Clapton 640
 Clarke 437: 639, 647
 Claudius 13
 Claus 648
 Cleland 5: 630, 632
 Clemens 645
 Coats 636, 659
 Cobbold 226, 228, 233, 234, 235, 239, 240:
 663
 Cohen (Solis) 573
 Cohn 183, 184, 185, 186, 191, 192, 211:
 619
 Cohnheim 18, 19, 21, 22, 25, 27, 30, 33,
 36, 47, 62, 79, 80, 84, 94, 95, 97, 99,
 117, 119, 125, 136, 140, 153, 177, 179,
 180, 221: 261, 277, 279, 324, 328, 344,
 351, 425, 460, 484, 490: 521, 523, 525,
 526, 530, 531, 540, 556, 584, 588, 589,
 680, 619, 620, 624, 622
 Colberg 596
 Coleman 440
 Colin 127, 201: 262: 550
 Colomatti 507
 Colosanti 657
 Colucci 492
 Cordua 68: 349
 Cormack 669
 Cornevin 206
 Cornil 58, 66, 76, 84, 120, 128, 156, 206:
 258, 292, 296, 328, 332, 342, 344, 391,
 425, 471, 490, 491, 498, 500: 523, 528,
 533, 535, 536, 537, 539, 540, 542, 550,
 551, 569, 572, 575, 582, 595, 596, 602,
 605, 607, 613, 618, 622, 623, 647, 662,
 663, 668
 Corrigan 582
 Cossy 667
 Cotard 651
 Coupland 261: 565: 604
 Courty 153
 Courvoisier 670
 Couty 266
 Coze 204, 211
 Creighton 127, 174: 495: 623 a, 669
 Crisp 471
 Crocq 600
 Crooke 474
 Cruveilhier 515: 577, 630, 632, 654
 Cuboni 206
 Cullen 94
 Cunningham 74, 193, 222
 Curling 13
 Curnow 31: 514
 Curshmann 579, 596, 625
 Cyon 648
 Czerny 154: 308, 399: 670
 Da Costa 565
 Dallinger 185
 Dalton 625
 Damaschino 470: 659
 Damsch 392
 Danjoy 526
 Danzel 178
 Daresté 3, 7, 10: 630, 632
 Daszkiewicz (Korybutt) 667, 668
 Dättwyler 460
 Davaine 204, 206, 209, 226, 230, 231,
 234, 235, 240, 250: 663
 Davida 641
 Davidsohn 515
 Davies 621
 Day 31
 Debove 537: 626
 Deiters 626, 639
 Déjérine 641, 647, 648, 667, 669
 De la Croix 190, 630
 Demiéville 398
 Demme 42: 261, 433, 454: 567, 577, 612,
 613, 621, 622, 623, 623 a, 631
 Denissenko 640
 Dennis 439
 Dentan 638
 Depaul 13: 607, 623 b
 Désert 315
 Dessoir 437
 Dickinson 58, 62: 526, 530, 531, 532, 537,
 539, 542, 550, 551, 552, 631, 641, 650
 Dieckerhoff 618
 Dilg 271
 Dittmer 5
 Dittrich 587
 Dobbert 668
 Dodds 625
 Dönitz 5
 Dowse 661
 Drasch 74
 Dreschfeld 490: 530, 602, 613, 641, 647
 648, 650, 659, 663
 Drummond 659

(The numbers refer to the articles.)

- Drysdale 185
 Dubler 669
 Dubois 623 b
 Du Casal 561
 Du Castel 272
 Duchamp 249
 Duchenne 647
 Duckworth (Dyce) 400: 623 a
 Duclaux 191, 201, 219
 Duguet 640
 Duhring 359, 367, 377, 392, 396, 399
 Dujardin-Beaumetz 659
 Duménil 647, 667, 669
 Dumolard 623
 Dunin 539
 Durand 561
 Durante 255
 Duret 625, 628
 Durham 568
 v. Dusch 620
 Duval 627
 Duzan 179

 Eberth 56, 59, 74, 79, 84, 87, 99, 153,
 204, 206: 281, 282, 316, 326, 328, 332,
 344, 474, 492: 539, 542, 556, 587, 602,
 619, 622, 623 b, 663
 Ebstein 28: 517, 531, 535, 550, 552, 555,
 556, 561
 Ecker 17: 408: 621, 625
 Eckstein 534
 Edinger 594, 625, 641
 Edwards 585
 Ehebald 594
 Ehrlich 127: 260, 261, 262, 295: 643
 Eichhorst 261, 274, 407: 626, 638, 667,
 668
 Eickler 304: 636
 Eichstedt 412
 Eickholt 650
 Eidam 189
 Eimer 55, 250
 Einsiedel 667, 668
 Eiselsberg 654
 Eisenlohr 642, 659, 667, 669
 Eisenmann 94
 Eldridge 577
 Eliaschoff 535
 Elsässer 453
 Emmerich 602
 Emmert 94
 Emminghaus 656
 Engelken 659
 Engelmann 190: 667
 Engelstedt 661
 Eppinger 63, 161, 204: 307, 490: 522,
 569, 570, 572, 573, 574, 575, 576, 577,
 594, 604, 622, 663
 Erb 260: 626, 627, 632, 644, 645, 646,
 647, 648, 659, 663, 667, 669
 Erler 651
 Erman 490
 Esoff 397
 Etard 191

 Etter 659
 Eulenburg 397
 Eulenberg 648, 667
 Eve 441: 551, 556
 Ewald 278, 453: 526, 539, 639
 Ewart 184, 186, 189, 204, 207
 Ewetzky, 87, 108, 163
 Exner 625

 Fagge (Hilton) 62: 277, 309, 399, 400:
 550, 623 a
 Falkenheim 667
 Falkson 663
 Farre 552
 Fauconneau-Defrésne 514
 Fauvel 575
 Fehleisen 204: 375
 Fehr 537
 Feinberg 669
 Feld 596
 Feltz 125, 204: 479
 Fenley 619
 Fenwick 453, 460
 Ferber 663
 Féré 625
 Ferrein 511
 Ferrier 625, 626, 627, 641, 646, 647
 Feuerstāk 584
 Feuerstack 261: 596
 Feustel 592
 Fick 630
 Fiedler 503: 640
 Filehne 262, 457: 598, 645
 Fischer 18: 633, 640, 645, 653, 667
 Fischel 206: 320: 539, 542
 Fitz 211, 219: 582
 Flechsig 625, 626, 627, 630, 633, 646,
 647, 648, 657
 Fleischer 260: 565
 Fleischmann, 377, 439, 632
 Flesch 633, 634
 Fleming 133
 Flemming 46, 74, 75, 84
 Flourens 625
 Flournoy 266
 Foà 255, 261, 318, 498
 Fokker 209
 Forel 625, 627, 641, 659
 Formad 204
 Förster 1, 4, 5, 7, 10, 13: 271, 404: 539,
 544, 604, 607, 619, 622, 623, 625, 630,
 632
 Fournier 648, 661
 Fox (Wilson) 125, 178: 460
 Fox (Tilbury) 385, 402
 Fraenkel 125: 490, 515: 532, 535, 567
 Fraentzel 613
 Frankenhäuser 261: 579
 Franks 567
 Frerichs 490, 495, 498, 500, 504, 510, 515:
 535, 539, 551
 Freund 500: 623 a
 Frey 596, 601
 Friedberg 18

(The numbers refer to the articles.)

- Friedländer 204, 206: 295, 309, 391, 392,
 474, 479: 539, 540, 542, 544, 584, 596,
 601, 602, 638, 667
 Friedleben 623 *b*
 Friedmann 639, 650
 Friedreich, 18, 58, 59, 61, 221: 320, 492,
 513, 515: 530, 620, 621, 637, 647, 648,
 650
 Frisch 199
 Fritsch 625
 Frobenius 602
 Froisier 630
 Frommann 647, 648, 650
 Fronista 174
 Frommüller 645
 Fuhr 623 *a*
 Fürbringer 221: 516, 534, 542, 620
 Fürst 3: 575, 577, 585
 Fürstner 625, 633, 637, 641

 Gaffky 189, 204, 205, 206, 209, 211: 474
 Galabin 539
 Galen 93
 Galton 625
 Gamgee 35, 54, 68: 258, 259
 Ganquillet 662, 663
 Gannet 135
 Ganser 641
 Garrod 259: 526, 531
 Gärtner 190
 Gaucher 534, 542
 Gaudard 659
 Gaule 120
 Gaultier 550
 Gautier 191
 Geber 377, 380, 397
 Geddes 207
 Gee 120: 327
 Gegenbaur 623 *b*
 Gelmo 633
 Georjevic 315
 Geppert 669
 Gerhardt 327, 397, 460: 574, 576, 578,
 589, 591, 607, 662
 Gerlach 5, 17, 127: 626, 639
 Gessler 667
 Germont 523
 Geuzmer 621
 de Giacomo 613
 Giacomini 625
 Gibbes 127, 206: 613
 Gibler 384
 Gierke 434: 627, 639
 Gies 437
 Gilbert 667
 Giovanni 292, 299
 Gjorgewic 152
 Glaser 612, 662
 Glax 97
 Glozier 233
 Gluck, 667, 668
 Gluge 112: 658
 Golgi 625, 628, 639, 662
 Goll 626

 Goltz 625
 Golubew 86
 Gombault 498: 526, 623, 626, 647, 661,
 667
 Goodhart 302, 490: 565, 607
 Goodsir 87, 94, 174
 Gordon 178
 Gore 621
 Gosselin 438
 Gottstein 567
 Gowers 260, 295, 328: 625, 641, 648, 650,
 659, 661
 Grancher 118: 582
 Grandidier 607
 Grassi 231
 Graves 572
 Grawitz 11, 214, 219, 222, 223, 224: 279,
 436: 522, 528, 539, 556
 Greenfield 130, 204, 206: 271: 530, 539,
 540, 550, 661
 Greenhow 565, 600
 Greenish 556
 Greiff 651, 656, 661
 Griesinger 231, 239: 502: 663
 Griffine 84
 Griffini 622
 Grimm 637
 Grohe 219, 222
 Gros (Leon) 661
 Gross 358
 Gruber 10, 11, 75: 517, 577
 Gruby 411
 Grundler 623 *a*
 Gubler 500
 Gudden 522, 625, 627, 633, 641, 646
 Guillebeau 37: 324: 526, 528
 Guillemard 239
 Guillot 621
 Gull 63: 279: 526, 539, 623 *a*, 637, 654
 Günsburg 460
 Gunz 631
 Günther 127: 602, 668
 Gurlt 1, 5
 Gussenbauer 67, 174: 513: 562
 Gusserow 552
 Gutknecht 621
 Guttmann 613

 Haab 204: 564, 625, 641
 Haberkorn 185
 Habershon 498
 Hadden 625, 628
 Hadlich 633, 638
 Haeckel 348: 637
 Hahn 623 *b*, 625
 Hafter 178
 Haight 371, 383
 Halford 262
 Hall 391: 635
 Haller 3, 94
 Hallier 185, 186, 218
 Hallopeau 637
 Hallwachs 115
 Hamilton 27, 96, 108, 120: 255, 259, 266,

(The numbers refer to the articles.)

- 324, 498: 528, 579, 582, 589, 596, 606,
 613, 625, 647, 659
 Hamlet 190
 Hammerich 439
 Hammond 659
 Hänel 631
 Hanot 498
 Hardy 397
 Hare 517
 Harley 623 *a*
 v. Harlingen 367
 Harms 127
 Harris, 600, 631, 637
 Harrison 561
 Hart 258
 Hartdegen 650
 Hartig 220
 Härting 619
 Hartmann 567, 656
 Harvouet 634
 Hasse 180: 658
 Hauff 574
 Hauser 460
 Haward 622
 Hayem 35: 252, 260, 261, 498: 646, 654,
 658, 659, 667
 Heath 622
 Hebra 152: 359, 364, 377, 388, 392, 397,
 401, 406, 412: 567
 Hecker 565, 607, 621
 Hedenius 623 *b*
 Hegar 115
 Heidenhain 108, 115: 520, 523
 Heimer 620
 Hein 240
 Heinemann 495
 Heine 94
 Heineke 631
 Heinze 572, 573
 Heitler 604
 Heitsch 602
 Heller 226, 229, 233, 243: 315, 396: 518,
 531, 552, 582, 592, 662, 663
 Henle 94: 625, 639
 Henning 62
 Henoeh 631
 Hensen 668
 Heppel 61
 Hering 27, 97, 120
 Hermann 52: 525, 625, 627
 Hertwig 89: 348
 Hertz 517, 551, 587, 591, 594
 Herz 667, 668
 Heschl 59, 178: 305, 491: 604, 622
 Hess 638, 640
 Hesse 600, 619, 630
 Heubner 130: 295, 425, 444: 628, 661
 Heusinger 8
 Hewett 631
 Heydenreich 207: 630
 Hickmann 11
 Hildebrand 552, 621
 Hill 31: 625, 627
 Hiller 191, 197, 201, 223, 226, 233: 607,
 613
 Hillis 392
 Hilton 632
 Hindenlang 268, 334
 Hink 135: 618
 Hintzen 500
 Hippocrates 433
 Hirsch 125, 146: 434, 495: 623 *a*, 669
 Hirt 600
 His 623 *b*, 668
 Hitchcock 670
 Hitzig 625
 Hjelt 514: 667, 668
 Hlava 490: 595
 Hobson 261
 Hodgkin 328, 344
 Hoffa 526
 Hoffman F. A. 94, 96
 Hoffmann 492: 518, 531, 550, 662
 Hofmeier 539
 Hoggan 667, 669
 Hollis 639
 Holmes 308, 632
 Holsti 526, 539
 Homén 626, 646
 Hopmann 568
 Hoppe-Seyley 52, 96, 191: 258, 259, 262,
 509
 Horsley 623 *a*, 667
 Hortolès 523, 539, 540
 Horwath 190
 Hosch 625, 641
 Houston 13
 Howits 607
 Huber 153, 162, 206, 247: 550, 556, 565
 Hubner 277, 295
 Hubl 358
 Hueter 11, 204
 Huguenin 613, 622, 625, 626, 631, 637,
 641, 652, 653, 654, 660, 664
 Hulke 437
 Humbert 343
 Humphreys 650, 659
 Humphry 253, 437: 585, 632
 Hunter 94
 Huppert 533, 567, 630, 633, 640
 Hutchinson 400, 402, 441
 Hutinel 607
 Immermann 28
 Inglessis 535
 v. Ins 334: 600
 Isartier 646
 Israel 134, 135: 279, 292, 299, 436: 522,
 528, 539, 543, 618
 Iwanowsky 277
 Jaccoud 292
 Jackson (Hughlings) 295: 625
 Jacobi 530, 534, 542
 Jacobson 266
 Jäderholm, 633, 647
 Jahn 292: 576, 638
 v. Jaksch 661
 Jamieson 376
 Jarisch 392

(The numbers refer to the articles.)

- Jastrowitz 625, 638, 639
 Jehn 28: 589
 Jendrassik 651
 Jenner 594
 Jensen 3: 633
 Jeffroy 572, 669
 Johne 35: 612
 Johnson 279: 523, 526, 536, 539
 Johnston 514
 Jolly 266: 630, 635, 645, 650, 658
 Joubert 188
 Julliard 10: 623 a, 661
 Junge 288
 Jürgens 29
 Jürgensen 265, 453: 542, 582, 602, 603,
 604, 605, 612, 637
 Kahler 625, 626, 633, 644, 646, 647, 648,
 650
 Kammerer 658
 Kannenberg 249: 542, 620
 Kaposi 152: 359, 364, 365, 366, 376, 377,
 378, 380, 383, 384, 392, 396, 397, 399,
 400, 402, 406, 407, 410, 411: 567
 Karl Theodor 639, 659
 Kassowitz 87, 88
 Kaufmann 219: 621, 622
 Keating 204
 Keber 204
 Kekulé 58
 Kellermann 641
 Kelsch 262, 334, 502: 539, 540
 Ker 479
 Kern 186
 Kessler 18
 Kesteven 637
 Key (Axel) 79, 99: 460: 533, 628, 645,
 666, 670
 Kidd (Percy) 613, 669
 Kiener 125: 296, 502
 Kiessling 249
 Kirchhoff 630
 Kirkes 528
 Kirmisson 561
 Kitt 221
 Klebs 84, 117, 125, 127, 128, 145, 161,
 174, 178, 183, 184, 185, 186, 188, 201,
 204, 206, 209, 226, 247, 250: 260, 262,
 281, 308, 314, 315, 343, 391, 400, 437,
 440, 448, 460, 490, 495, 504, 513, 514,
 515: 517, 518, 534, 539, 540, 542, 550,
 554, 556, 561, 565, 602, 612, 623 a,
 630, 633, 634, 642, 656, 658, 662, 663,
 665
 Klein 63, 74, 76, 86, 119, 120, 125, 186,
 206, 209, 211: 318, 320, 474: 540, 542,
 584, 602, 613, 626, 628, 639
 Klemensiewicz 97
 Klemm 669
 Klenke 440
 Klob 515
 Knauff 600
 Knauth 594
 Knoll 533
 Kölner 131: 670
 Koch 94, 117, 120, 125, 127, 183, 184,
 185, 186, 188, 189, 190, 193, 196, 199,
 201, 204, 206, 208, 209, 211, 219, 222,
 250: 390, 473: 602, 606, 613, 632, 645
 Kocher 153, 171, 177, 204: 466: 556, 622,
 623, 623 a
 Kohlrausch 178
 Kohn 535
 Kohts 567, 568
 Kolaczek 161
 Kolessnikow 642, 659
 van der Kolk 626
 Kölliker 5, 7, 88, 115: 516, 579, 584,
 623 b, 636, 639, 658, 668
 Koller 631
 König 11: 621
 Kopp 578, 607
 Korányi 605
 Korn 318
 Körte 460
 Köster 119, 120, 143, 163, 171, 204: 292,
 299, 316, 391: 612, 613
 Kostjurin 638, 641
 Kottmann 260
 Kowalewsky 516
 Krafft 302
 Krafft-Ebing 645
 Kräpelin 637, 656
 Kratter 623 a
 Kraus 647, 659
 Krause 564, 567
 Krauss 471: 637
 Kraske 89
 Kremiansky 664
 Krieger 272
 Krönlein 11, 77
 Küchenmeister 221, 226, 246: 575
 Kühle 572
 Kühn 556
 Kühne 58, 69: 639
 Kundrat 435, 470: 630
 Kunkel 67, 68, 69: 268, 317
 Kupffer 516
 Küss 107
 Kussmaul 206: 292, 453, 470: 550, 600,
 625, 647, 667
 Küssner 498
 Küttner 579, 584
 Kyber 68, 61, 62, 64: 326, 397
 Laache 258, 261
 Labbé 399
 Laborde 266
 Lachmann 663
 Laennec 118: 498: 604, 613
 Lahmann 670
 Lancereaux 130: 277, 295, 304, 500: 539,
 550, 623 b, 653, 661, 663, 664, 667
 Landau 458: 517
 Landerer 454
 Landois 625, 627, 635, 667
 Landouzy 633
 Landsberger 556
 Lang 376, 392
 Lange 659

(The numbers refer to the articles.)

