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THE ESSENTIALS

OF

PATHOLOGY.

BY

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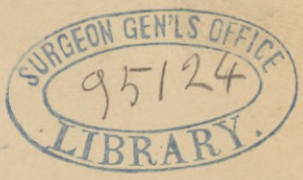

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PREFACE.

The object of this little book is to unfold to the beginner the fundamentals of pathology in a plain, practical way, and by bringing them within easy comprehension to increase his interest in the study of the subject. It is not, therefore, intended to supplant more pretentious works by allaying, but rather to lead up to them by kindling, a thirst for pathological investigation. Some departures from the ordinary have been made in the arrangement of the work, but it is believed that they will conduce to a more thorough and easy understanding of the subjects treated. I have, in great measure, purposely avoided the discussion of unsettled questions, and have occasionally stated dogmatically that which admits of question. This has been done with a view to prevent confusion in the mind of the student, and to impart clear-cut conceptions of the generally accepted doctrines of to-day. For the same reason I have avoided the slight detractions incident to bibliographical references, though, I fear, with questionable propriety. A very considerable experience in teaching, extending through some years past, leads me to hope that this effort will not prove barren of some good results.

D. Tod Gilliam.

42 North Fourth St., Columbus, O., July, 1883.

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THE ESSENTIALS OF PATHOLOGY.

CHAPTER I.

GENERAL CONSIDERATIONS OF DISEASE.

Pathology treats of disease; its nature, causes, course, termination, etc. Diseases are divided into general and special. A *general* disease bears the same relation to a special disease as, with the naturalist, the species does to the individual. All the members of a species have certain marks in common by which they may be recognized as belonging to the same family, and yet each individual has certain peculiarities by which he may be distinguished from every other. So it is with diseases—there are general or family diseases, and special or individual diseases. Fever is a general disease, as also are inflammation, cancer, tuberculosis, scrofula, etc. Now, all fevers have certain points in common by which they are recognized as belonging to the same family, and yet there are many special forms of fever by which they are differentiated one from another. Thus, we have typhoid fever, intermittent fever, remittent fever, etc., each of which constitutes a special disease. A treatise on general diseases is called *general pathology*—a treatise on special diseases, *special pathology*. Special pathology is taught in works on the practice of medicine.

Many attempts have been made to define disease, health, and life, as they are all correllated, but no perfect definition has ever been devised. We know, practically, what is meant by these terms, and it is more important for us to understand the relationship subsisting between them than to be able to

frame a definition. Health and disease are not opposites, as is generally supposed, but are closely related. A diseased organ has essentially the same structure, and works essentially the same way, as does the healthy organ. There is no substance created in disease, no force or function evolved, that does not exist in health. Take, for instance, a morbid growth —cancer. We are wont to look upon this as something foreign to the body; something that has no counterpart in the natural tissues, and that is not amenable to the natural laws. Place a section under the microscope, and it is found to consist of epithelial cells impacted in the meshes of a connective tissue network. Epithelial cells and connective tissue are two of the most widely distributed of the histological constituents of the body. Observe the process of growth; the cells divide and subdivide, as do the cells of normal tissue; they depend for their sustenance on the materials furnished by the blood, as do the normal tissues, and like the latter, die when this is withdrawn. Now, as to function; this is also the same in *kind* as that of health, though deviating from the healthy standard. The diseased brain evolves thought; the diseased glandular organ, if it does anything, secretes; muscles contract, and so on, through the whole category. So we might continue to illustrate, and it would be found that disease processes are the same in *kind* as the processes of health. Hence, pathology and physiology are closely related. Pathology has indeed been defined as the physiology of disease. It is of the utmost importance that the student should charge his mind with the intimate relation between health and disease, or he will not be able to obtain an intelligent conception of the teachings of pathology.

The healthy as the type of the morbid. It will be seen from the foregoing that every disease process copies after the healthy—endeavors, as it were, to reproduce the healthy.