- v. Langenbeck 295, 346, 435
 Langenfeldt 668
 Langer 364, 396
 Langhans 61, 67, 68, 82, 115, 119, 120:
 287, 299, 328, 329, 343, 344, 345, 399:
 533, 539, 540, 544, 556, 562, 578, 600,
 619, 637, 659
 Langley 626, 646
 Lankester 185
 Lassar 25, 96: 407: 534, 535, 539
 Laura 626, 627
 Laveran 206: 277: 657, 667, 668
 Laycock 67
 Lebedeff 9: 530, 534, 535, 630
 Leber 61, 219, 221: 440: 641
 Lebert 125, 173, 178: 490, 495: 582, 621,
 654, 662, 663, 664
 Lecorché 539
 Leech 540
 Leegard 667, 668
 Lefferts 468, 575
 Léger 292
 Legg (Wickham) 28: 490, 498
 Legros 399
 Leichtenstern 17: 258, 469, 479: 522, 542
 Leitz 415: 621
 Leloir 365, 397
 Lemcke 526
 Lenhosseck 633
 Leopold 140, 179
 Lépine 261, 314: 542, 604, 625, 647
 Leroy 582
 Lesser 262, 315, 383, 457: 530
 Létiévant 667
 Letzerich 204: 474: 539, 542, 543
 Leube 194, 206: 260, 263, 453, 460, 470:
 531, 532
 Leuckart 225, 226, 228, 231, 233, 234,
 235, 245, 246, 247, 250
 Leut 668
 Lewaschew 299
 Lewin 53: 367: 574, 600
 Lewinski 315
 Lewis 222, 225, 250
 Lewitzky 490
 Leyden 262, 281, 284, 288, 490: 526, 539,
 542, 579, 603, 604, 612, 626, 630, 632,
 635, 637, 638, 641, 644, 645, 646, 647,
 648, 650, 659, 663, 669
 Lichtheim 25, 219, 221: 262: 530, 582,
 591, 594, 612, 618, 620, 659
 Lieberkühn 250
 Liebermann 231
 Liebermeister 482, 498
 Liebig 190
 Liman 531
 Limen 457
 Liouville 302
 Lippe 125
 Lippl 601, 612
 Lissauer 647
 Lister 94, 97, 185, 186, 194
 Litten 30, 37, 64: 261, 324, 484, 498: 523,
 526, 527, 528, 529, 532, 535, 537, 539,
 542, 543, 544, 576, 584, 588, 589
 Little 18
 Littré 465
 Lockwood 9
 Löffler 189, 201, 219: 618
 Lomer 564
 Long 231
 Longstreth 565
 Lorenz 271
 Lösch 314, 515
 Lotzbeck 439
 Louis 572
 Löwe 628, 639
 Löwenberg 567
 Löwenfeld 636
 Löwenthal 646
 Lowne 1
 Lubbock 94
 Lubimoff 63, 120: 642, 656
 Lucae 161
 Lucas 18
 Luchsinger 530
 Lücke 136, 149, 171, 173, 178, 204: 515:
 621, 622, 623, 623 a
 Ludwig 55
 Lukkowsky 204
 Luschka 516, 637, 664
 Lütkemüller 13
 Luton 621
 Luys 641, 656
 Lyon 259
 Maas 88, 140, 179, 180: 258, 437, 438:
 561, 654
 Macewen 88
 Mackenzie (Hunter) 613
 Mackenzie J. 574
 Mackenzie (Morell) 567, 568, 569, 572,
 573, 575, 576, 578
 Mackenzie (Stephen) 361: 530
 McConnell 231: 495
 Madelung 621
 Maennel 631
 Magendie 266
 Magnan 650, 656
 Magitot 441
 Mahomed 539
 Maier 152, 156, 161, 163, 204: 261, 271,
 282, 292, 454, 455, 470: 647, 667
 Maizel 74
 Malassez 261
 Malinverni 630
 Manfredi 400
 Mangelsdorf 498
 Mansell-Moullin 266
 Manson 235: 315: 620
 Manz 656
 Maragliano 206
 Marcacci 625
 Marchand 5, 7, 153, 206: 262: 530, 534,
 535, 539, 556, 565, 604, 618, 625, 632,
 641, 663, 669
 Marchiafava 206
 Marie 651, 659
 Markwald 542
 Martin 74, 125, 126: 296: 564, 567, 632

(The numbers refer to the articles.)

- Martinache 623
 Martini 178
 Martinotti 646
 Masius 261: 530, 638
 Massei 572
 de Massy 358
 Mathieu 568
 Matterstock 471
 Maurer 161
 Mauriac 437
 Mauthner 625, 641
 Mayer 223: 453: 588, 641, 646, 667
 Maylard 585
 Mayr 367
 Mayser 641
 Meckel 5, 8
 Mégnin 231
 Meier 136
 Meinel 600
 Menche 613
 Mendel 646, 656
 Mendelsohn 602
 Mendelson 525
 Merkel 600, 633, 639
 Meschede 633, 638, 656, 662, 663
 Meyer 288, 292, 297, 474: 654, 662
 Meynert 625, 627, 633, 639, 640, 656
 Michaelis 555
 v. Michalovicz 625
 Michaud 644
 Michel 567
 Mierzejewsky 650, 656
 Miller 440
 Miquel 193
 Minkowski 647
 Mitchell-Bruce 17
 Möbius 638
 Moczutkowsky 207
 Moeli 647
 Mögling 528
 Moinel 567
 Moleschott 35
 Mommsen 542
 v. Monakow 627, 641, 667
 Monod 18, 149
 Montegazza 35
 Monti 570
 Moore 181: 402, 515: 556
 Morgan 619
 Morin 247
 Morison 400
 Moritz 667
 Morris 552, 663
 Mosler 260, 262, 322, 327, 328: 550, 575
 Mosso 628, 635
 Mott (Valentine) 399
 Moxon 165, 174: 277, 297, 490, 500: 550,
 635, 650, 661, 663
 Mügge 296: 613
 Muhr 631
 Müller 127, 147, 165, 206, 226: 261, 272,
 460: 605, 613, 621, 622, 638, 645, 646,
 663, 669
 Munk 262, 490: 620, 625, 635
 Murchison 328, 343, 490, 495: 572, 669
 Muron 266
 Murri 530
 Nägeli 186, 188, 190, 191, 192, 193, 201,
 204, 209, 211, 223
 Nasse 668
 Nassiloff 204
 Nathan 515
 Näunyn 246: 253, 490, 504, 638, 667
 Nauwerck 204: 281, 455: 534, 535, 537
 539, 540, 542, 544, 606, 612, 614, 620,
 654, 659
 Nedopil 437
 Neelsen 63: 316, 358: 642, 646
 Negell 550
 Neisser 117, 131, 204, 206, 248: 262: 530,
 564
 Nelaton 399
 Neligan 437
 v. Nencki 183, 184, 191, 194, 197: 479
 Nepveu 204
 Neubauer 531, 532
 Neumann 8, 79, 85, 89, 161: 260, 297,
 317, 359, 363, 364, 376, 383, 397, 406,
 409, 440: 556, 622, 659, 662, 667, 668
 Neupauer 631
 Neureutter 633, 650
 Newman 517, 523
 Nicaise 667, 670
 Nicati 498
 Nieden 152: 315
 Niedick 669
 Niépce 621
 Nolen 605
 Noman 490
 Nonat 637
 v. Noorden 523
 Normand 231
 Nothnagel 470, 479: 589, 604, 625, 635,
 669
 Obermeyer 207
 Obersteiner 625, 628, 635, 638, 640, 645
 Oellacher 5
 Oeller 288
 Oemler 201
 Oertel 204: 425: 542, 575, 669
 Oldham 153
 Ollivier 526
 Oppenheim 648, 669
 Ord 531, 623 *a*
 Oordt (Van) 128
 Ormerod 647, 648
 Orth 1, 8, 13, 69, 114, 125, 127, 204: 271,
 285, 292, 324, 334, 342, 432, 501: 570,
 587, 595, 605, 606, 613
 Osler 556, 630, 662
 Ossikovszky 490
 Otto 642, 650
 Overbeck 525
 Owen 233
 Pagenstecher 231: 316: 620, 635
 Paget 42, 71, 80, 86, 89, 94, 107, 136, 146,

(The numbers refer to the articles.)

- 147, 149, 165, 171, 173, 178, 181, 233: Poulin 292
 630, 633 Pramberger, 579
 Pagliani 231 Prazmowski 186, 188
 Pankritius 607 Prévost 647
 Pansch 625 Proujeansky 247
 Panum 3, 5, 7, 13, 178, 190, 197: 460: Prince 513
 589, 630 Prior 472
 Papp 631 Priestly 74
 Parker 619 Proust 607, 659
 Parona 231 Prudden 670
 Parrot 663 Puichaud 623
 Parsons 621 Pullar 359: 659
 Pasteur 183, 186, 188, 191, 201, 206, 209, Purjesz 602
 223 Purtscher 641
 Paulizky 61 Putiata 346
 Paulus 664 Putjatin 277
 Pautynski 520, 528 Pütz 133: 433: 605, 618
 Pawlinoff 607 Pye-Smith 261
 Payne 150: 504: 622
 Peacock 271, 272, 309: 579
 Pearson 600
 Penzoldt 260, 261, 453, 454: 565
 Pepper 514
 Perchappe 656
 Perewerseff 556
 Perl 517
 Perls 1, 3, 7, 9, 12, 13, 68, 85, 153, 154, Quain 52: 495
 156, 173, 174, 194, 199, 204, 226, 231, Quincke 261, 268, 304, 315, 317, 350, 460,
 248: 316, 400, 504: 522, 523, 533, 539, 481
 619, 630
 Perroncito 226, 261
 Peters 63: 332
 Peterssen-Borstel 510
 Petrina 625, 662
 Petters 315
 Peyerani 667
 Pfeiffer 613
 Pfitzer 308
 Pfleger 633
 Pflug 135: 618
 Philippeau 667, 668
 Pierret 633, 640, 647, 648
 Pierson 625, 669
 Pick 625, 630, 633, 637, 644, 646, 647, Rebsamen 334
 648, 650
 Pinel 589
 Pinner 152: 622
 Pitres 525, 647, 669
 Platen 539
 Poels 605
 Poensgen 453
 Poland 133
 Pollack 650
 Pollard 650
 Pollender 206
 Ponfick 81, 114, 135: 260, 261, 262, 266, v. Recklinghausen 63, 99, 154, 205: 349,
 268, 302, 314, 322, 328, 349, 436: 530, 392, 397, 398, 399, 439, 453, 511, 514:
 534, 539, 542, 618 595, 645, 650, 670
 Popoff 498: 659
 Popow 641, 667
 Posner 498: 523, 533, 539, 562, 588
 Pospelow 152
 Poster 437
 Potain 343
 Pouchet 261
 Raab 255, 631
 Rabe 618
 Radcliffe 653
 Ralfe 531
 Ramdohr 607
 Ranke 632, 659
 Ranvier 52, 66, 76, 84, 89, 120, 128, 146, Rauber 5
 156: 258, 261, 292, 328, 332, 425, 500: Rauchfuss 271: 569, 570, 578
 528, 539, 550, 551, 569, 572, 575, 596, Rauschenbach 252
 607, 613, 623, 639, 662, 663, 667, 668 Rayer 383: 517, 539, 550
 Raphael 531 Raymond 613, 647
 Rättig 250
 Rauber 5
 Rauchfuss 271: 569, 570, 578
 Rauschenbach 252
 Rayer 383: 517, 539, 550
 Raymond 613, 647
 Raynaud 204
 Reali 631
 Rebsamen 334
 v. Recklinghausen 63, 99, 154, 205: 349,
 392, 397, 398, 399, 439, 453, 511, 514:
 595, 645, 650, 670
 Redfern 87
 Reess 219: 223: 490
 Rehn 8: 458
 Reichel 13, 152
 Reid 18
 Reil 271
 Reinhardt 51: 619
 Reinke 190
 Reisinger 637, 662
 Reiss 490
 Remak 76, 174, 178: 667, 668
 Renaut 662
 Rettelheim 654
 Retzius 79: 628, 633, 666
 Reubold 436, 439
 Reuss 96
 Reverdin 84: 623 a
 Reynolds 635

(The numbers refer to the articles.)

- Rheiner 570
 Ribbert 520, 521, 522, 533, 539, 540, 542,
 619, 630
 Richard 206
 Richaud 498
 Richet 625
 Rickards 536, 556
 Riedel 255: 628
 Riegel 577, 579, 594, 613
 Riehl 574
 Riess 204: 263
 Rindfleisch 42, 59, 66, 76, 81, 84, 85, 86,
 109, 114, 117, 119, 120, 125, 150, 165,
 173, 174, 204: 261, 296, 388, 502: 530,
 534, 539, 573, 582, 587, 613, 619, 632,
 647, 650, 660, 663, 664, 668
 v. Rinecker 661
 Ripping 637
 Rivolta 250
 Roberts 190, 194: 513: 517, 523, 530, 532,
 539, 552, 555, 561
 Roberts J. B. 555
 Robin 260: 556, 600, 628, 663, 664, 667
 Robinson 376: 523, 567, 641
 Roellinger 623
 Roger 659
 Rohon 633
 Rohrer 179: 556
 Rokitansky 58, 149: 271, 514: 539, 578,
 585, 604, 619, 621, 637, 650, 663, 664
 Röhl 623 *a*
 Rollet 517
 Romelaere 591
 Rose 577, 622
 Rosenbach 194: 262, 284, 453: 669
 Rosenberger 115, 196, 211
 Rosenstein 517, 526, 539, 550, 620
 Rosenthal 661
 Ross 333: 625, 626, 627, 628, 630, 635,
 641, 647, 669
 Rossbach 196: 579
 Rószahgyi 201
 Roth 9: 302, 304, 305, 464, 510: 574, 628,
 636, 638, 662, 669
 Rottenstein 440
 Rouis 495
 Roustan 125
 Rovida 533
 Roy 279, 318: 521
 Ruboni 513
 Rudneff 58
 Rühle 612, 613
 Rumler 143
 Rumpf 639, 650
 Runeberg 520, 523
 Runge 605
 Ruppert 266: 600
 Rütimeyer 648
 Russell 361
 Rustizky 664
 Ryneck 97
 Sabourin 498: 556
 Saccharjin 607
 Sachs 212, 215, 218, 220, 223: 625
 Sahli 659
 Sakaky 648
 Salkowski 191, 197: 479, 490: 531, 532,
 579
 Salter 441
 Salvioli 260, 318, 498: 602, 639
 Samuel 80, 94, 95, 96, 97: 539
 Samuelsohn 641
 Samuelson 277
 Sander 630, 633, 641
 Sanders 259
 Sanderson (Burdon) 94, 95, 99, 119, 120,
 225, 183, 186, 189: 328: 625, 653
 Sanquirico 623 *a*
 Sansom 282
 Santi Sirena 667
 Sattler 163
 Saundby 533, 539, 565
 Savage 637
 Sawyer 517
 Säxinger 552
 Schachowa 535
 Schäfer 261
 Schäffer 612
 Schatz 562
 Schech 574
 Schede 8, 180
 Scheiber 367
 Scherer 259
 Scheube 669
 Schiefferdecker 626, 638, 646
 Schiff 623 *a*, 667, 668
 Schklarewsky 27, 96
 Schlesinger 636, 637
 Schlossberger 531
 Schmidt 35: 252, 261, 485, 498: 600, 631
 Schmidlein 550
 Schmidt-Rimpler 641
 Schmiedeberg 191, 197
 Schnitzler 607
 Schopfhagen 637, 639
 Schön 668
 Schönlein 409
 Schott 654
 Schotte 190
 Schottelius 570, 576, 577, 600, 601, 612,
 619
 Schreiner 260
 Schroeter 191
 Schroetter 575, 578
 Schrön 171
 Schuberg 479: 664
 Schuchardt 526
 Schuchart 591
 Schule 630, 650, 656
 Schüller 132
 v. Schulthess-Rechberg 277
 Schultz 255, 256, 308
 Schultze 5: 252: 531, 626, 633, 637, 646,
 647, 648, 651, 656, 659, 662, 667
 Schultzen 490
 Schulz 52: 344, 358, 490: 647
 Schulze 54
 Schüppel 119, 120, 127: 342, 491, 500,
 504, 510, 512: 605, 637, 662, 664

(The numbers refer to the articles.)

- Schülte 491
 Schütz 539, 607, 618
 Schützenberger, 223
 Schwalbe 625, 626, 627, 628, 639
 Schwarck 470
 Schweigger 288
 Schweninger 84, 125: 425: 601, 612
 Schwimmer 437
 Scoda 633
 Scott 531
 Scriba 266
 Sedgwick 516
 Sée (Germain) 613
 Seegen 612
 Seguin 625
 Seitz 472
 Seligsohn 600
 Selvili 656
 Semmer 196, 201, 204, 209
 Semmola 539
 Semper 516
 Senator 278: 523, 531, 539, 542
 Senftleben 108, 115: 255
 Senger 602
 Senise 612
 Sermani 613
 Shepherd 606
 Shuttleworth 633
 v. Siebold 225: 551
 Sigel 612
 Siemens 651
 Silbermann 605
 Simmerling 648
 Simon 94, 125, 174: 400: 551, 552, 578,
 633, 637, 656
 Simon 646
 Simons 498
 Simpson 14
 Singer 626
 Skwortzoff 625
 Slavjansky 266: 600
 Smith 154: 523, 542, 556, 600, 626, 628,
 639
 Smith (Everett) 648
 Socoloff 320: 579
 Sokolow 156
 Solly 647
 Sommerbrodt 574, 596
 Sonderegger 241
 Sonnenberg 13
 Sonsino 239
 Southey 550
 Soyka 154, 193: 266, 334, 600
 Spaet 663
 Spatz 272
 Spear 206
 Spengel 516
 Sperling 630, 664
 Spiegelberg 458: 621
 Spilling 260
 Spring 631
 Stadelmann 647
 Stadfeldt 552
 Staudenmeyer, 623
 Steffen 504, 631
 Stein 266: 562
 Steiner 471: 570, 633, 650
 Steinrück 668
 Steinthal 550, 561
 Sternberg 194, 204, 206: 564, 602
 Steudener 88, 156: 570, 578, 623 b, 659
 Steven 543
 Stewart 648, 656
 Stewart (Grainger) 537, 539, 669
 St. Hilaire (Geoffroy) 3, 5, 7: 630, 631
 Stieda 250: 623 b, 639
 Stilling 94: 315: 619: 627
 Stirling 625, 627
 St. Lager 623 a
 Stoffela. 647
 Stöhr 442
 Störck 578
 Strasburger 74, 75, 76, 84
 Strauss 537
 Streckeisen 621
 Strelzoff 88
 Stricker 79, 86, 95, 99
 Stroganow 292, 380
 Stromeyer 621, 658
 Struck 208
 Strümpell 515: 637, 647, 648, 651, 653,
 659, 669
 Struthers 17
 Sturge 659
 Sturges 604
 Sturm, 556
 Suchard 205
 Surre 498
 Sussdorf 605
 Sutton 63: 279: 526, 539
 Szymanowski 631
 Talko 631
 Takacs 647
 Talma 292: 528
 Tappeiner 125: 262: 601, 602]
 Taruffi 271
 Tautain 277
 Taylor 261, 457, 490: 637
 Teppel 327
 Teuffel 498, 512
 Thierfelder 358, 490, 495, 498: 594
 Thiersch 109, 171, 181: 402
 Thin 367, 380, 392, 400, 402, 407: 574
 Thoma 95, 96, 97, 131: 258, 261, 272,
 288, 392, 467: 522, 526, 539
 Thomas 206: 533, 534, 542, 603, 604,
 623 b
 Thomson 600
 Thomson (Allen) 516
 Thorn 551
 Thorspecken 453
 Thudichum 568
 Tiegel 185
 v. Tieghem 185, 186, 189
 Tiesler 669
 Tiffany 607
 Tigges 656
 Tillmanns 5, 11, 85, 108, 109, 115, 204:
 285: 667

(The numbers refer to the articles.)

- Tills 85
 Tizzoni 204, 206: 261, 317, 492: 623 a,
 667
 Tobbold 572
 Toldt 665
 Tommasi-Crudeli 204, 206
 Tornwaldt 567
 Tourneux 632
 Toussaint 201, 206
 Touton 371
 Toynbee 654
 Traube 101: 279, 495: 523, 526, 539, 591,
 596, 600, 601
 Travers 86
 Trélat 18
 Trendelenburg 204
 Treub 669
 Treves 120: 342
 Tripier 625
 Trojanowsky 582
 Trompeter 292
 Tschirjew 659
 Trouseau 261, 328, 344, 572
 Tuzek 648, 656
 Tüngel 633
 Türk 569, 574, 576, 578, 626, 627, 646,
 647, 656
 Turner 17, 62: 277, 315, 633, 639, 659
 Tyndall 193

 Ungar 579
 Unna 128: 371, 385, 388, 404
 Unruh 542
 Urlichs 209
 Uskoff 440
 Uskow 277
 Utthoff 528

 Vacca 95
 Vacher 204
 Vaillard 346: 669
 Vallat 332
 Vallienne 11
 Valsuani 11
 Vandye Carter 222
 Vanlair 261: 638, 667, 668
 Variot 437
 v. Velden 657
 Veraguth 596, 601, 612
 Verneuil 13, 154: 402
 Verriers 605
 Veyssière 625
 Vierling, 578, 607
 Vierordt 579, 633, 647, 669
 Villaret 600
 Villemin 125, 133: 594
 Virchow 5, 8, 13, 14, 30, 35, 48, 56, 58,
 61, 62, 68, 72, 76, 77, 78, 80, 81, 84,
 85, 87, 89, 90, 94, 114, 117, 118, 125,
 127, 128, 131, 136, 138, 145, 146, 147,
 149, 150, 152, 153, 154, 156, 165, 171,
 177, 179, 201, 221, 233, 247: 252, 260,
 272, 287, 299, 305, 314, 326, 328, 332,
 334, 343, 344, 392, 399, 400, 425, 437,
 438, 439, 441, 457, 460, 483, 495, 500,
 514: 530, 531, 539, 544, 550, 551, 552,
 556, 561, 565, 568, 570, 574, 577, 587,
 589, 600, 607, 619, 621, 622, 623, 623 a,
 623 b, 628, 631, 632, 633, 634, 636, 637,
 648, 650, 658, 660, 661, 662, 664, 669,
 670
 Vogel 94: 437: 531, 532
 Vogt 179, 633
 Voigt 10
 Voisin 561, 656
 Voit 52, 191, 201: 485, 490: 531
 Volkmann 562, 567, 577
 Vrolik 1
 Vulpian 641, 647, 667, 668

 Wagner 56, 59, 62, 120, 128, 129, 206:
 316, 327, 358, 383, 425, 436, 470, 491,
 498, 500, 515: 526, 534, 539, 542, 570,
 596, 602, 604, 607, 619, 623 a, 633, 661
 Wagstaffe 532
 v. Wahl 453: 612
 Waldenburg 118, 125, 250
 Walder 206
 Waldeyer 84, 161, 171, 173, 178, 204, 206:
 260, 316, 358, 490, 504: 556
 Waldstein 247: 261
 Waller 96: 646, 667, 668
 Waller B. C. 540
 Wallis 99
 Wardell 222
 Wargunin 612
 Warren 399, 402
 Wartman 87
 Wasserthal 13
 Watney 623 b
 Webber 669
 Weber 86, 125: 437, 438, 500: 591, 664
 Weddel 613
 Wedl 9: 440: 642
 Wegner 115, 120, 152: 315, 437, 438, 490
 Weichselbaum 556, 567, 600, 601, 612,
 619, 665
 Weidner 383
 Weigert 13, 36, 96, 123, 179, 204, 207:
 288, 296, 314, 324, 371, 388, 425, 504:
 518, 528, 533, 534, 535, 536, 539, 542,
 556, 570, 613, 623, 653, 665
 Weil 174: 577, 579
 Weir 437
 Weir-Mitchell 667, 668
 Weiss 639, 647, 650
 Weissgerber 194: 523, 533, 539
 Welander 564
 Welch 588
 Welcker 17
 Weller 659
 Wendt 161, 233
 Werner 618
 Wernich 193, 201, 209, 211: 474
 Wernicke 625, 627, 644
 v. Werra 528
 Wesener 515
 West 631
 Westphal 625, 629, 633, 637, 646, 647,
 648, 650, 656, 657, 659, 661

(The numbers refer to the articles.)

- Wever 327
Weyl 400
Whipham 536, 637
Whistler 574
White 623 *a*, 637
Whitehead 470
Whitley 500
Wiederhöfer 453, 458
Wieger 63: 332: 638
Wienkowski 315
Wiktorowski 460
Wilbrand 625
Wille 630, 633
Wilks 165, 181: 261, 277, 297, 321, 328,
491, 500: 539, 660, 661, 663, 664
Williams 96, 153: 556
Willigk 589
Wilson 125
Wilson (Erasmus) 408
Windle 535, 556
v. Winiwarter 97, 117: 292, 343, 346,
438, 490: 622
Winkel 262
Winogradow 318
Winternitz 367
Winslow 3
Witkowski 637, 645
Wittich 250: 623 *b*
Wolberg, 667, 668
Wolf 565
Wolfenden 659
Wolf 88, 177, 197, 201, 204, 209: 647
Wolffhügel 189, 190
Wölfler 471: 517, 621, 622, 623
Wood 204
Woodhead (Sims) 436: 647
Woodward 470
Wooldridge 35
Worms 647
Wucherer 231
Wulff 504
Wunderlich 343: 653
v. Wyss 84, 108, 125, 206: 383, 490, 498,
514: 613, 654
Yeo (Burney) 125
Yeo (Gerald) 625
Youatt 133
Zacher 633, 637, 651, 656
Zaeslein 261: 602
Zahn 61, 140, 179: 252, 261, 425, 482:
595
Zander 279
Zanger 206
Zenker 38, 153, 222, 229, 233, 243: 260,
261, 304, 449, 490, 498, 513: 579, 587,
600, 636, 637, 638, 650, 653, 663, 664,
665
Zesas 623 *a*
Ziegler 28, 37, 59, 61, 68, 85, 86, 88, 108,
109, 110, 115, 119, 120, 123, 140, 145,
150, 156, 173, 174, 179, 184, 193, 204:
255, 268, 277, 281, 288, 375, 376, 388,
437, 444: 526, 539, 575, 600, 604, 612,
613, 628, 631, 633, 637, 648, 658, 663
Ziehl 602, 613
v. Ziemssen 449, 460: 569, 570, 573, 574,
575, 576, 653
Zuckerkindl 567, 568, 584
Zülzer 204
Zunder 490
Zürn 226: 575

INDEX OF SUBJECTS.

(The numbers refer to the articles.)

- abnormalities of the heart 270 sqq
of the kidney 517 sqq
(see malformations)
- abrachius 10
- abscess 102, 116
alveolar 440
bronchopneumonic 611
lung 605
metastatic 116
of brain 653, 654
of kidney 543
of liver 493 sqq
of œsophagus 450
perinephritic 543, 554
spleen 322, 324
stomach 457
tonsils 442
tuberculous 428
- absorption by peritoneum 349
of serous effusion 352
- acardiacus 13
- acarus folliculorum 225
scabiei 225, 413
- accessory lobes of lung 585
suprarenals 565
thymus glands 623 b
thyroid glands 621
- achirus 10
- achorion Schönleinii 222, 410
- achroma 365
- acids, corrosion by 450, 457
- acne 405
albida 404
mentagra 405
rosacea 360
sebacea 403
- acrania 7, 620
- actinomyces 222
- actinomycosis 134, 135, 222, 436
of lung 618
- acute miliary tuberculosis 123
atrophy of the liver 204
- Addison's disease 362, 565
- adenia 328, 344
- adenocarcinoma 169, 173, 431, 462, 478,
512
- adenoma 166, 167 sqq
false 422
of intestine 478
of liver 502
of mucous membrane 431
of sweat-glands 402
of thyroid, 621
- adhesive inflammations 352
- adipose tissue, growth of 85
- adiposity 50
- æcidium elatinum 220
- ægagropili 479
- aërobious fungi 188, 206
- ætiology of goitre 623 a
- agenesis of brain 630
- agnathia 8
- agrotis segetum 222
- ague-cake 321
- air, bacteria in the 193
in blood 265, 266
- air-passages, structure of 566
- albinism 365
- albumen, excretion of 520
- albuminuria 523, 528, 533, 538 sqq
- albuminoids, putrefaction of 191, 192
- alcoholic fermentation 212
fermentation set up by mu-
cor 219
fermentation set up by yeasts
223
- algæ 212
- alimentary tract Sect. VII. (Part II.)
- alkalies, corrosion by 450, 457
- allantois 516
- alopecia 407
- alternation in mould-fungi 218
- aluminosis 600
- alveolar abscess 440
colloid 247
colloid of liver 507
ducts 584
sarcoma 161
- alveoli of lung 584
- amelus 10
- amœba coli 250
rotatoria 250
- amputation, intrauterine 10
nerve-changes after 641
- amputational neuroma 154, 668
- amyelia 630
- amyloid change of bladder 561
change of heart 275
change of kidney 537
change of liver 491
change of lung 595
change of lymphatic glands
332
change of mucous membrane
417
change of spleen 325

(The numbers refer to the articles.)

- amyloid change of thyroid 623
 change of vessels 288
 concretions 61
 degeneration 57 sqq
 degeneration, results of 60
 degeneration, seat of 59, 62
 substance, nature of 59, 62
 substance, reactions of 58
 amyotrophy 640
 amyotrophic lateral sclerosis 647
 anæmia 19, 258, 261
 of brain 635
 of kidney 524
 of liver 483
 of lung 586
 collateral 22
 anæmic necrosis 40
 necrosis from atheroma 300
 anaërobios fungi 188
 anasarca 23
 in nephritis 539
 anastomotic aneurysm 151, 289, 301
 varix 151
 anchylostoma duodenale 231, 479
 anencephalia, 7, 630
 Aneurysm 301 sqq
 of basilar arteries 663
 dissecting 309
 false 308
 miliary 636
 of heart 284
 aneurysmal varix 301, 311
 angina 442
 Ludovici 447
 angiolithic sarcoma 663
 angioma 148, 312
 congenital 179
 lymphatic 152
 of brain 663
 of liver 504
 of mouth 438
 of skin 401
 angiosarcoma, myxomatodes 163
 plexiform 161
 anguillula stercoralis (rhabditis) 231
 angular gyrus 624
 anhydræmia 258
 annectant convulsions 624
 anomaly, congenital 1
 anthracosis 600
 anthrax (see bacillus anthracis) 199
 genesis of 206
 history of 206
 intestinal 477
 simplex 405
 specific 390
 symptomatic 206
 vaccination in 201
 antheridium 218
 anus, imperforate 464
 aorta, aneurysm of 303
 degeneration of 287
 inflammation of 292
 primitive 270
 aortic bulb 270, 271
 aortitis, acute 292
 apex of lung in phthisis 616
 aphasia 625
 aphemia 625
 aphtæ 433
 aphtous stomatitis 433
 aplasia of the limbs 10
 of the brain 630, 633, 641
 apneumatosi 591
 apoplexy 27, 304
 cerebral 636
 pancreatic 513
 pulmonary 586
 aprosopia 8
 apus 10
 arachnoid 628
 arachnida 225
 arachnitis 656
 archenteron 348
 area Celsi 407
 argyria 362
 argyris 70
 argyrosis of kidney 530
 archinencephalia 630
 arsenic, causing fatty change 52
 arterial trunks, defect of 271
 hæmatoma 308
 arteries, syphilis in 130
 arterio-capillary fibrosis 279, 526
 arterioles, hyaline change in 288
 arterio-sclerotic kidney 525, 526
 arteritis 291, 292
 deformans 299
 syphilitic 295
 arthropoda 225 sqq
 ascaris lumbricoides 228, 479
 mystax 228, 479
 ascending degeneration of cord 646
 ascites 23, 350, 497
 chylous 31
 ascococcus 185
 ascogonium 216
 ascopore 213, 216
 ascus 216
 aspergillus glaucus 216, 221
 flavescens etc. 219, 222
 asteatosis 403
 ataxy, locomotor 647
 atelectasis of lung 591
 atheroma causing aneurysm 302
 of endocardium 276
 of vessels 288, 297 sqq
 (sebaceous) 404
 atheromata (congenital) 8
 atheromatous ulcer 297
 atresia ani 464
 of great vessels 271
 of intestine 468
 urethræ 519
 atrophic pigmentary induration of
 stomach 456
 cirrhosis of liver 498
 proliferation 46
 atrophy, active 47
 in mouth 437

(The numbers refer to the articles.)