We say, therefore, that all morbid states have their *types* in the normal. Thus, if we find a morbid growth, we submit it to inspection to ascertain to which one or more of the healthy tissues it is related; and having ascertained, we assign it to its proper place. We find in every instance that it belongs to one or the other—that it partakes of the nature of muscle, nerve, bone, cartilage, common connective, epithelial, or some of the other tissues, structures or organs of the body. So it is with function; the processes of disease imitate and aspire to the healthy. Virchow considers disease processes as being healthy processes occurring at the *wrong time* or at the *wrong place*. Thus, a hemorrhage from the uterus at the menstrual period would be physiological—it would be at the right time and at the right place. Occurring from any other organ, or from the uterus at any other time, it would be pathological. Disease processes are usually characterized by an *excess* or *deficiency*, as compared with the normal. We may conclude by saying that disease is a deviation from health, and that this deviation consists, for the most part, in an excess or deficiency, or a perversion as to time or place.

Extension of Disease. Most diseases are local at the onset, as the causes of disease do not usually operate upon the whole organism at once. Ordinarily, one or more foci of disease are established, from which the disease extends.

The methods of extension are by continuity or contiguity; by the blood and lymph; by migrating cells, and by similarity of structure and function.

By Continuity or Contiguity. When a disease extends along the same structure in an unbroken line, as, for instance, along the skin, the mucous membrane, or through the substance of an organ, it is said to extend by continuity. When it passes over from one structure to another which touch, but are not united to each other, it is said to extend by contiguity. Thus an inflammation of the pleura covering the lung

may be communicated to the costal pleura by mere contact of the opposing surfaces. The extension by contiguity is frequently more apparent than real, as a continuity of tissue—connective tissue, for instance—often may be traced from structure to structure, that are apparently distinct and separate.

By the Blood and Lymph. The *materies morbi*, or germs of disease, may be conveyed from place to place on the blood or lymph currents, and thus establish new foci of disease.

By Migrating Cells. Cells which move about from place to place, both within and outside the vascular channels, and known as mobile or migrating corpuscles, may also prove the medium of extension.

By Similarity of Structure and Function. It is a matter of common observation that organs of similar structure and function are prone to become "sympathetically" diseased, from each other. As, for instance, if one eye be affected the other is liable to become affected also, and so with other bilateral organs, and organs remote from each other, but of analogous structure. Many of the so-called metastatic diseases belong to this category—the inflammation of the testes in mumps, etc. Why such is the case does not admit of ready explanation. Possibly in some instances it is due to the similarity of vascular and nervous endowment, and in others to the increased functional activity imposed on the well organ by the disablement of its fellow; or possibly to a peculiar susceptibility of certain kinds of structure to special morbific influences.

Organic and Functional Diseases. Authors have been in the habit of dividing diseases into organic and functional. By the former is meant a disease attended by structural changes in the tissues or organs; by the latter a disease unaccompanied by such changes. As we advance in our researches we find the number of functional diseases con-

stantly diminishing—structural changes being found where they were not supposed to exist.

It is very probable that all diseases are attended by such changes, therefore are organic diseases; nevertheless, the distinction is for the present convenient, as indicating such as have, and such as have not, been found to be so attended.

Diseases are furthermore divided into *idiopathic* and *symptomatic*, according to the absence or presence of an obvious cause. Typhoid fever is an idiopathic disease, because we are unable to demonstrate the presence of that which gives rise to it. The fever which follows an injury, however, or one which depends upon some other evident disease, is symptomatic—the cause being apparent. In other words, a symptomatic disease is one of the *symptoms* of an obvious disturbing agency, whether that be another disease or not.

An *acute* disease is one which runs a rapid course; a *chronic* disease one that pursues a lingering course. Acute diseases are usually characterized by intensity of morbid action; chronic diseases by the opposite. There is no definite time when a disease ceases to be acute and becomes chronic. The terms are relative, and are used with much latitude. A *regular* disease is one which runs a methodical course, in which the phenomena follow each other in regular order. An *irregular* disease is one in which this order of succession is not observed. The term regular has reference solely to the order in which the phenomena occur, and does not take into account the duration of these, or the intervals between them. Thus, ague is a regular disease, because it invariably presents, first, a cold stage; second, a hot stage; and third, a sweating stage, in the order named. Each stage, however, may be of long or short duration, mild or severe, or present other peculiarities without affecting its title as a regular disease. Most diseases run a regular course. Regular diseases are, for the sake of convenience, divided into stages. These are usually

three in number: the stage of invasion, an intermediate stage, and the stage of decline.