- atrophy, of inaction 47
of anterior horns 640
of brain 638, 640
of cerebrum 640
of cerebellum 640
of cord 640
of heart 273
of intestine 468, 470
of kidney (congenital) 517,
(anæmic) 525
of liver 483, 485 sqq
of liver, acute yellow 489, 490
of lymphatic glands 331
of mucous membrane 417
of nerves 667
passive 47
pigmentary 45, 46
serous 46
simple 43, 45
of spleen 325
of stomach 455
trophoneurotic 47
of vessels 288
- attenuation of virus 201, 211
attraction theory of inflammation 94
autochthonous thrombus 253
autosite 13
axis-cylinder 666, 667
- bacilli in cholera 473
of anthrax 390
of typhoid 474
- bacillus amylobacter 186
anthracis 185, 186, 188, 189, 190,
199, 206
anthracis, transmutation of 211
lepræ 131, 185, 186, 206
malarie 185, 206
œdematis 206
subtilis 185, 186, 211
of glanders 618
of typhoid 206
of tubercle in glands 342, 613
of tubercle in lung 606, 613
of tubercle in sputum 613
of tubercle in vessels 296
tuberculosis 120, 127, 186, 206
(Fig. 80)
detection of 127
- bacon liver 57, 491
spleen 325
- bacteria 183 sqq
biology of 188 sqq
in air, soil, etc. 193
in catarrh 420 (see bacilli,
micrococci)
classification of 183
diffusion of 193
effect of agitation on 190
effect of heat on 189
effect of light on 190
effect of poisons on 190
effect on nutrient liquid 191
in endocarditis 281
in erysipelas 375
in hepatic abscess 494
inflammation excited by 198,
199
in health 194
in kidney 529, 543
in intestine 479
in leprosy 392
in lymphatic glands 335
mutability of 192, 208, 209, 211
non-pathogenous 197
pathogenous 195, 196, 198
in pemphigus 384
in phlegmon 390
in purpura hæmorrhagica 361
in smallpox 388
specific nature of 208, 209
in splenic abscess 322, 324
in stomach 453
in syphilis 391
textural changes caused by 200
in urine 558
- bacterial action, theories of 210
bacterium decalvans 407
lineola 185, 205
subtile 211
termo 185, 189, 192, 205
- balantidium coli 250
baldness 407
barber's itch 411
Basedow's disease 623 *a*
bed-bug 226
bed-sores 33
gangrenous 390
- belladonna-rash 367
beriberi 669
bezoars 479
bile in blood 259, 268
bile-ducts, cancer of 503
inflammations, etc. of 508
sqq
new-formed 497
- bile-pigments 69, 481
in gall-stones 508, 509
- bilharzia hæmatobia 239
in blood 265
in kidney 557
- biliary abscess 493, 495
colic 510
concretions 508 sqq
hepatitis 498
infiltration of kidney 530
- bilirubin 268
in gall-stones 508, 509
- biliverdin in gall-stones 508, 509
bird's-nest body 172
- bladder, development of 516
dilatation of 563
disorders of 558
malformations of 519
tumors of 562
- blastomycetis 223 sqq
blebs 370
bleeders 28
blisters 370, 371, 372, 381
blood, a tissue 251

(The numbers refer to the articles.)

- blood, air in 265, 266
 -casts in urine 558
 changes in 258 sqq
 coagulation of 252
 composition of 251, 258
 -corpuscles, changes in 260 sqq
 hyperplasia of 258
 impurities in 263 sqq
 parasites in 265, 266
 -pigments 68
 -plates 252, 261, 263
 -vessels, growth of new 86
 -vessels in tabes dorsalis 648
 -vessels, wounds of 256 (see vessels)
- blood and lymph Sect. I. (Part II.)
 and lymph, functions of 251
- bloody sweat 361
- Blutplättchen 35, 252, 261, 263
- body-cavity, development of 348
- boils 405
- bones, growth of 88
 metaplasia of 91
 regeneration of 88
- bothriocephalus cordatus 240
 cristatus 249
 latus 249, 479
- botrytis bassiana 222
- 'bots' 226
- bovine tuberculosis 127, 206
- Bowman's capsule 516, 520
- brain-disease, lymphatics in 269
- brain, anemia of 635
 atrophy of 638, 640
 compression of 644
 concussion of 645
 contusion of 645
 degeneration of 638
 disorders of 629 sqq
 histology of 639
 hyperæmia of 635
 hypertrophy of 633, 651
 inflammations of 652 sqq
 malformations of 630 sqq
 membranes of 628
 parasites of 66 sqq
 sclerosis of 649, 650, 651
 softening of 639, 642
 structure of 624 sqq, 639
 syphilis of 661
 tuberculosis of 660
 tumors of 662
 vessels of 628
 wounds of 658
- bridge-building, paralysis in 645
- Bright's disease 539
 disease and cardiac hypertrophy 279
 disease and vascular hypertrophy 289
- bronchi, disorders of 579 sqq
- bronchial vessels 584
 glands, tuberculosis of 613
- bronchiectasis 579, 582, 583
- bronchiole 584
- bronchiolitis, exudative 579
- bronchitis 579
- bronchoblennorrhœa 579
- bronchocele 621
- bronchopneumonia 596, 599, 610 sqq
- bronchorrhœa 579
- bronzed skin 362, 565
- bronzing 67
- brood-capsules (ecchinococcus) 245
- brood-cells 76
- brown atrophy of heart 273
 induration of lung 587
- bubo 391
 hard syphilitic 342
 suppurating 337
- bulbar nuclei, atrophy of 640
 paralysis 647, 659
- bullæ (see blebs and blisters)
- bullous emphysema 594
- Burdach, columns of 626
- burn, blisters from 370, 372, 381
- burns, effect on blood 262
- cachexia of tumor 141
 strumipriva 623 a
- cadaveric poison 197, 390
- caisson-paralysis 645
- calcaneus (talipes) 11
- calcareous deposits 64, 65
 deposits in bile-ducts 508 sqq
 deposits in kidney 532
 deposits in pancreatic ducts 514
 deposits in thyroid 623
 deposits in vessels 288
 calculi 532, 560
- calcarine fissure 634
- calcification, after necrosis 34
 of lymphatic glands 333
 of brain 638
 of thrombi 254
 of vessels 288, 297
- calculi, biliary 508 sqq
 intestinal 479
 pancreatic 514
- calculous pyelitis 555
- calculus, salivary 448
 vesical 560
 urinary 560
- callosities 394
- canal of Wirsung 513
- canalization of thrombus 255
- canals, biliary 480
- cancellous osteoma 147
- cancer-cells 170
- cancer, endothelial 316, 358, 663, 664
 (see carcinoma)
 of lymphatic glands 347
 of serous cavities 358
 of skin 402
 stroma 170
- cancroid 402
 dry 404
- cancrum oris 434
- canities 365

(The numbers refer to the articles.)

- canker in cattle 135
 cantharides, blisters from 381
 gastric ulcer from 459
 cystitis from 561
 capillary aneurysms 305
 ectasis 305
 capillaries, growth of 86
 capsule of Bowman 516, 520
 of Glisson 480
 internal 625 (Fig. 245)
 external 625 (Fig. 245)
 caput medusæ 497
 carbonic acid poisoning 259
 carbonic oxide poisoning 259
 carbuncle 405
 carcinoma 166, 170 sqq
 aetiology of 181
 growth of 171
 of intestine 478 (see cancer)
 of liver 503
 of meninges 663, 664
 metastases in 174
 of mucous membrane 431
 of oesophagus 451
 of pancreas 515
 of serous membrane 358
 of skin 402
 of stomach 461, 462
 varieties of 173
 cardiac ganglia, changes in 277
 hypertrophy and renal disease 279
 hypoplasia 272
 malformations 271
 polypus 253, 277
 thrombosis 253
 caries of teeth 440
 carnification of lung 592, 604
 carpoonium 216
 carrier-cells 114
 cartilage, growth of 87
 laryngeal, disease of 576
 metaplasia of 91
 caruncle 564
 caseation 39
 after necrosis 34
 in tubercle 118
 of lung 598
 of lymphatic glands 332, 333, 342
 casts in urine 523, 533, 558
 caseous pneumonia 606
 necrosis of lung 611
 catarrh 55
 desquamative 103
 purulent 102
 serous 102
 of intestine 470
 of larynx 570
 of lung 597
 of mucous membrane 420, 421
 of nose 567
 of oesophagus 450
 of stomach 456
 catarrhal stomatitis 433
 cavernous angioma 150
 angioma of liver 504
 metamorphosis 150
 caudate nucleus 625
 cauliflower excrescences 564, 575
 cavities in lung (see vomica, bronchiectasis) 616
 cebocephalia 630
 cells, division of 74, 75
 multiplication of 80, 81
 cell-nests 170, 172
 cellulitis 390
 micrococci in 204
 pelvic 669
 central fissure of cerebrum 624
 lobe of cerebrum 624
 nervous system Sect. IX. (Part II.)
 red atrophy of liver 483
 centrum ovale 625
 cephalocele 631
 cercaria 236, 239
 cercomonas 250
 in lung 620
 intestinalis 479
 cerebellum 624, 627
 cerebellar tract 626
 atrophy 640
 cerebral abscess 653, 654 (see brain)
 atrophy 640
 axis 624, 626 (Fig. 247)
 vesicles 630
 cerebrospinal meningitis 653
 cerebrum 624 (see brain)
 cestoda 240 sqq
 chalicosis 600
 chalky concretions 65
 chancre 128
 (hard) 391, 564
 (soft) or chancroid 391, 564
 Charcot's crystals 260, 579
 cheilognathopalatoschisis 8
 chicken-pox 388
 chigoe or chigger 226
 chilblains 367, 389
 chionyphe Carteri 222
 chloasma 362
 chloroma 162
 chlorosis, anæmia of 258, 261
 Egyptian 231
 hypoplasia in 272, 286
 cholecystitis 512
 cholera 473
 anhydræmia in 253
 cholesteatoma 161, 663
 cholesterolin 54
 in gall-stones 508, 509
 chondroma 146
 choroid plexuses 628
 chronic parenchymatous nephritis 539, 544 sqq
 chronic ulcer of stomach 459
 ulcer of duodenum 471
 chylous ascites 31, 350
 hydrothorax 31, 235

(The numbers refer to the articles.)

- chyluria, from filariæ 235
 cicatricial tissue 82, 105
 tissue, growth of 103, 109
 cicatrix, after necrosis 34
 in blood-vessel 255, 256
 syphilitic, of liver 499
 ciliata 250
 cimex lectuarius 226
 cinnabar in blood 266, 267
 circulation of kidney 521
 cirrhosis of liver 497 sqq
 of lung 581, 592, 598, 604, 611,
 616
 pancreas 515
 cirrhotic kidney 526, 539, 547 sqq
 cirroid aneurysm 301
 cisterns of subarachnoid 628
 Clarke's vesicular columns 626
 claustrum 625
 clavities 407
 clavus 394
 cleft palate 8, 567
 'clegg' 226
 clostridium butyricum 186, 188, 192
 clots, post-mortem 253
 cloudy swelling 48
 swelling of heart 274
 swelling of kidney 534
 swelling of liver 488
 club-foot 11
 coagulation, intravascular 252 sqq
 coagulative necrosis 35, 36
 coal-dust in blood 265, 266, 267
 in lungs 600
 coccidium 250
 in lung 620
 coccobacteria 185
 cœliac flux 472
 Cohnheim's embryonic theory of tu-
 mors 177 sqq
 colic, biliary 510
 renal 531, 555
 colitis 471
 collapse of lung 591 sqq, 610
 collier's lung 600
 colliquative necrosis 40
 colloid, alveolar 507
 cancer of intestines 478
 cancer of stomach 462
 casts 525, 533
 degeneration 56
 degeneration of thyroid 623
 combined degenerations of cord 647
 comedones 404
 of mouth 439
 commissures of brain 625
 commotio cerebri 645
 compensatory hypertrophy of kidney
 522
 composition of blood 251
 compression, softening from 644
 concentric globes 172, 663
 hypertrophy 278
 concretion pericardii 353
 concretions, amyloid 61, 638
 concretions, biliary 508
 intestinal 479
 pancreatic 514
 salivary 448
 urinary 560
 concussion of brain and cord 645
 condyloma 129
 acuminatum 394, 564, 574
 endocystic 400
 latum 379
 congenital encephalitis 638
 hernia 465
 hypertrophy 18
 syphilis of liver 500
 tuberculosis 612
 tumors 178
 congestion 21
 of brain 635
 of kidney 522
 of liver 483
 of lung 586, 602
 of spleen 319
 conidia 213
 conidiophore 215
 connective tissue, metaplasia of 91
 tissue regeneration of 85
 connective-tissue tumor 138
 contagious disease 202
 disease, evidence of organic
 nature of virus in 203
 contracted kidney 525, 528, 545, 547 sqq
 contraction of stomach 454, 460
 convolutions of cerebrum 624 sqq (Figs.
 243, 244)
 cord (spinal), atrophy of 639, 640
 (spinal), compression of 644
 (spinal), concussion of 645
 (spinal), contusion of 645
 (spinal), inflammations of 652 sqq
 (spinal), malformations of 630, 632
 (spinal), sclerosis of 646, 647, 648,
 649, 650, 651
 (spinal), softening of 643, 644
 (spinal), structure of 626
 (spinal), tuberculosis of 660
 (spinal), wounds of 658
 cordyceps militaris 222
 cornea, mould-fungi on 231
 cor villosum 352
 corns 394
 cornua of cord 626
 cornu cutaneum 394
 corona radiata 625
 coronary embolism 277
 corpora albicantia 627
 amylacea 61, 638
 Arantii, degeneration of 276
 geniculata 627
 quadrigemina 627
 corpus callosum 624
 callosum, absence of 630
 corpuscles, changes in 260 sqq
 corrosion of œsophagus 450
 of stomach 457
 corrosive poisons on skin 389

(The numbers refer to the articles.)

- cortical centres 625
 coryza 567
 crab-louse 226
 cranial nerves 626, 627
 craniopagus 12
 craniorachischisis 7
 cranioschisis 7, 630
 cretinism 623 *a.*, 634
 criminal brain 634
 croup 570
 croupous exudation 103
 inflammation of intestine 470
 inflammation of larynx 570
 inflammation of lung 597
 inflammation of mucous
 membrane 423
 inflammation of nose 567
 inflammation of œsophagus
 450
 inflammation of stomach 457
 crura cerebri 627
 crural hernia 465
 crustæ 368, 373
 culicidia 226
 cultivation of bacteria 186, 211
 cuneus 624
 cuniculi in scabies 225, 413
 cutis œnea 362, 565
 cyanosis 271
 cyanotic atrophy of liver 483
 induration of kidney 523
 cyclopia 7, 567, 630
 cyclops, host of Guinea-worm 234
 cylinders in urine 523, 533
 cylindrical aneurysm 301
 epithelial cancer 173
 cylindroma 163, 173
 of brain 663
 cystadenoma 168
 of thyroid 621
 cystic hygroma 438, 439
 sarcoma 448
 cysticercus celluloseæ 242, 244
 celluloseæ in brain 663
 celluloseæ in kidney 557
 celluloseæ in lung 620
 of brain 663
 of heart 285
 racemosus 243
 of serous membranes 358
 cystine calculi 532, 560
 cystitis 561
 cystocele (vaginal) 563
 cystoma 168
 multilocular, of thyroid 623
 cysts 71
 apoplectic 636
 biliary 511
 dermoid 178
 following necrosis 34
 of intestine 464, 470
 of jaws 441
 laryngeal 575
 meningeal 637
 mucous 422, 439, 446
 cysts, pancreatic 514
 renal 551
 serous 358
 of trachea 578
 dandriff 403
 daughter-cysts (echinococcus) 246
 Davaine's septicæmia 204
 decubitus 33
 decubital necrosis of larynx 576
 necrosis of pharynx 450
 necrosis of skin 390
 defects of the heart 270
 of the vessels 271
 definitive inflammation 34
 degeneration, amyloid 57
 colloid 56
 dropsical 49
 dropsical of kidney 535
 fatty 50
 gelatinous, of nerve-centres 639
 gray, of nerve-centres 639
 hyaline 63
 'hyaline-fibrous' 63
 lardaceous 57
 mucoid 55
 parenchymatous 48
 secondary, of tracts 646
 vitreous 63
 waxy 68
 degenerations
 of brain 638
 of heart 273 sqq
 of liver 488 sqq
 of lung 595
 of lymphatic glands 330
 sqq
 of neuroglia 639
 of pancreas 514
 of suprarenals 565
 of spleen 325 sqq
 of vessels 287 sqq
 Deiters' cells 639
 demarcation, line of 34, 41, 115
 dementia paralytica 648, 656, 657
 demodex 225
 folliculorum 404
 dental osteoma 441
 dentigerous cysts 441
 deposits in kidney 529 sqq
 dermatitis 366 sqq
 contusiformis 367
 exfoliative 377
 dermatolysis 399
 dermatomycosis 409
 dermoid cysts 71, 178
 tumors 358
 descending degeneration of cord 646
 desmobacteria 183, 186, 206
 desquamation 373
 desquamative catarrh 103
 destruction of blood-corpuscles 262,
 268, 318

(The numbers refer to the articles.)