A *continuous* disease is one which pursues an even course with slight variations of intensity. A *remittent* disease is one characterized by very pronounced variations in intensity. An *intermittent* disease is one which comes and goes at intervals. Remittent and intermittent diseases are usually *periodical*—that is, they recur at stated intervals.

The tendency of diseases to periodicity is more common than generally supposed. Many diseases of the nervous system; neuralgia, epilepsy, insanity; of the circulatory system; congestions, anæmias, hemorrhages; syphilis, gout, rheumatism, erysipelas, and many other diseases, are often distinctly periodical. The underlying cause of this tendency to periodicity is not known. We know that many of the processes of health are periodical, and as disease is, for the most part, an excess or deficiency of health processes, the clue may lie here. The rhythmical action of the heart and of respiration, the periods of activity and repose of mind and muscle, of secretion and excretion, and the diurnal variations of temperature, are suggestive examples.

Terminations of Disease. Diseases terminate in recovery, partial recovery, in other diseases, or in death. A disease seldom leaves one in all respects as it found him. An impression has been left which entails an increased or a diminished susceptibility to the same or other diseases. This is sometimes to the benefit of the individual, as when an attack of smallpox, measles, scarlatina or whooping cough secures immunity from subsequent attacks of the same disease. Oftener, however, it is otherwise, and one attack predisposes to subsequent attacks of the same or other diseases. As has been intimated, many, if not all, diseases are attended by structural changes in some one or more of the tissues. These changes consist either in the loss of substance, or in the addi-

tion of new material. In the first instance repair is effected by restitution, in the latter by resolution. Both may co-exist. The time devoted to the reparative process is called the *period of convalescence.*

Not infrequently the recovery from disease is only partial, and a permanent disability remains. Sometimes disturbances occur in the course of, or as the result of, a disease, which give rise to other diseases, as, for instance, the bronchitis or pneumonia occurring in typhoid fever, the heart complications in rheumatism, the strictured urethra as the result of gonorrhœa.

Causes of Disease. The causes of disease may be external or internal, predisposing or exciting. An *internal* cause is one originating within the system ; an *external* cause one that assails it from without.

Some of the internal causes are of a mechanical nature, as strictures, dilatations, contractions, retractions, displacements, etc. ; some of a chemical nature, as the effete and excrementitious matters which have been retained in the system. Many of the internal causes are the result of previous disease.

The external causes are to be sought in the food and drink, their quantity and quality ; the atmosphere, its composition, temperature, humidity and density ; the clothing, bedding, and habitation ; the soil and the various emanations therefrom ; and the atoms that infest the air, the water and the food.

A *predisposing* cause is one which creates or develops a tendency to a disease; an *exciting* cause one which directly produces a disease.

Predisposing causes frequently operate by impairing the general health and by diminishing the resisting power of the organism, thus increasing its liability to all kinds of disease. At other times they conduce to the development of a special

disease. Thus, by exposure, privations, long continued residence in a vitiated atmosphere, etc., the vital energies may be so reduced that the individual falls an easy prey to any disease. On the other hand, the predisposing cause may lay the foundation for a scrofulous, tuberculous or cancerous outbreak—one or the other, as the case may be. Predisposing causes are occasionally inherited, as when they descend from generation to generation. These give rise to the so-called *inherited* diseases. The number of inherited diseases is not great, but the subjects of such are extremely numerous. Syphilis, scrofula, cancer, epilepsy, insanity, rheumatism, and above all, consumption, cast their baneful shadows over successive generations. Hereditary diseases do not always descend in a right line from parent to child; they sometimes skip members of a family, or even a whole generation. The healthy children of a blighted family sometimes bring forth diseased offspring, or, conversely, the diseased may bring forth healthy offspring.

An hereditary disease does not always assume the same form in the progeny as in the parent. This is especially true of diseases of the nervous system. Thus, a parent suffering from epilepsy may entail upon his offspring the same disease, or in lieu of it, an asthma, insanity, or obstinate neuralgia. These are allied forms of an underlying morbid condition. Children are sometimes born with disease. These *congenital* diseases are acquired in utero. They may be inherited, as in the case of syphilis, or acquired otherwise. The fœtus in utero is subject to many ailments, and their blighting influence does not always end with the intra-uterine sojourn. In this way arise malformations, deficiencies and monstrosities. Children have been born in the eruptive stage of the exanthemata.