- development of blood-vessels 86
of urinary organs 516
- dextrocardia 272
- diabetes, kidney in 535
lipæmia in 259
- diapedesis 27, 96
- diaphragmatic grooves on liver 482
hernia 467
- dicephalus 14
- diffuse aneurysm 301
nephritis 541
sclerosis 651
- dilatation of bile-ducts 510, 511
of bronchi 582
of capillaries 305
of heart 278 sqq
of intestine 468
of œsophagus 449
of pancreatic ducts 514
of stomach 453, 454
of trachea 577
- diphtheria 443, 444, 570
and myocarditis 284
coagulative necrosis in 38
micrococci in 204
nephritis in 540, 542
paralysis in 669
- diphtheritic endocarditis 281, 282
inflammation 38, 103
inflammation of intestine 470
inflammation of larynx 570
inflammation of mucous membrane 424, 425, 443
inflammation of œsophagus 450
inflammation of stomach 457
- diplobacteria 185
- diplococcus 184, 185, 602
- diprosopus 14
- dipygus 15
- direct cell-division 76
- discoloration of skin 362
- disinfectants 190
- disinfection by heat 189
- disintegration of blood-corpuscles 262,
268, 318
cysts of 71
- dislocation, congenital 11
- dispora Caucasica 186
- dissecting-room warts 390
- distoma hæmatobium 239
hæmatobium in kidney 557
hepaticum 237
lanceolatum 238
ringeri 620
- diverticula of bladder 519
of intestine 464, 468
of œsophagus 449
- dochmius duodenalis 231, 479
- dorsal stratum of cerebral axis 627
- dracontiasis 234
- dracunculus medfnensis 234
- dropsy 23
- dropsy of gall-bladder 511
of serous cavities 350
- dropsical degeneration 49
degeneration of kidney 535
lacunæ of cord 637
- dry inflammation of serous membrane 352
- dry-rot 220
- ductus arteriosus 271
Botalli 271
- duodenitis 471
- duodenum, ulcer of 471
- duplicitas anterior 14
posterior 15
- duplication of bladder 519
of limbs 17
of central canal of cord 637
of mammary glands 17
of ureter 517
of viscera 17
- dura mater, hæmorrhage of 664
mater, hygroma of 664
mater, inflammations of 664
mater, structure of 628
mater, tumors of 664
- dust-cells 600
diseases 600
- dwarfs 6, 43
- dyschromatosis 362
- dysentery 421, 472
hepatic abscess in 493
- dystopia of kidney 517
- ear, mould-fungi in the 221
- eburnated osteoma 147
- ecchondroses 146
of larynx 576
- ecchymoma 361
- ecchymoses 26, 261
- echinococcus cysts 245
granulosus 246
hydatidosus 246
multilocularis 247
scolecipariens 246
tænia 245
veterinorium 246
of heart 285
of brain 663
of liver 507
of lung 620
of serous membranes 358
- ectasis 305
- ecthyma 385
- ectogenous virus 203
- ectophytes 182
- ectopia cordis 9, 272
(ecstrophia) vesicæ 9, 519
- ectozoa 182
- eczema 385
marginatum 411
- efflorescence of skin-disease 368
- effusions 26
- effusion in serous cavities 350, 354
- Egyptian chlorosis 231
- elephantiasis arabum 315, 395, 396

(The numbers refer to the articles.)

- elephantiasis, congenital 399
 græcorum 131
 græcorum (see leprosy)
 of lymphatic glands 341
- embolic abscess 257, 267
 aneurysm 302
 infarction 37
 pneumonia 605
 tuberculosis of lung 606
- embolism 29
 of kidney 527
 of lung 590
 of spleen 624
- embolus 257, 263, 267, 282
- embryonic hypothesis 177 sqq
 tissue 180
- emphysema of lung 593, 594
- empusa 222
- empyema 354
- encephalitis, congenital 638
 purulent 654, 658, 659
- encephalocele 7, 631
- encephaloid cancer 173
 (medullary) cancer of stomach 462
- encephalomalacia 643
- enchondroma 146
 of skin 401
- endarteritis 293
- endemic goitre 623 *a*
- endobronchitis 581
- endocarditis 280 sqq
 micrococci in 204
- endocardium, degeneration of 275,
 276
- endocystic condyloma 400
- endogenous gemmation 76
 virus 203
- endoneurium 666
- endophlebitis 293
- endosporium 215
- endothelial cancer 316, 358
- endothelioma 161, 316
 melanodes 504
 of meninges 663, 664
- endothelium of serous cavities, its nature 348
 of vessels as impurity in blood 263
 of vessels in organization 255
 of vessels in thrombosis 253
- engastrius 13
- engorgement 21
 of brain 635
 of glottis 571
 of kidney 523
 of liver 483
 of lung 556
 of spleen 323
- engouement* 602
- enlarged prostate 564
- enlargement of heart 278
 of liver 492, 498
 24
- enlargement of lymphatic glands 338
 sqq
 of spleen 321, 323, 327 etc.
- enostosis 147
- enteric fever 474
- enteritis 470
- enterocystoma 464
- enteroliths 471, 479
- enteromycosis bacteritica 477
- entophytes 182
- entozoa 182
- eosinophilous cells 260
- epencephalon 630
- ependymal sclerosis 650
- ephele 362, 398
- epidemic cerebrospinal meningitis 653
- epidermal pearls 172, 398, 663
- epidermic globes 172, 398, 663
- epidermidophyton 376
- epigastrius 13
- epignathus 13
- epileptic brain 634
- epipygus 13, 14
- epistaxis 26, 567
- epithelial casts 533, 558
 catarrh 420
 pearls 172, 663
 tumors 138, 166 sqq
- epithelioid cells in granulations 108
 cells in tubercle 119
- epithelioma 170, 172
 (adenocarcinoma) 431
 (cancerous) 402
 molluscum 400
 of mouth 438
- epithelium, growth of 84
 regeneration of 84
- epispadias 519
- epizoa 182
- epulis 438, 441
- equinus (pes) 11
- erectile tumors 150
 tumors of nose 568
- ergotism 648
- erysipelas 375
 laryngitis in 572
 micrococci in 204, 375
- erysipelatous stomatitis 433
- erythema 360, 366
 multiforme 367
 nodosum 367
- essential anæmia 258
- état criblé* 637, 643
- état mammelonné* of stomach 456
- ethmocephalia 630
- eurotium aspergillus 216, 221
- eustachian valve, development of 270
- eustrongylus gigas 231
 gigas in kidney 557
- exanthemata, rash in 367
- excentric hypertrophy 278
- excitability of cells 78
- exfoliative dermatitis 377
- exophthalmic goitre 623 *a*
- exosporium 215

(The numbers refer to the articles.)

- oxostosis 147
 extraneous matters in blood 265
 matters in lymphatic glands
 334 sqq
 extravasation 26
 cysts of 71
 extroversion of bladder 519
 exudation-corpuscles 112
 exudation from serous membranes 350,
 354
 in skin disease 368
 exudations, inflammatory 96
 inflammatory, re-absorp-
 tion of 112
 inflammatory varieties of
 102
 fæcal abscess 468, 471
 fæces, parasites in, 479
 false adenoma 422
 aneurysm 308
 membrane 35, 102
 membranes in croupous inflam-
 mations 423
 membranes in serous inflamma-
 tions 352
 passages 564
 farcy 133
 fat-embolism of lung 588
 fat in blood 259, 264, 266
 fatty casts 533
 degeneration 50 sqq
 degeneration, cause of 52
 degeneration of brain 638
 degeneration of endocardium 275
 degeneration of heart 274
 degeneration of kidney 536
 degeneration of liver 488
 degeneration of lymphatic glands
 332
 degeneration of pancreas 514
 degeneration of vessels 287
 enlargement of heart 279
 infiltration 50, 53
 kidney 536, 545
 liver 487
 favus 222, 410
 femoral hernia 465
 fenestration of valves 282
 ferro-albuminoids 268
 fermentation (see bacteria) 191, 223, 224
 fibrin 35, 252
 fibrinogen 252
 fibrinoplastin 252
 fibrinous blocks in spleen 324
 exudation 102
 inflammation of serous sur-
 faces 352
 necrosis 35, 36
 fibroblastic cells in organization 255
 cells in arteritis 295
 fibroblasts 85
 in granulations 108, 109
 fibroid induration of heart 277
 induration of liver 496 sqq
 fibroid induration of lung (see cirrhosis)
 induration of lymphatic glands
 341
 induration of pancreas 515
 induration of spleen 321
 induration of stomach 445
 uterine 142, 153
 fibroma 142
 molluscum 399, 670
 fibromyoma 153
 fibroneuroma 504
 fibroplastic degeneration 135
 fibrosarcoma 157, 160
 fibrous hyperplasia of brain and cord
 (see sclerosis)
 hyperplasia of liver 496 sqq
 hyperplasia of lymphatic glands
 341
 hyperplasia of mucous mem-
 branes 422
 hyperplasia of stomach 456
 tissue, growth of 85
 tissue, regeneration of 85
 filaria in blood 265, 395
 in kidney 557
 medinensis 234
 sanguinis hominis 235
 filobacteria 186
 fissura abdominalis 9
 vesicæ 519
 fistula colli congenita 8
 in ano 471
 salivary 448
 fixed tissue-cells in cicatrization 111
 flagellata 250
 flea 226
 Flechsig's zones 625
 floating kidney 517
 liver 482
 flukes 236
 foetal atelectasis 591
 cysts of kidney 551
 inclusions 358
 foetus papyraceus 13
 follicular ulceration 442
 ulcers 470
 folliculitis barbæ 405
 fomites 202
 foot-and-mouth disease 433
 foramen ovale 270
 foreign bodies in lymphatic glands 334,
 335
 bodies in trachea 577
 substances, re-absorption of
 113, 114, 115
 fowl-cholera 202, 204
 freckles 362, 398
 Friedreich's disease (hereditary tabes)
 648
 frontal lobe 624
 fungi, classification of 212
 in stomach 453
 fungous tumor 137
 fungus-disease of India 222
 funiculus gracilis 626

(The numbers refer to the articles.)

- funiculus cuneatus 626
 fur of the tongue 221, 433, 437
 furfuraceous desquamation 373
 furrows of brain 624 sqq
 furunculi 405
 fusiform aneurysm 301
- gad-flies 226
 gall-bladder, anomalies of 482
 dropsy of 511
 inflammation of 512
 gall-stones 508
 ganglion-cells of cord 626
 ganglia of nerves 666
 gangrene, dry 41
 hospital 390
 moist 42
 of lung 598, 603
 gangrenous bed-sores 390
 emphysema 42
 inflammation 426, 445
 gastradenitis 459
 gastric polypi 455 (see stomach)
 ulcer 459
 gastritis 456
 gastromalacia 453
 gastrochisis 9
gattine 204
 gelatinous cancer of stomach 462
 infiltration of lung 617
 degeneration 639, 650
 gemmation in cells 76
 in yeasts 223
 genesis of tumors 177 sqq
 germ-theory, evidence for 203
 giant-celled cancer 173
 giant-cells 76
 in granulations 108
 in tubercle 119
 in syphilis 128
 glanders 133
 larynx 574
 lung 618
 mucous membrane 430, 568
 glanders-bacilli 618
 gleet 564
 gliacoccus 185
 glioma 145, 662
 gliomyxoma 663
 gliosarcoma 663
 glomeruli, development of 516
 functions of 520
 glomerulo-nephritis 540, 545
 glossitis 434
 glossocele 437
 glosso-labio-pharyngeal paralysis 659
 glossophytia 437
 glottis, œdema of 571
 tumors of 575
 Gluge's corpuscles 112
 glycerine on kidney 530
 glycocholic acid 481
 glycogen 481
 glycogenous degeneration of kidney 535
 goitre 621 sqq
- Goll, columns of 626
 gonococcus 564
 gonorrhœa 204, 564
 gonorrhœal endocarditis 281
 gout, deposits in 66
 lead-poisoning and 526
 kidney in 526, 531, 535
goutte militaire 564
 granular casts 533
 (cirrhotic) kidney 526, 547 sqq
 (cirrhotic) liver 497 sqq
 ependymal sclerosis 650
 laryngitis 570
 granulation-tissue 105
 growth of 108
 granule-carrying cells 51
 granuloma 117
 granulomata, infective 117 sqq
 gravel 531, 560
 Graves' disease 623 a
 gregarinosis pulmonum 620
 gray degeneration 639, 650
 gray induration of lung 592
 grayness of hair 365
 grinder's asthma or rot 600
 grutum 364, 404
 Guinea-worm 234
 gum-boil 434, 440
 gumma 129
 gummata of brain 661
 of heart 285
 of liver 499, 500
 of lung 607
 of spleen 327
 of throat 444
 of vessels 295
 gummatus hepatitis 500
 node 130
 pneumonia 607
 ulcer 391
 gynœcophoric canal 239
 gyri of cerebrum 624 sqq
- hæmatemesis 26
 hæmatidrosis 361
 hæmatin 68
 hæmatoblasts 35, 252, 261, 263
 hæmatocele 26
 hæmatogenous nephritis 538 sqq
 hæmatoidin 68, 268
 hæmatoma 26, 306, 361
 arterial 308
 of dura mater 664
 of pancreas 513
 hæmatometra 26
 hæmatopota pluvialis 226
 hæmaturia 26
 endemic 239
 from filariæ 235
 hæmoglobin 68
 infarction of kidney 530
 proportion in blood 258,
 261
 proportion in blood after
 removal of spleen 318

(The numbers refer to the articles.)

- hæmoglobinuria, after hæmorrhage 349, 520, 530
 epidemic 262
 experimental 520
 intermittent 262, 268
 paroxysmal 262, 530
- hæmopericardium 26
- hæmophilia 28
 hypoplasia in 272
 neonatorum 28, 204
- hæmoptoë or hæmoptysis 26, 590, 613
- hæmorrhage 26
 aneurysmal 304
 by rupture (apoplexy) 27
 from mucous membranes 416
 from serous membranes 349
 of brain 636
 of lung 589
 of pancreas 513
 of dura mater 664
 of stomach 458, 460
 of thyroid 623
 of thymus 623 b
- hæmorrhages of skin 361
- hæmorrhagic diathesis 28
 erosion of stomach 458
 exudation 102
 infarct 26
 infarct of kidney 527
 infarct of lung 589
 infarct of spleen 324
 infiltration of kidney 530
 infiltration of liver 484
 infiltration of lung 589
 inflammation of serous membranes 352
 nephritis 544
 softening of brain 642
- hæmorrhoids 149, 306
- hæmothorax 26
- hair, disorders of 407, 408
- hair-balls 479
- hairy men 408
- hairy tongue 437
- 'hard sore' 128
- hare-lip 8
- Haubenstrahlung* 627
- hay-bacilli, transmutation of (see bacillus subtilis) 211
- head of tape-worm 240
- heart, abnormalities of 270 sqq
 aneurysm of 289
 atrophy of 273
 degeneration of 273 sqq
 development of 270
 dilatation of 278 sqq
 hypertrophy of 278 sqq
 hypoplasia of 272
 inflammations of 280 sqq
 malformations of 270 sqq
 misplaced 272
 parasites of 285
 rupture of 274, 277
- heart, sclerosis of 277
 size of 272, 278
 tumors of 285
- heat, effect of, on skin 381
 effect of, on blood 262
- hemianopsia 625, 641
- hemicephalus 7
- Henle's loops 520
- hepar mobile 482
- hepatic abscess 493, 494, 495
 artery, closure of 484
- hepatization of lung 597, 602
- hepatitis 493 sqq
 artificial 498
 biliary 498, 512
 gummatous 500
 indurative 496 sqq
 purulent 493 sqq
 sequestrans 498
 syphilitic 499, 500
 tuberculous 501
- heredity of phthisis 612
- hereditary tabes dorsalis 648
- hernia 464, 465
 cerebri 7, 631
 funis 9
- hernial aneurysm 302, 303
- herpes circinatus 367, 383
 iris 367, 383
 simplex, labialis etc. 383
 tonsurans 383, 411
 zoster 371, 383
- heterologous tumor 138
- heteroplasia 83
- heteroplastic tumor 138
- hide-bound condition 396
- high tension of arteries in apoplexy 636
- hirsuties 408
- histioid tumor 138
- histology of brain and cord 639
- hob-nailed liver 497, 498
- Hodgkin's disease 328, 344
- homoeoplastic tumor 138
- homologous tumor 138
- horns of gray matter in cord 626
- horns of the skin 394
- horse-shoe kidney 517
- hospital gangrene 390
- Hunterian chancre 391
- hyaline casts 523, 533
 change of heart 276
 change of lymphatic glands 332
 change of vessels 288
 change of vessels in brain 642
 degeneration 63
 necrosis 35, 36
- 'hyalin-fibrous' degeneration 63
- hydatid cyst 245, 248
- hydatids 240, 245
 of brain 663
 of heart 285
 of liver 507
 of lung 620
 of serous membranes 358
- hydræmia 258

(The numbers refer to the articles.)

- hydræmic plethora 25
 hydrobilirubin 68
 hydrocele colli 8
 hydrocephalus 631, 637
 (causing acrania) 7, 630
 chronic 652
 hydrencephalocoele 7, 631
 hydromyelia 632, 637
 hydronephrosis 518, 552
 hydropericardium 350
 hydrophobia, encephalitis in 659
 hydrops 23
 hydrorachis 7, 632
 hydrothorax 350
 chylous 31
 hygroma, cystic 438, 439
 of dura mater 664
 hypalbuminosis 258
 hyperæmia 19
 appearances of 20
 collateral 21
 idiopathic 21
 of kidney 522
 of liver 483
 of lung 586
 of mucous membranes 415
 passive 21
 of serous membranes 349
 of skin 360
 of spleen 319, 323
 hyperinosis 258
 hyperostosis 147
 hyperplasia, cell-processes in 72 sqq
 of bronchi 581
 of heart 278
 of liver 492
 of lymphatic glands 341
 of mucous membrane 418
 of skin 393
 of spleen 328
 of vessels 289
 hypertrichosis 408
 hypertrophic bronchiectasis 582
 cirrhosis of liver 498
 hypertrophy, congenital 18
 cell-processes in 72 sqq
 numerical 72
 simple 72
 of bladder 563
 of heart 278, 279
 of kidney 522
 of liver 492
 of stomach 455
 of tongue 437
 of vessels 289
 hyphæ 213
 hyphomycetes 212 sqq
 in skin 409
 in stomach 453
 hypophysis cerebri 665
 hypoplasia of heart 272
 of spleen 321
 of vessels 286
 hypospadias 519
 hypostasis 21
 hypostatic engorgement of lung 586
 pneumonia 589
 ichthyosis 397
 sebacea 403
 icterus 69, 259, 471, 498, 512 (see jaundice)
 gravis 490
 gravis kidney in 535
 neonatorum 69, 530
 idiocy 634
 idiopathic anæmia 258, 261
 skin-diseases 359
 ileitis 471
 imperforate anus 464
 impetigo 385
 impurities in blood 263 sqq
 inhaled 600
 incarcerated hernia 466
 inclusio fœtalis 13
 incompetence of the ostia venosa 270, 283
 incrustation 64
 indigo calculus 532
 indigo-carmin, excretion of 520
 indirect cell-division 74
 induced thrombus 253
 indurated chancre 391
induration ardoise 614
 induration of heart 277, 284 (see fibroid)
 of kidney 526, 539, 547 sqq
 of lung 587, 592
 of lymphatic glands 337, 340
 indurative hepatitis 496 sqq
 pancreatitis 515
 peribronchitis 581
 infantile paralysis 659
 infarct 26, 30
 infarction, embolic 37
 of kidney 527, 528
 of lung 589
 of spleen 324
 infective diseases, classification of 202
 diseases, organisms in 203
 granulomata 117 sqq
 granulomata of mucous membrane 428 sqq
 infectiveness, marks of 117
 infiltrating tumor 137
 infiltration with salts 64
 inflammation 93 sqq
 altered blood-current in 96
 attraction theory 94
 causes of 98
 definition of 93
 diapedesis in 96
 dilated vessels in 96
 exudation in 96
 later stages of 104 sqq
 migration of blood-cells in 96
 necrosis after 100
 neuropathic theories of 94

(The numbers refer to the articles.)

- inflammation, recovery after 104
 repair after 98
 stasis in 96
 symptoms of 93
 temperature in 97
 terminology of 101
 textural changes in 99,
 103
 varieties of 101
 vascular changes in 95, 96
- inflammations of gall-bladder 512
 of brain 652 sqq
 of cord 652 sqq
 of heart 280 sqq
 of intestine 470, 471, 472
 of kidney 538 sqq
 of liver 493 sqq
 of lung 596 sqq
 of lymphatics 314
 of meninges 652 sqq
 of mouth 433
 of mucous membranes
 419 sqq
 of nerves 669
 of œsophagus 450
 of pancreas 515
 of serous membranes
 351 sqq
 of skin 366 sqq
 of spleen 320
 of stomach 456
 of throat 442 sqq
 of vessels 290
- inflammatory infiltration 101
 œdema 102
 œdema of brain 637
 œdema of kidney 541
 stimulus 99
 tissue 105
- infundibulum of kidney 520
 of lung 584
- infusoria 250
- inguinal hernia 465
- inhalation-diseases 600
- inhalation in phthisis 612
- initial sclerosis of syphilis 391
- injuries of liver 482
 of spleen 320, 326
 of vessels 256
- inoculation in anthrax 201
 in fowl-cholera 201
 in septicæmia 196, 201
- insane brain 634
- insecta 226
- intention, first 110
 second 110
- inter-brain 627
- intermedio-lateral tract 626
- internal capsule 625
 hernia 467
- interstitial hepatitis 496 sqq
 inflammation 101
 nephritis 526, 542
- intestinal calculi 479
 diverticula 9
- intestinal mycosis 206, 477
 obstruction 467
- intestine 463 sqq
 anomalies of 464
 cancer of 478
 concretions of 479
 hernia of 465, 466
 inflammations of 470 sqq
 mycosis of 477
 parasites of 479
 syphilis of 476
 tuberculosis of 475
 tumors of 478
- intima in thrombosis 253
- intraparietal furrow 624
- intussusception 469
- inversio vesicæ 9, 519
- iron-compounds in blood 268
 in liver 481
 in lymphatic glands
 334
 in spleen 318
- iron in morbid pigmentation 68
- Irritabilität* 78
- ischæmia 21
- ischæmic softening of brain 642, 658
- ischiatric hernia 465
- ischtopagus 12
- island of Reil 624
- itch, barber's 411
 common 413
- itch-insect 225
- ixodes ricinus 225
- janiceps 12
- jaundice 69, 259, 362, 512
 catarrhal 471
 from cirrhosis 498
 malignant 490
- kakke 669
- karyokinetic cell-division 74
- karyolytic figures 75
- keloid 399
 Addison's 399
 cicatricial 399
- keratoma 397
- kidney, argyrosis of 530
 atrophy of 525
 biliary infiltration of 530
 calcareous deposits in 532
 degenerations of 534 sqq
 deposits in 529 sqq
 development of 516
 disorders of 521 sqq
 embolism of 527, 528
 fatty 536, 545
 gouty 535
 granular 526, 547 sqq
 hæmoglobin infarction of 530
 hæmorrhagic infiltration of 530
 hyperæmia of 522, 523
 in diabetes 535
 inflammations of 538 sqq
 leukæmic infiltration of 530

(The numbers refer to the articles.)

- kidney, malformations of 516 sqq
 mottled 545
 necrosis of 535
 parasites of 557
 pigmentary infiltration of 530
 structure of 520
 surgical 554
 syphilis of 550
 tuberculosis of 549
 tumors of 556
 uratic infiltration of 531
 uric acid in 531
 white 545
- labyrinth of kidney 520
 Laennec's cirrhosis 498
 lateral sclerosis 647
 lardaceous degeneration (see amyloid)
 57
 kidney 537
 liver 491
 spleen 325
- large-celled hyperplasia of lymphatic
 glands 340
 large kidney 545
 laryngeal phthisis 573
 laryngitis 570, 571, 572, 573
 larynx 569 sqq
 malformations of 569
 stricture of 569
- lateral sclerosis 647
 lathyrism 648, 659
 lead, action on kidney 526
 action on nervous system 641, 667
- leaf-rust 220
 leiomyoma 153
 lenticular nucleus 625, 626
 syphilide 379
- lentigo 362, 398
 leptomeningitis 652
 leprosy 392
 anæsthetic 659, 669
 bacillus of 131, 206
 Lombardian 367 *
 of larynx 574
 of mucous membrane 430
- leptothrix 186
 leptus autumnalis 225
 leucin in acute atrophy of liver 489, 490
 in blood 259
- leucocytes, diapedesis of 96
 dissolve in infective dis-
 eases 201
 in granulations 108
 migration of 96, 99, 108
 peripheral disposition of 96
- leucocythæmia 260
 leucocytosis 260
 leukæmia 52, 260, 328, 343, 344
 leukæmic hyperplasia of spleen 328
 infiltration of kidney 530
 infiltration of liver 480
 infiltration of lung 599
- leukoderma 365
 leukomyelitis 659
- leukopathia 365
 leukoplakia 437
 Leyden's crystals 579
 lice 226
 lichen 406
 hæmorrhagicus 361
 pilaris 397
 syphiliticus 379
 urticatus 367
- lichenes 212
 lienal leukæmia 260, 328
 ligature, thrombosis from 255
 ligula nodosa 249
 lineæ albicantes 364
 lingual psoriasis 437
 lipæmia 259
 lipofibroma 144
 lipoma 144
 of mouth 438
 of skin 401
- lipomatosis 50
 of heart 279
 of liver 478
 of pancreas 514
- lipomyxoma 144
 liquefaction, after necrosis 40
 lithopædium 6, 64
 Littre's hernia 465
 livedo 360
 liver Sect. VIII. (Part II.)
 acute atrophy of 204
 amyloid 491
 anomalies of 482
 atrophy of 485 sqq
 cavernous tumor of 150
 degeneration of 488 sqq
 disorders of circulation in 483 sqq
 enlargement of 492
 floating 482
 gumma of 499, 500
 hydatid of 507
 hypertrophy of 492
 inflammations of 493 sqq
 leukæmic infiltration of 480
 metabolism in 481
 parasites of 507
 pigmentation of 480
 structure of 480
 syphilis of 499, 500
 tuberculosis of 501
 tumors of 502 sqq
 wounds of 482
- liver-fluke 237
 livor 360
 livores 21
 lobules of lung 584
 locomotor ataxy 647
 Lombardian leprosy 367
 loops of Henle 520
 lung, apoplexy of 586
 atelectasis of 591 sqq
 cirrhosis of 592
 collapse of 591
 congestion of 586
 degeneration of 595 sqq

(The numbers refer to the articles.)

- lung, disorders of 585, 586 sqq
 emphysema of 593, 594
 hæmorrhages of 586
 hyperæmia of 586
 infarction of 589
 inflammation of 596 sqq
 œdema of 588
 parasites of 618, 620
 structure of 584 sqq
 syphilis of 609, 618
 tuberculosis of 606, 612 sqq
 tumors of 619
- lupus 132
 erythematosus 380
 larynx 574
 of mouth 435
 mucous membrane 430
 nose 567
 skin 392
 throat 446
- lymph, changes in 269
 functions of 251, 269
 transudation of 23
- lymphadenitis 336 sqq
 lymphadenoma 155, 344, 345
 lymphangiectasis 315, 396
 lymphangioma 152, 316, 438, 504
 lymphangitis 314
 in phthisis 613
 with chancreoid 391
- lymphatic glands Sect. III. (Part II.)
 glands degenerations 330
 sqq
 glands, inflammations of 336
 sqq
 glands in leukæmia 260
 glands, tubercle in 122
 glands, tumors of 343 sqq
- lymphatics in brain-disease 269
 in œdema 24
 morbid changes in 313 sqq
 of lung 584
 radicles of 269
- lymphoma 155, 338, 343
 malignant 260, 343, 344
- lymphorrhagia 31, 315, 396
 lymphorrhœa 152
 lymphsarcoma 155, 158, 344, 345
 lymph-spaces of brain 628
 lyssa 659
- macrocheilia 315, 437
 macrocytes 261
 macroglossia 315, 437
 madura-foot 222
 maggots 226
 in nose 568
- maggot-worm 229
- malaria (see bacillus malarie) 206
 melanæmia in 262
 nephritis in 442
 spleen-changes in 321
- malformations, artificially produced 3, 5
 congenital Sect. I. (Part I.)
- malformations fissural 7, 8, 9
 of the brain 630 sqq
 of the cord 632
 of the heart 270 sqq
 of the lung 585
 of the nose 567
 of the organs 11
 of the thyroid 621
 of the trachea 577
 of the urinary organs
 516 sqq
 of the vessels 286
 origin of 2, 3, 12
- malignancy 140
- malignant adenoma (see adenocarcinoma)
 œdema 188, 204, 206
 pustule, 390
- malpighian bodies of kidney 516
 follicles, new-formed 318
 follicles of spleen 317
 pyramids of kidney 520
- malposition of the organs 11
- mal rosso (del sole) 367
- malum senile arteriarum 299
- marasmic thrombosis 253
- margaric acid 54
- margarin-crystals 54
- marginal convolution 624
 sclerosis of cord 651
- marrow in leukæmia 260
- mason's lung 611
- matter or pus 102, 108
- maw-worm 228
- measle of brain 663
 of pork 242, 243
- measles 367
- meat-poisoning 206, 477
- Meckel's diverticulum 9, 464, 465
- mediastinal tumors 358
- medulla oblongata 627
- medullary cancer 173
 cancer of stomach 462
 leukæmia 260
 rays of kidney 520
 sheath of nerves 666
- melæna neonatorum 458
- melanæmia 262
- melanin 67
- melanocarcinoma 173
- melanoma 162
- melanosarcoma 162
 of liver 504
- melasma suprarenale 565
- membranaceous desquamation 373
- membranes of brain and cord 628
- membranous croup 570
- meninges, structure of 628
- meningeal dropsy *ex vacuo* 637
 tumors 663
- meningitis 204
 chronic 655, 656
 purulent 653
 serous 652
 tuberculous 660

(The numbers refer to the articles.)

- meningocele 7, 631, 632
 meningoencephalitis 656
 meningomyelitis 656
 mentagra, acne 405
 mental disorders 629
 merulius lacrimans 220
 mesarteritis 293
 mesencephalon 630
 mesoblastic tumor 138, 142 sqq
 mesobronchitis 581
 mesonephron 517
 mesophlebitis 293
 metamorphosis (see degeneration)
 metaplasia 90
 metastases in cancer 174
 metencephalon 630
 methæmoglobin 259
 methæmoglobinuria 530
 metritis 204
 metrorrhagia 26
 miasmatic disease 202
 miasmo-contagious disease 202
 micrencephalia 633
 microbacteria 183, 185, 205
 microbrachius 10
 microcephalia 633
 micrococci in acute yellow atrophy 490
 (see bacteria)
 in arteritis 291
 in diphtheria 444
 in dysentery 472
 in endocarditis 281
 in erysipelas 375
 in gangrene of skin 390
 in hepatic abscess 493, 494
 in lupus 132
 in lymphatics 269
 pathogenous 204
 in plebitis 291
 in purulent effusion 354
 in small-pox 388
 in softening of thrombi 254
 in syphilis 391
 micrococcus 184
 cyaneus 191
 diphtheriticus 185
 erysipelatis 204, 375
 luteus 184, 191, 195
 prodigiosus 191, 211
 septicus 185, 199, 204
 variola 204
 microcytes 261
 microcythæmia 261
 microgyria 633
 micromelus 10
 micromyelia 633
 microparasitic theory of contagium 203
 micropus 10
 microsporina 185
 microsporon furfur 222, 412
 Miescher's cylinders 250
 migration of leucocytes 96, 99, 108
 mikrosomia 6
 mildew (vine) 220
 miliaria crystallina 382
 miliary aneurysms 303, 636
 syphilide 379
 tubercle 118
 tumors 137
 milium 364, 404
 of mouth 439
 milk-spot of pericardium 352
 miner's lung 70, 600
 mitral stenosis 283
 mixed cancerous tumors 176
 connective-tissue tumors 164 sqq
 mole, congenital 179
 fleshy 6
 hydatidiform 6
 moles 362, 398
 sarcoma in 401
 molluscum bodies 400
 contagiosum 400
 elephantoid 399
 fibroma 142
 monadina 185
 monads in intestine 479
 in lung 620
 monas hæmorrhagicum 204
 lens 620
 monobrachius 10
 monopus 10
 monsters, double 1, 5, 12 sqq
 double, origin of 5, 12
 single 1, 6 sqq
 monstrosities by defect 3
 by perversion 4
 morbilli 367
 morbus Brightii 539
 maculosus Werlhofii 361
 morels (mushrooms) on blood 262
 (mushrooms) on kidney 530
 mortification (see gangrene)
 mosquitoes 226
 hosts of filaria 235
 mother's marks 398
 motor centres of cerebrum 625
 mottled kidney 545
 mould-fungi 212 sqq
 in invertebrates 222
 in lung 620
 in moist gangrene 42
 mutability of 219
 pathology of 221
 reproduction of 218
 mouth 433 sqq
 movable kidney 517
 mucoid change of heart 276
 degeneration 55
 mucor mucedo 215, 221
 mucedo, mutability of 219
 racemosus 219
 mucous cysts 422
 membranes Sect. VI. (Part II.)
 membranes, atrophy of 417
 membranes, degeneration of 417
 membranes, hæmorrhage from 416
 membranes, hyperæmia of 415

(The numbers refer to the articles.)

- mucous membranes, hyperplasia of 418
 membranes, hypertrophy 418
 membranes, inflammations of
 419 sqq
 membranes, structure and
 functions of 414
 membranes, tubercle of 124,
 428
 patch 129, 379
 tissue, growth of 85
 mucus-corpuscles 414
 muguet 436
 Müllerian duct 516, 518
 multiple neuritis, 667
 sclerosis 649, 650
 multiplication of cells, causes of 80, 81
 mummification 41
 mumps 447
 muscle, growth of 89
 regeneration of 89
 mutability of bacteria 208 sqq
 mycelium 213
 mycetoma 222
 mycoderma 223
 vini 436
 mycomycetes 212
 mycoprotein 183, 184
 mycosis, intestinal 206
 of lungs 221
 microsporina 412
 myeline 666, 667
 myelitis, purulent 654, 659
 transverse 659
 myelogenic leukaemia 260
 myelomalacia 643
 myelomeningocele 632
 myeloid cancer 173
 sarcoma 159
 myocarditis 280 sqq
 myoma 153
 myomalacia cordis 277
 mysarcoma 153
 myxoma 143
 of skin 401
 myxoedema 623 a
 myxofibroma 143
 myxolipoma 143
 myxomycetes 212
 myxosarcoma 163

 nævi 149
 nævus pigmentosus 362, 398
 nails, disorders of 407, 408
 nanosomia 6
 nasal cavities, disorders of 567
 polypi 568
 neck of hernial sac 465
 necrobiosis of vessels 288
 necrogenic warts 390
 necrosis 32 sqq
 after inflammation 100
 anæmic 33, 40
 coagulative 35, 56
 colliquative 40
 of lymphatic glands 333, 337
 necrosis of mucous membrane 417, 426
 of pharynx 450
 of skin 389
 of vessels 288, 291
 necrosis mycotica typhosa 572
 necrotic inflammation 103
 nematoda 227 sqq
 nephritis 538 sqq
 nephrolithiasis 532
 nerves, atrophy of 667
 inflammations of 669
 regeneration of 668
 severed 668
 structure of 666
 tumors of 370
 nerve-tissue, growth of 89
 regeneration of 89, 668
 nervous disease, causes of 629
 neurofibroma 399, 670
 neuritis 667, 669
 migrans 669
 neuroglia, growth of 85
 structure of 625, 626, 639
 neuro-keratin 639
 neuroma 154, 670
 neuromata, amputational 154, 668
 false 399
 ganglionic 670
 medullary 633
 papillary 399
 neuropathic papilloma 397
 theories of inflammation 94
 neurotization 668
 new blood-vessels, growth of 86
 blood-vessels in granulations 109
 'nightingale' (two-headed) 14
 nitrite of amylo on blood 262
 nitrobenzol on blood 262
 node, syphilitic 130
 of Ranvier 666
 nodular tumor 137
 noma 434
 non-pathogenous bacteria 197
 nose, disorders of 567, 568
 nosema bombycis 204
 nuclear figures 74, 75
 nucleated red corpuscles 260, 261
 nucleolus (nuclear or nucleolar corpus-
 cle) 74
 nucleus-division 74
 nucleus, structure of 74
 nuclei of cerebrum 625
 of cranial nerves 627
 of medulla 627
 nutmeg-liver 483, 487

 obesity 50
 of heart 279
 obliterating thrombus 253
 obturator hernia 465
 occipital furrow 624
 occlusion of lymphatics 315
 of vessels 307
 of vessels in liver 484
 odontoma 441

(The numbers refer to the articles.)