Age, sex, idiosyncracy, occupation, habits of life, etc., predispose to disease in various ways, according to the anatom-

ical and physiological peculiarities of the individual, or the modifying influences by which his system is affected. In infancy and childhood the first and second dentitions, together with the many anatomical and physiological changes occurring at the same time, predispose to gastro-intestinal and nervous disorders. Thus, convulsions, epilepsy, chorea, true asthma, and spasmodic croup are the special heritage of this period. Scrofula, true croup, intestinal worms also manifest at this time. At the period of adolescence the sexual system is unfolding, accompanied by the most striking changes in the physical, moral and mental constitution of the individual. These predispose to erotic and religious manias, moral perversions, etc. With the decline of life come retrograde changes of all kinds, among which may be enumerated changes in the brain substance, leading to childishness, imbecility, fatuity; brittleness of the vessels, leading to dropsies and hemorrhages; non-specific diseases of the genito-urinary apparatus, etc. Paralysis and cancer are more common at this period. Of the two sexes, *males* are more prone to diseases resulting from exposure and hardship, as pneumonia, heart disease, rheumatism, paralysis, etc.; *females* to the functional and reflex ailments, such as hysteria and spinal irritation. Many of the ailments of females may be traced to confinement, sedentary habits, ungratified sexual desires, but, also, many to conditions arising from her constitutional peculiarities and the relations of maternity.

The Germ Theory. The cause of contagious and infectious diseases deserves more than a passing notice. The contagious or infectious principle, unlike all other causes of disease, accumulates after it enters the system. We can account for this accumulation in no other way than that it is a living, growing germ, capable of reproducing itself. A drop of matter taken from the pustule of a smallpox patient, and introduced into the body of another, produces smallpox.

Here, again, are multiplied hundreds of pustules, each of which contains many drops of matter identical with that first introduced. That it has not lost any of its virulence or potency is evidenced by the fact that it will produce the disease in a third person as surely and quickly as the original drop did in the second. From the first drop there has been a prodigious increase in quantity, together with an unchanged quality; and thus it has been throughout the ages. No other cause, whether it be animal, mineral, or vegetable in its nature, if not endowed with life and the power of procreation, will perpetuate a disease of unabated intensity through successive individuals. Strychnine given to an animal will produce its characteristic effects, but these effects cannot be maintained by transmission from one animal to another. So it is with the mineral poisons, and with the non-contagious animal poisons. The experiment has often been made of submitting a fowl to be bitten by a venomous reptile, and establishing therefrom a series of inoculations. The fowl bitten speedily succumbs to the virulence of the poison introduced into its system. A second one, inoculated from the blood of this, may also die, but less speedily. A third inoculated from the second is much less profoundly affected, and so on continually, the poison losing its strength as it becomes diluted by dissemination through different bodies, until it finally becomes practically inert. So it is with all other known substances, except such as consist of living elements.

Every contagious disease has its own special contagium, which differs from that of all others, and which imparts to the disease its distinguishing characters. Thus, the contagium of smallpox differs from that of scarlet fever, cholera, or any other contagious disease, and always produces smallpox. So it is with the other contagia; each produces its kind and nothing else.

The ordinary parasites of the body are the grosser repre-

sentatives of the minute organisms which we call *contagia*. Fleas, lice and tics infest the surface of the body; they grow and multiply, pass from individual to individual, and produce their characteristic effects on each. They are contagious. The same may be said of the intestinal worms; and by the aid of the microscope numerous other parasites are revealed. These are too small to be detected by the naked eye, yet none the less certainly the producers of disease.

As familiar examples, we may mention the itch mite, the trichina spiralis, and the filaria medinensis, each of which gives rise to its characteristic disease. Lowly organisms have been found in most of the contagious and infectious diseases; notably in cholera, typhoid fever, diphtheria, smallpox, erysipelas, relapsing fever and the septic diseases.