- œdema 23
 cachectic 25
 hydræmic 25
 inflammatory 25, 102
 malignant 206
 purulent 102
 varieties of 24
 of brain 637, 652
 of glottis 571
 of lung 587, 588
 of skin 360
 œdema-bacilli 206
 transmutation of 211
 œsophagus 449 sqq
 œstrida 226
 oïdium 214, 220, 222
 albicans 436
 identical with mycoderma 224
 oil-drops in fatty degeneration 51
 oligæmia 21, 258
 oligocythæmia 258, 261
 olivary nuclei 627
 omentum, hernia of 465 sqq
 tuberculosis of 356
 omphalopagi 12
 odontoma 147
 onychogryphosis 222, 408
 favosa 410
 tonsurans 411
 oogonium 218
 oosphere 218
 oospore 218
 optic thalamus 627
 'organization' 86
 of thrombi 255
 organoid tumor 138
 osteoblasts 88
 osteoclasts 115
 osteoid chondroma 165
 osteoma 147
 dental 441
 osteophyte 147
 osteosarcoma 165
 ostia, defects at 270
 ovigenous organ in tænia 241
 oxalic acid calculi 532, 560
 oxyuris vermicularis 229, 479
 ozæna 567

 pacchionian bodies 628
 pachydermatocele 399, 670
 pachydermia 395
 pachymeningitis 664
 packing-cells 216
 palate, soft 442
 panaritium 390
 pancreas 513 sqq
 panneuritis epidemica 669
 panophthalmitis causing meningitis 653
 papillæ of kidney 520
 papilloma 137
 of bronchi 582
 of larynx 575
 of mucous membrane 422,
 446
 papilloma of stomach 455, 456
 papillomata, inflammatory 394
 neuropathic 397
 papulæ 366
 papular syphilide 379
 paracentral lobule 624
 paraglobulin 252
 parallel furrow 624
 paralysis of the insane (paralytic de-
 mentia) 648, 656, 657
 paramœcium coli 250, 479
 parasites Sect. VII. (Part I.)
 animal 225 sqq
 in blood 265
 vegetable 183 sqq
 of heart 285
 of intestine 479
 of kidney 557
 of larynx 575
 of lung 620
 of liver 507
 of mouth 436
 of skin 400 sqq
 parasitic twin 13
 parchment skin 364
 parenchymatous inflammation 101
 nephritis 539, 544 sqq
 parietal lobe 624
 thrombus 253
 paronychia 390, 408
 parostoses 147
 parotitis, epidemic 447
 paroxysmal hæmoglobinuria 262, 530
 parulis 434, 440
 Pasteur's septicæmia 188, 204, 206
 pathogenous bacteria 195, 196, 198, 210
 sqq
 pearls, epidermal 172, 398, 663
 pearly disease (bovine) 127, 206
 tumor 161, 663

 pébrine 204
 pediculi 226
 peliosis rheumatica 361
 pellagra 367, 648
 pelvis of kidney 520
 pemphigus 384
 syphiliticus 386
 penicillium glaucum 217
 pentastoma constrictum 225
 denticulatum 225
 denticulatum in kidney
 557
 denticulatum in lung 620
 in liver 507
 in spleen 329
 in tæniodes 225
 perforating ulcer of stomach 459
 ulcer of duodenum 471
 perforation of intestine 468
 of œsophagus 449, 451
 of stomach 460
 of trachea 577
 of valves 282
 periarteritis 293
 causing aneurysm 302

The numbers refer to the articles.)

- peribronchitis 581
 pericarditis 352, 353, 354
 tuberculous 357
 pericardium, development of 348
 perichondritis, laryngeal 576
 pericystitis 561
 periencephalitis, chronic 656
 perihepatitis, syphilitic 500
 perilymphangitis 314
 perineal hernia 465
 perinephritic abscess 543, 554
 perineurium 666
 periostitis, infective 204
 peripheral disposition of leucocytes 96
 nerves in tabes dorsalis 648
 nervous system Sect. XII.
 (Part II.)
 periphlebitis 293
 periproctitis 471
 perisplenitis 321
 perithecium 216
 peritoneal absorption 349
 fascia of hernia 465
 peritoneum, development of 348
 peritonitis 352, 353, 354
 deformans 353, 454
 tuberculous 357
 perityphlitis 471
 perniones 367, 389
 perobranchius 10
 perochirus 10
 perodactylus 10, 18
 peromelus 10
 peronospora infestans 220
 petalobacterium 185
 petalococcus 185
 petechiæ 26, 361
 petrification 64
 Peyer's patches 346
 patches in typhoid 474
 pharyngitis 442
 pharyngocele 449
 pharynx 449 sqq
 phlebitis 291, 293
 phleboliths 254, 306
 phlegmon laryngis 571
 phlegmonous inflammation of larynx
 571
 inflammation of mucous
 membranes 427
 inflammation of nose 567
 inflammation of œsoph-
 agus 450
 inflammation of skin 390
 inflammation of stomach
 457
 inflammation of throat
 445
 phlyctænoses 368
 phocomelus 10
 phosphatic calculi 533, 560
 phosphorus, causing fatty change 52
 poisoning 434, 490
 phthisical sputum, inhalation of 601
 phthisis, bacilli in sputum of 206
 phthisis, minute aneurysms in 303, 304
 pulmonary 614
 tuberculous pleurisy in 356,
 357, 613
 tuberculous 612, 613, 614,
 615
 phycomyces 215
 phycomyces 212
 pia mater 628
 mater pigmentation of 638
 pigment in blood 265 sqq
 in brown atrophy 273
 in lymphatic glands 334, 335
 pigmentary atrophy 45
 atrophy of liver 486
 infiltration of kidney 530
 infiltration of liver 480
 induration of stomach 456
 pigmentation of skin 362
 pigments, hæmatogenous 68
 normal 67
 pigment-spots, congenital 179
 piles 149, 306
 pineal body 665
 pits of small-pox 374, 387
 pituitary body 665
 pityriasis 222
 rosea 412
 rubra 374, 377
 tabescentium 364, 403
 versicolor 412
 plagues 203
 plaques opalines 435, 437
 plastic bronchitis 579
 pleomorphism in fungi 218
 plethora 258
 pleura, development of 348
 pleurisy 353, 353, 354
 tuberculous 357
 pleuro-pneumonia of cattle 605, 608
 plexiform neurofibroma 670
 angiosarcoma 161
 pneumonia, catarrhal 204
 croupous 204, 602
 croupous micrococci in 602
 dissecting 608
 forms of 602 sqq
 hypostatic 589
 nephritis in 542
 pleurogenous 599, 608
 pneumococcus 602
 pneumoconiosis 600
 pneumonocystis 620
 pneumothorax 609, 616
 poikilocytosis 261
 poliœncephalitis, acute 659
 poliomyelitis anterior 640, 659
 poliosis 365
 pollinodium 216
 polyæmia 258
 polymelia 15
 polymorphism in fungi 212, 218
 polyneuritis 669
 polyposis ventriculi 456
 polypous growths of intestine 470, 478

(The numbers refer to the articles.)

- polypous growths of mucous mem-
 brane 418
 growths of larynx 575
 growths of nose 568
 growths of stomach 455, 456
 tumor 137
 polypus of heart 253, 277
 of larynx 575
 of nose 568
 polytrichia 408
 polyuria in nephritis 539
 pons Varolii 627
 popliteal aneurysm 303
 porencephalia (porencephalus) 630
 porridge decalvans 407
 portal system of kidney 520
 vein, closure of 484
 vein, engorgement of 497
 post-mortem clots 253
 mortem staining 21
 potassium chlorate on blood 262
 chlorate on kidney 530
 potato-disease 220
 præcentral furrow 624
 præcuneus 624
 primary sclerosis of cord 647, 648
 thrombus 253
 primordial kidneys 516
 proctitis 471
 proglottis 240
 progressive paralysis of the insane 648,
 656
 projective system of brain 625
 prolapse 464
 of bladder 563
 of bowel (anus) 469
 of the tongue 437
 proliferation, cell-processes in 73
 factors of 80, 81
 proscolices 240
 prosencephalon 630
 prostate, enlarged 564
 prostatic concretions 61
 protection by inoculation 201
 protophyta 223
 protozoa 250
 prurigo 377
 psammoma 662, 663, 664, 665
 pseudo-diphtheritis 424
 pseudoleukæmia 260, 261, 328, 344
 pseudo-parenchyma 216
 psoriasis 376
 syphilitic 379, 435, 437
 psorospermia 250
 in lung 620
 psychological functions of brain 625
 puerperal peritonitis 204
 pulex irritans 226
 penetrans 226
 pulmonary vessels 584
 œdema 588
 puriform softening of thrombi 254
 purpura, blood-changes in 261, 268
 hæmorrhagica 361
 papulosa 361
 rheumatica 361
 scorbutica 361
 senilis 361
 simplex 361
 variolosa 361, 387
 purulent arteritis 291
 catarrh 102, 204, 420
 encephalitis 654
 exudation 102
 hepatitis 493
 meningitis 653
 myelitis 654
 myocarditis 284
 œdema 102
 phlebitis 291
 pus, origin of 99, 102, 107, 108, 112
 pustulæ 368, 372
 pustulation 372, 388
 pustule, malignant 390
 putrefaction in moist gangrene 42
 putrefactive diseases 204
 putrid decomposition 191, 192, 197
 exudation 102
 pyæmia 204
 spleen-change in 320, 322
 from thrombosis 291
 pyelitis 553, 554, 555
 micrococci in 204
 pyelonephritis 554
 pygopagus 14
 pylephlebitis 484
 pylorus, stenosis of 453, 454, 460
 pyonephrosis 554
 pyopneumothorax 616
 pyramidal tracts 626
 pyrexia, kidney in 525
 pyrogallic acid on blood 262
 quinine-rash 367
 racemose aneurysm 289, 301
 Rainey's corpuscles 250
 ranula 439, 448
 pancreatic 514
 rash from medicaments 367
 from specific fevers 357
 ray-fungus 436
 re-absorption 104
 imperfect 112
 recovery after inflammation 104
 rectum, (see intestine)
 syphilitic disease of 476
 red atrophy of liver, acute 489
 atrophy of liver, central 483
 corpuscles, genesis of 261, 318
 corpuscles, destruction of 262, 268,
 318
 corpuscles, nucleated 260, 261
 nucleus 627
 softening of brain 642
 softening of thrombi 254
 regeneration after inflammation 104
 after necrosis 34
 cell-processes in 72 sqq
 of nerves 668

(The numbers refer to the articles)

- regurgitation 279, 283
 Reil, island of 624
 relapsing fever, spirillum of (see spirochæta Obermeyer) 207
 renal calculi 531
 circulation 521
 cirrhosis 539, 547 sqq
 cysts 551
 disease 521 sqq
 disease and cardiac hypertrophy 279
 parasites 557
 syphilis 550
 tuberculosis 549
 tumors 556
 renculi 517
 respiratory organs Sect. x. (Part II.)
 bronchiole 584
 resting-spore 215
 retention, cysts of 71
 reticular induration of lymphatic glands 341
 retroperitoneal hernia 467
 Reverdin's skin-grafting 84
 rhabdomyoma 153
 rhachischisis 630
 rhagades 373
 rheumatic endocarditis 281
 rhinitis 567
 rhinoliths 568
 rhinophyma 400
 rhizopoda 250
 rhythmic contraction of spleen 318
 rice-water stools 473
 rigor caloris in bacteria 189
 frigoris in bacteria 189
 ringworm 222
 common 411
 crusted 410
 rodent ulcer 402
 roestelia cancellata 220
 rolandian fissure 624
 roseola 360, 367
 furfuracea herpeticiformis 412
 rostellum of tænia 241
 'rot' in sheep 237
 round-celled sarcoma 158
 round ulcer of duodenum 471
 ulcer of stomach 459
 round-worm 228
 in kidney 557
 in larynx 575
 rubeola 367
 rupia syphilitica 386, 391
 rupture of blood 563
 of heart 258, 274, 277
 of œsophagus 449
 of spleen 320, 326
 of vessels 308
 (hernia) 465
 saccharomyces 223
 albicans 436
 albicans in nose 568
 sac of hernia 465
 sacculated aneurysm 301
 sago-spleen 57, 325
 saliva, causing septicæmia 204
 salivary calculus 448
 fistula 448
 glands 447, 448
 sanious exudation 102
 saprophytes 221
 in mouth 436
 in lung 620
 sarcina 184, 185, 204
 in lung 620
 sarcoma 156 sqq
 alveolar 161
 myeloid 159
 myxomatodes 163
 peculiar 161
 round-celled 158
 spindle-celled 160
 varieties of 157
 (see tumors) of liver 504
 of lymphatic glands 356
 of mouth 438
 of skin 401
 sarcophagus crystals 533
 sarcoptes 225
 scabies 413
 scabs 373
 scales 373
 scar, syphilitic of liver 499
 scarlatina 367
 laryngitis in 572
 micrococci in 204
 nephritis in 540, 542, 543
 schistomycetes 183 sqq
 schistoprosopia 8
 schizomycetes 183 sqq, 212
 Schneeberg miners' disease of lung 619
 scirrhus cancer 173
 scirrhus of stomach 462
 sclerema neonatorum 396
 scleroderma 396
 sclerosis (fibrous hyperplasia) 82, 111, 129
 marginal 651
 multiple 549, 650
 posterior 647, 648
 primary 647, 648
 secondary 640, 646
 of cord, 646, 647, 649, 650, 651
 of heart 277, 284
 of kidney 526
 of nerve-tissues 639
 of vessels 293, 297
 of vessels causing aneurysm 302
 sclerotium 217
 scolecida 227 sqq
 scolex 242
 scrofula 127
 scrofulous lymphadenitis 339
 pneumonia 618
 ulcer 391
 scurvy 361
 blood-changes in 261

(The numbers refer to the articles.)

- scutula of favus 410
 scybala 471
 seat-worm 229
 sebaceous cysts 404
 disorders 403 sqq
 wart 400
 seborrhœa 403
 secondary thrombus 253
 senile atheroma 299
 atrophy of brain 640
 atrophy of skin 364
 kidney 526
 retrogression 45
 sensory-motor zone 625
 sepsin 191, 197
 septa of the heart, anomalies of 270
 septicæmia, Davaine's 204
 from saliva 204
 of mice 201, 204
 micrococci in 204
 Pasteur's 188, 204, 206
 septic poison 191, 197
 pneumonia 605
 sequestrum 115
 serous catarrh 102
 cavities, development of 348
 cysts 358
 exudation 102
 membranes, Sect. IV. (Part II.)
 membranes, effusion from 330
 membranes, hyperæmia of 349
 membranes, inflammations of 351
 membranes, parasites of 358
 membranes, tuberculosis in 355,
 356
 membranes, tumors of 358
 serpent-venom on blood 262
 sheath of Schwann 666
 shellac-concretion in intestine 479
 shingles 383
 Siamese twins 12
 siderosis 268, 600
 siliquose desquamation 373
 silk-worm-diseases 204
 silver-staining 70
 simple atrophy of liver 485
 cancer 173
 siren-monster 10
 situs transversus (heart) 272
 transversus (inversus) 11
 transversus (liver) 482
 skin, atrophy of 363 sqq
 discoloration of 362
 diseases of Sect. V. (Part II.)
 functions of 359
 hyperæmia of 360
 hyperplasia of 393, 397
 inflammations of 366 sqq
 inflammatory hypertrophy of 393
 sqq
 parasites of 409 sqq
 tumors of 399 sqq
 ulcers of 391
 skin-diseases, classification of 359
 fungi in 222
 skin-grafting 84
 slough 115
 small-pox 361, 372, 374, 387
 laryngitis in 572
 micrococci in 204
 softening 40
 of brain 639, 642
 of heart 277
 of œsophagus 449
 of stomach 453
 of thrombus 254, 257
 soil, anthrax-spores in 206
 bacteria in 193
 somatic death 32
 spasm of œsophagus 449
 'specific inflammations' 117
 nature of tissues 77
 spermatozoid 218
 sphacelus 42
 sphærobacteria 184
 spina bifida 7, 632
 ventosa 135
 spinal cord (see cord), structure of 626
 paralysis, anterior, 659
 spirillum of relapsing fever (see spiro-
 chæta Obermeyer's) 207
 tenuis 187
 undula 187
 volutans 185, 187
 spirobacteria 184, 187, 207
 spirochæta denticola 187
 Obermeyer's 185, 187, 207
 spleen, changes in Sect. III. (Part II.)
 congestion of 319
 degenerations 325
 engorgement of 323
 enlargement of 321, 323, 327 etc
 granulomata of 327
 hyperplasia of 328
 inflammation of 320
 in leukæmia 260, 328, 329
 rupture of 320, 326
 structure and functions 317, 318
 suppuration of 322
 tumors of 329
 splenic abscess 322
 spleniculus 317
 splenization of lung 589
 splenitis 320
 sporangia 214, 215
 sporangiophore 215
 spores of mould-fungi 213
 sporozoa 250
 spurious aneurysm 308
 sputum of pneumonia 602
 of phthisis 613
 squamæ 368
 squamous epithelial cancer 173
 staining, post-mortem 21
 starvation, liver in 485
 stasis (as a cause of necrosis) 33
 steatoma 404
 steatorrhœa 403
 steel-dust in blood 265, 268
 stellate veins of kidney 520

(The numbers refer to the articles.)

- stenosis of the great vessels 271, 279
 of the bronchi 580
 of the intestine 468
 of the larynx 569
 of the œsophagus 449
 of the ostia venosa 270, 282
 of the pylorus 453, 454
 of the trachea 577
- sterigma 216
- sternopagi 12
- St. Gothard tunnel, anchylostoma in 231
- stigmata 27, 97
- stimuli, action of, on cells 79
- stomach, 452 sqq
 anomalies of 454
 cancer of 461
 corrosion of 457
 dilatation of 453, 454
 erosion of 458
 fermentation in 453
 fungi in 221
 hæmorrhage of 458
 hypertrophy and atrophy of 455
 induration of 456
 inflammations of 456, 457
 polypi of 455, 456
 softening of 453
 tumors of 461
 ulcer of 456, 459
- stomata 27, 97
 of serous surfaces 348
- stomatitis 433
- stomoxys calcitrans 226
- stone 560
- storage-fat 53
- strangulation of hernia 466
- streptobacteria 185
- streptococci 185
- stricture of larynx 569
 of œsophagus 449
 of pylorus 453, 454
 of trachea 577
 of urethra 519 (congenital), 564
- strongylus duodenalis 231
 longevaginatus (bronchialis) 231, 620
- struma (goitre) 621
- strumæ lipomatodes 556
 lipomatosæ suprarenales 565
- strumitis 623
- strumous inflammations 204
- subarachnoid 628
- subcutaneous emphysema 593
- subthalamic region 627
- suctorial worms 236
- sudamina 382
- sugillations 26
- sulphindigotate of sodium, excretion of 520
- sulphuretted hydrogen poisoning 259
- sulphuric acid on blood 262
- sun-burn 362
- sun-spots 362
- sun-stroke, anhydræmia in 258
- supernumerary bones and muscles 16
 mammæ 16
- suppurating bubo 337
- suppuration (see pus) 112
 of kidney 543
 of liver 493 sqq
 of lung 598, 603
 of lymphatic glands 337
 of mouth 434
 pancreas 515
 spleen 322
- 'suppuration of the blood' 260
- suppurative nephritis 543
- suprarenals in Addison's disease 392, 565
 disorders of 565
- surgical kidney 554, 561
- suture of nerves 668
- sweat-glands, adenoma of 402
- sycosis nonparasitaria 405
 parasitaria 405, 411
- sylvian fissure 624
- symptomatic anthrax 206
 skin-diseases 359
- sympus 10
- syncephalus 12
- syndactylus 10
- synophthalmia 7, 630
- synotia 8
- syphilides, papular 379, 391
 pustular 386
- syphilis 128 sqq
 micrococci in 206
 of brain 661
 of bronchi 579
 of cord 601
 of intestine 476
 of larynx 574
 of kidney 550
 of mouth 435
 of mucous membranes 429
 of throat 446
 of trachea 578
- syphilitic arteritis 295
 bubo 342, 391
 chancre 391
 enlargement of spleen 327
 hepatitis 499, 500
 laryngitis 574
 origin of tabes dorsalis 648
 pneumonia 607
 teeth 441
 tracheitis 578
- syphiloma of heart 285
 of liver 500
- syringomyelia 637
- systemic degeneration of cord 646, 648
- tabanida 226
- tænia cucumerina 244, 479
 echinococcus 245
 elliptica 244
 malformations of 243, 244

(The numbers refer to the articles.)

- tænia mediocanellata 244, 479
 nana 244, 479
 saginata 244, 479
 solum 241, 479
 tabes dorsalis 647
 tape-worms 240 sqq
 tarichium megaspermum 222
 tartar of teeth 440
 tattooing 70, 334, 362
 taurocholic acid 481
 teeth, changes in 440
 syphilitic 441
 tegmental region 626, 627
 radiations 627
 telæ choroidæ 628
 telangiectasis 152, 305
 temperature, effect on bacteria 189
 effect on moulds 219
 temporal furrows 624
 teratoid tumors 358
 teratoma 13, 178, 179
 textural changes in inflammation 99
 changes in inflammation, varieties of 103
 thalamencephalon 630
 thalamus, optic 627
 thallophytes 212
 thoracic duct, closure of 315, 396
 duct, rupture of 31
 thoracogastroschisis 9
 thoracopagus 13
 parasiticus 13
 thread-worm 229
 throat 442
 thrombophlebitis 254, 291
 thrombosis 29, 252
 cardiac 253
 factors in 253
 from atheroma 300
 in aneurysms 305
 issues of 254, 255
 marasmic 253, 256
 of kidney 523
 of lymphatics 315
 thrombus 252
 calcification of 254
 mottled 252
 organization of 255
 red 252
 softening of 254
 white 252
 'thrush' 224, 433, 436, 449, 479
 thymus gland 623 b
 gland, atrophy of 331
 gland, lymphadenoma of 345
 thyreocele 621
 thyroid gland 621 sqq
 thyroiditis 623
 Tierra del Fuego, natives of 472
 tight-lacing 482
 tinea 222
 favosa 410
 furfuracea 403
 sycosis 411
 25
 tinea tonsurans 411
 versicolor 412
 tipulida 226
 tonsils 442 sqq
 torula 223
 trabecular induration of lymphatic glands 341
 trachea, disorders of 577
 tracheitis 578
 tracheotomy-granulations 578
 tracts of cord, degeneration of 646
 transverse-frontal furrow 624
 transverse myelitis 659
 trematoda 236
 tricephali 16
 trichina spiralis 232, 233, 479
 trichinæ in blood 265
 in larynx 575
 in peritoneum 358
 trichocephalus dispar 230, 479
 trichomonas 250
 trichophyton tonsurans 222, 411
 triple-phosphate 531, 560
 triplets, homologous 16
 tropical abscess of liver 493
 tube-casts 523, 533
 tuberacæ 216
 tubercle 188 sqq
 clinical characters of 125
 crude 121
 definition of 118
 inoculability of 125
 miliary 118
 of heart 285
 of liver 501
 of spleen 327
 in blood-vessels 234, 264, 296
 tubercula 366, 368
 tuberculosis (see bacillus tuberculosis)
 188 sqq
 acute miliary 123
 bacillus of 120, 127, 186, 206
 diffusion of 121, 122, 124
 in lung 606, 612, 613
 in sputum 613
 of brain 660
 of bronchi 579
 of intestine 475
 of bladder 561
 of kidney 549
 of larynx 572
 of liver 501
 of lung 606, 612, 613
 of lymphatic glands 122
 of meninges 660
 of mouth 425
 of mucous membranes 124, 428
 of nose 567
 of pancreas 515
 of serous membranes 355
 of throat 446
 of thyroid 623
 of trachea 578

(The numbers refer to the articles.)

- tuberculosis, transmissibility of 125
 tuberculous inflammation of vessels 296
 inflammation of lymphatics 314
 lymphadenitis 342
 meningitis 660
 myelitis 660
 ulcer 391
- tuberous tumor 137
 tubules of kidney 520
 tumor-cells in blood-vessels 264, 312
 cells in lymphatics 316
- tumors Sect. VI. (Part I.)
 aetiology of 177 sqq
 cachexia of 141
 Cohnheim's theory of 177
 congenital 178
 definition of 136
 growth of 139
 malignancy of 140
 metastasis of 140
 of bronchi 583, 619
 of heart 285
 of intestine 478
 of kidney 556
 of larynx 575
 of liver 502 sqq
 of lung 619
 of lymphatic glands 343
 of mouth 438
 of mucous membranes 431
 of nose 568
 of œsophagus 451
 of pancreas 515
 of salivary glands 448
 of serous membranes 358
 of spleen 329
 of stomach 461
 of trachea 578
 of thymus 623 b
 of thyroid 622
 varieties of form in 137
 vascular 312, 504
- Türck, columns of 626
 twins, homologous 12
 tylomata 394
 typhlitis 471
 typhoid fever 474
 fever, bacilli in 206
 fever, brain in 637
 fever, laryngitis in 572
 fever, nephritis in 541
 ulcer 474
- tyrosin in acute atrophy of liver 489,
 490
 in blood 259
- tyrosin 39
- ulcer 102, 115, 116
 cancerous 175
 follicular 421, 470
 rodent 402
 tuberculous 121 sqq, 428, 475
 typhoid 474
 of the bronchi 582
- ulcer of the duodenum 471
 of the intestine 470
 of the pharynx 450
 of the skin 391
 of the stomach 456, 459
- ulcerative endocarditis 282
 stomatitis 434
- umbilical cord, withering of 41
 hernia 465
- umbilication in cancer 175
 of pustules 388
- uncinate gyrus 624
- union of nerves 668
- urachus 516
- uræmia 259, 539
- uratic concretions 560
 concretions, structure of 531
 infiltration of kidney 531
- urea, excretion of 520
- ureter, development of 516
 malformations of 517
- urethra, disorders of 564
- urethral caruncle 564
- uric acid in gout 259
 acid in kidney 531
- urinary organs Sect. IX. (Part II.)
 fistula 563, 564
- urine, foreign matters in 558, 559
- urobilin 268
- urobilinuria 68
 after hæmorrhage 349
- urogenital cloaca 516
- urticæ 366
- urticaria simplex 367
 tuberosa 367
- uterine fibroid 142, 153
- vaccination 201
 in anthrax 201
- vaccinia 388
 micrococci in 204
- vagus-pneumonia 601
- valgus (pes) 11
- valves, deformity of 271
- valvular aneurysm 282
 thrombus 253
 vegetations 280
- varicella 388
- varicocele 151, 306
- varicose aneurysm 310
 atrophy of liver 483
 ulcer 306, 391
 ulcer of œsophagus 450
- variola 387
 hæmorrhagica 361, 387
 micrococci in 204
 pustule of 372
- varix 306
 anastomotic 151
 aneurysmal 301, 311
 false 308
 of brain 663
 urethral 564
- varus (pes) 11
- vasa vasorum in organization 255

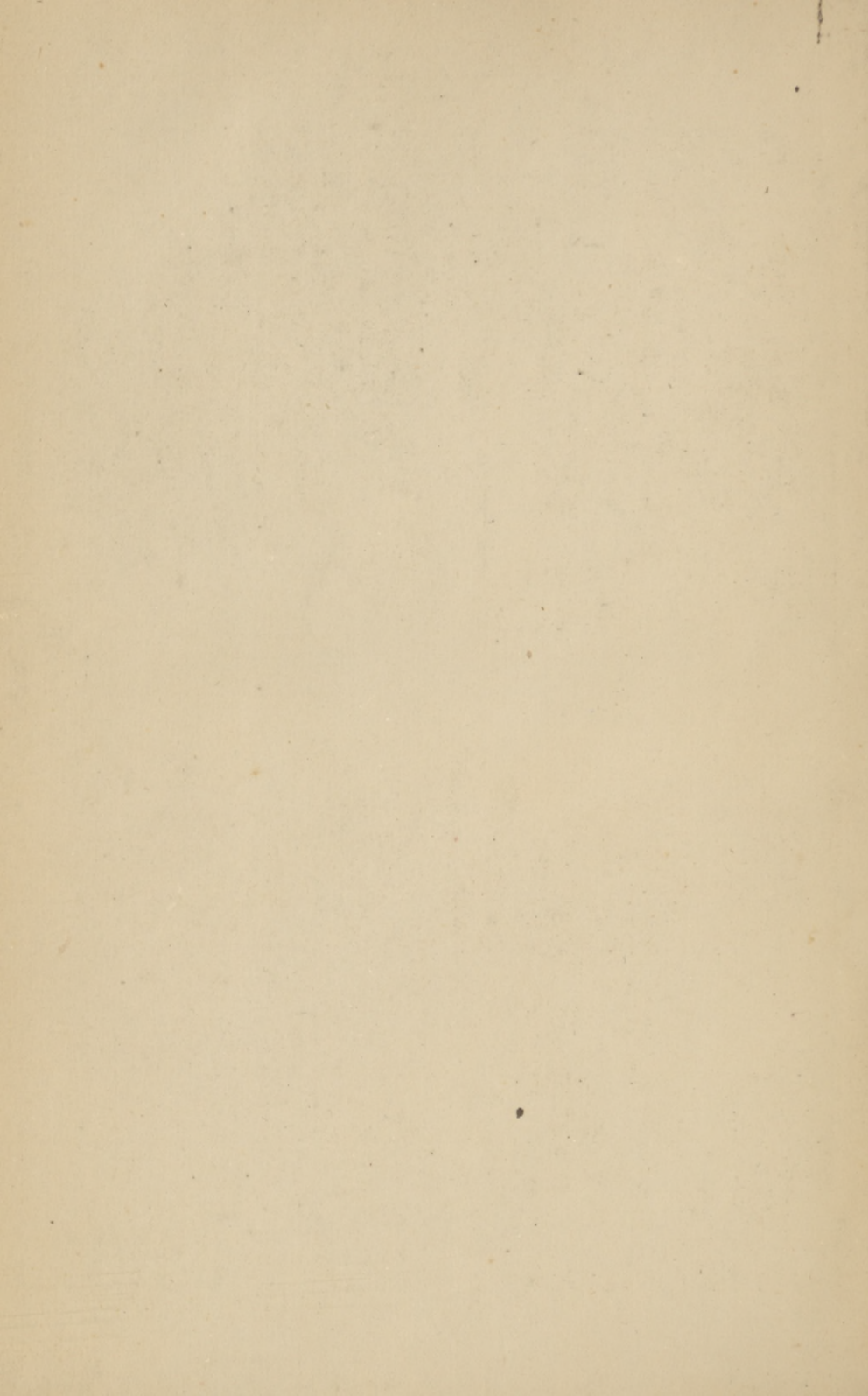
(The numbers refer to the articles.)

- vascularization of thrombi 255
vascular mechanism, Sect. II. (Part II.)
 neoplasms 312, 504
vegetative endocarditis 280, 281
vein-stones 254, 306
venereal warts 394
venom of serpents on blood 262
venous engorgement of liver 483
 engorgement of spleen 323
 trunks, defects of 271
ventral hernia 465
vermiform appendage, inflammation of
 471
 appendage, cyst of 471
verrucae (see warts)
vesical calculi 560
 hæmorrhoids 561
vesicles 366, 370, 371
vesiculæ 368
vesicular emphysema 593, 594
vessels, air in 265, 266
 changes in calibre of 301
 degeneration of 287
 dilated in inflammation 96
 hypertrophy of 289
 hypoplasia of 272, 286
 inflammations of 290
 rupture of 308
 size of 286
 wounds of 256
vessel-walls in inflammation 97, 98
vibices 361
vibrio 186
 serpens 185
vibrio butyrique 186
villous tumor of bladder 562
virus, attenuation of 201, 211
 of tubercle 126, 127
viscera, transposition of 11
visual centres 625
visual tract, atrophy of 640
vitelligenous organ in tænia 241
vitiligo 365
vitreous degeneration 63
volvulus of intestine 467
vomica, bronchiectatic 583
 phthisical 616
warts, congenital 156, 179
 warts, hyperplastic 398
 inflammatory 394
 necrogenic 390
 sebaceous 400
 venereal 394
warty endocarditis 280
water canker 434
waxy casts 533
 degeneration 38
 degeneration of heart 284
 liver 57
wens 399, 404
wheals 366
whip-worm 230
white blood 260
 hæmorrhage 260
 kidney 536, 537
 pneumonia 607
 softening 642
whitlow 390
Wirsung, canal of 513
witches-brooms 220
wolffian bodies 516
 ducts 516
wood-tick 225
woolsorters' disease 206
worms 227 sqq
wound infection 204
wounds, healing of 107
 of blood-vessels 256
 of brain 658
xanthelasma 401
xanthine calculi 532, 560
xanthoma 401
xeroderma 364
xiphopagi 12
yeast-fungi 223, 224
 in urine 559
yellow atrophy of liver 489, 490
 softening of brain 642
 softening of thrombi 254
zona 371, 383
zoogloea 184
zoster, herpes 371, 383
zygospore 213, 215



1870
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1873
1874
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1876
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1878
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