It can hardly be claimed that for the present the specific contagium for either of the above has been affixed beyond question, though the field is being cleared for subsequent investigations. Beale believes the contagious principle to consist of cells belonging to the body which have acquired specific properties under the stimulus of inflammation or otherwise. This accords to it life, but not an extraneous origin.

CHAPTER II.

NORMAL HISTOLOGY.

Constituents of the Organism. All living organisms consist of living and lifeless elements. The living elements have received various names, such as protoplasm, bioplasm, germinal matter, etc. The lifeless elements consist of mineral, earthy and inert animal or vegetable matters, which have been placed there through the agency of the living elements.

Protoplasm or *germinal matter* is an albuminous substance, which is colorless, transparent and viscid. Its primitive form in a state of rest is globular; as found in the tissues, however, it is of every conceivable shape, and varies greatly in its physical characters as regards color, consistence, etc. These little masses of protoplasm are called cells.

Cells. There are three principal varieties of cells; (1) cells consisting of a small clump of homogeneous or granular protoplasm; (2) cells containing a dark spot in their interior —the nucleus; and (3) cells with a nucleus and also an investing membrane. Cells of the first class are not common in the human organism. Those of the second class are called *embryonic*, or *germinal cells*, and those of the third class *typical nucleated cells*. The *nucleus* also consists of protoplasm. It represents the protoplasm in its pristine condition, and is in all respects similar to the fresh and youthful protoplasm as it exists in the non-nucleated cells. Inside the nucleus may frequently be seen another differentiated spot—the *nucleolus*, and, at times, yet another within this. As the nucleus grows and expands its outer margin undergoes a change, and constitutes the body of the cell, while the nucleolus in its interior develops into the nucleus. Thus, by successive changes from centre to circumference the cell is made

up, the freshest protoplasm always occupying the centre. The investing membrane is the oldest and most hardened part of the cell. The vitality of the cell diminishes from the centre toward the circumference.

Structure of the Cell. Until within a recent period the cell has been supposed to be structureless. The higher powers of the microscope, however, reveal the fact that the cell, including the nucleus, consists of a network of extremely fine threads, filled in with a structureless material.

The network can be more easily demonstrated in the nucleus than in the surrounding substance, but the threads are continuous from one into the other. Although the entire cell consists of protoplasm in various stages of senescence, it is customary to speak of it as consisting of a nucleus, protoplasm and an investing membrane,—the protoplasm here having reference to the intervening substance between the nucleus and the investing membrane.

Physical Properties of the Cell. Cells vary greatly in size and form. In *size* they may range all the way from the one hundred thousandth to the one hundredth of an inch in diameter. In *form* they are round, oval, fusiform, spindle-shaped, stellate or irregular.

Functions of the Cell. The functions of the cell pertain to the maintenance of itself, the perpetuation of its kind, and other functions of a special character, by which it subserves the general economy. The cell is a living organism in miniature. As such it feeds, grows and multiplies. This implies the selection of proper food, its assimilation and the casting off of effete and excrementitious matters. This is the *nutritive* function of the cell. It receives its food from the blood and from the nutritive fluids that escape therefrom. It discharges its excreta into the blood and lymph.

Reproduction of Cells. A cell is always the offspring of a preëxisting cell. Commencing with the primary germ cell,

which is itself derived from the mother cell, the work of reproduction goes on and on, to the evolution of a new organism. It does not cease here; for the maintenance of the organism depends on the ever recurring birth and death of cells.

Cells are reproduced in three ways:—

1. *By simple division*, in which the cell divides into halves, each of which constitutes a new cell. These again may divide in like manner, and so on indefinitely.

2. *By vacuolation*, in which a brood of young cells form inside the mother cell—they are supposed to be formed from the substance of the mother cell. They make their escape

FIG. 1.

MYELOID OR GIANT CELLS.

through natural openings in the cell wall or by the bursting of the latter. This is called the *endogenous* method of cell formation.

3. *By gemmation*, in which a portion of the cell projects at the periphery, becomes constricted at the base, and separates, forming a new cell. In all these instances, a certain amount of substance becomes separated from the parent cell and forms a new cell. A portion of the nucleus is almost invariably included in the separated part, and on this account it has been

supposed that the power of reproduction was vested in the nucleus. This, however, is not the case, as the non-nucleated cells have been known to divide ; and as we recognize in the nucleus nothing more nor less than a fresh and vigorous protoplasm, it may be seen that it is not indispensable to the reproductive act. Occasionally there is a nuclear division without a corresponding division of the cell substance. The cell enlarges, however, in the same ratio of growth, and as a consequence there results a larger mass of protoplasm, containing many nuclei. This is known as the myeloid or giant cell.

Special Function. Aside from the nutritive functions, the cells have a special function, by which they subserve the general economy. These special functions are as varied as the varied processes of the economy, of which, indeed, they are the authors. Secretion, excretion, muscular contraction, nerve and brain force, are examples of the special function of cells.

Amœboid Movement. Young cells that are not fixed in the tissues, are endowed with the property of changing their form, by which they throw out processes and by flowing into the same change their locality. This is called the *amœboid* movement. By flowing around substances in their course they sometimes become filled with particles of extraneous matter.

Differentiation of Cells. All cells at birth resemble each other, and are not to be distinguished by any points of difference capable of recognition. In the process of development they assume widely different properties and functions. Thus one becomes a secreting, another a nerve, another a connective tissue cell, and so on until all the varied types of cell are evolved. This is called the *differentiation* of cells. Just how it is effected is one of the mysteries of life. In some instances, as will be seen further on, it would seem that cells of a certain kind when brought in contact with new-formed cells

have the power of converting them into their own kind. This will not apply, however, to the differentiation as it occurs in the original formation. The progeny of certain cells of the higher order, as those of the muscular and nervous systems, do not differentiate.

Intercellular Substance. The intercellular substance is the substance occupying the spaces between the different cells. It is for the most part lifeless and inert, and is placed there through the agency of the cells. It is sometimes fluid, as in the blood; at others solid or semi-solid, as in the solid tissues. In some situations it consists largely of earthy matter, as in bone; in others of animal matter, as in common connective tissue. Just how the intercellular substance is formed is not definitely known.

By some it is regarded as a secretion from the cell, by others as the outgrowth of the cell, and others still are of the opinion that its formation is coeval with that of the cell. Lifeless cells are frequently seen scattered throughout the intercellular substance, and constituting a part of the same.

Sometimes a tissue is composed of a network of cells, the meshes of which are filled with other cells. In such cases each acts in the capacity of an intercellular substance to the other. Several of the higher order of tissues are thus composed.

Tissues. Tissues are formed of cells and intercellular substance, variously arranged and combined. From these tissues are formed all the organs and structures of the body. The number of different tissues is not as great as might at first seem. Many of them, though entirely dissimilar in their outward appearance, belong to the same class. Thus bone, cartilage, tendon, areolar tissue and the soft, jelly-like substance that constitutes the vitreous body of the eye, are of one class.

The scales that cover the outer surface of the skin and the

secreting cells of the liver, belong to another class. Probably the simplest classification of tissues is that in which they are arranged into three classes: the epithelial, the connective, and those of a higher order.

1. *Epithelial Tissues.* These comprise the laminated arrangement of cells as found on the outer surface of the body and which line the various mucous passages and ducts in the interior, also the secreting cells of all glandular organs. The lining of serous membranes, of blood vessels and lymphatics, are also included in this class. The characteristic mark of epithelial tissue, and which distinguishes it from all other tissues, is, *that the cells lie in immediate contact one with another, there being no appreciable amount of intercellular substance.*

2. *Connective Tissues.* The connective tissue group is even more comprehensive than the epithelial. The tissues of this class are, in one form or other, everywhere present throughout the organism. Bone, cartilage, tendons, ligaments and fascia belong to this group, besides the common connective tissue which permeates all structures, investing and supporting their proper elements. The connective tissues are bounded by the epithelial lamina on the interior and exterior of the body, through which they never penetrate. The distinguishing mark of connective tissue is, *the presence of an intercellular substance between the individual cells.*

3. *Tissues of a Higher Order.* In this class are embraced muscles, nerves, blood vessels, lymphatics, etc. The individual peculiarities of each are so striking as to need no further comment here.

Having now considered in a general way the elementary parts of the living organism, their nature and properties and their manner of combination, in order to form the tissues and organs in the *normal* state, we are prepared to consider the deviations from the standard.

These deviations consist not only of structural changes, but also of functional derangements. Hence we have a pathology of structure and a pathology of function. The former is called *morbid or pathological anatomy*—the latter *pathological physiology*. Pathological anatomy, or the study of the structural changes in disease, constitutes the groundwork of pathology, and yields more definite and satisfactory results than the study of functional disturbances. Structural changes are always due to a disturbance of nutrition. It is through and by the nutritive processes that the tissues are built up, maintained and repaired, when injured. If these nutritive processes be disordered, the tissues suffer accordingly. This disorder of the nutritive processes may assume one of two forms: an inordinate activity or a diminished activity. The first leads to overgrowth and the last to wasting or retrograde changes in the tissues or their elements. If nutrition be arrested entirely, the tissue dies, because life consists of incessant changes, and these changes are the nutritive processes. We shall first consider the disturbances of nutrition in a general way, indicating how and in what manner they affect the tissues of the body. Subsequently they will be studied with reference to special structures, and as occurring in special diseases.

CHAPTER III.

CONSTRUCTIVE PROCESSES IN DISEASE.

The disturbances of nutrition occur either as an excessive or deficient activity of the nutritive functions. The first tends to the formation, the last to the destruction of tissue elements. We shall therefore consider them under the respective heads of constructive and destructive processes.

As the result of increased nutrition, there occurs an increase in the size or the number of the histological elements. These elements go to form tissues. The tissues so produced are called *new formations*. New formations occur as regenerations, hypertrophies and morbid growths.

Regeneration.

Physiological regeneration, or the supply of tissue waste as it occurs in the ordinary wear and tear of the body, is continually transpiring. Pathological regeneration is such as takes place after injury or disease, in which the tissue waste has been of such degree as to produce lesions. This consists in the reorganization of disorganized parts, or the restoration of lost parts. Nearly, if not all, the tissues of the body are capable of regeneration. In some this takes place perfectly and with great facility; in others, slowly and imperfectly. *True regenerations* are those in which the supplied parts are analogous in every particular to the original. *Spurious regenerations* are those in which the supplied parts differ in some essentials from the original. Replacements of lost muscular tissue by muscular tissue is an example of true regeneration; replacement of the same by cicatricial tissue is an example of spurious regeneration. Spurious regenerations sometimes precede true regenerations, as a preliminary stage.

These are called *provisional* regenerations. The replacement of cartilage by ordinary connective tissue, which subsequently becomes converted into true cartilage, is an example of provisional regeneration. Provisional regenerations are quite frequent in the repair of injuries to bones. Some of the lower orders of animals are endowed with the power of restoring entire limbs and other important organs. In man only the simple tissues or tissue systems can be regenerated, such as the epithelial, connective, muscular or nervous tissue, or blood vessels and lymphatics.

Hypertrophy.

Hypertrophy is an overgrowth of tissue, and may depend on an increase in the *size* or the *number* of the histological elements. When due to an increase in the size of elements it is called *simple* hypertrophy; when due to an increase in the number of elements, it is called *numerical* hypertrophy, or hyperplasia. In hypertrophy of an organ all the tissue elements are equably increased, and the various tissues of which the organ is composed maintain their relative proportions. When this equipoise is not preserved, as, for instance, when certain tissues develop and others remain stationary, it constitutes *spurious* hypertrophy. Under the head of spurious hypertrophy are also included inflammatory products and various forms of infiltration by which an organ becomes enlarged. In spurious hypertrophy the essential tissue elements (muscular fibres in muscles, the secreting cells in glandular organs, etc.,) often suffer from being crowded upon by the adventitious products, and actually waste away. On this account, organs, though greatly enlarged, are sometimes wanting in even the normal development of their essential constituents, and are correspondingly deficient in their functional capabilities.

Physical Properties. An hypertrophied organ does not

materially change in form, color or consistence, because of the even distribution of the tissue elements in their normal proportions. In some situations this equable growth in all directions is impossible, and the organ does not develop symmetrically. A muscle, for instance, with bony attachments at a fixed distance, cannot elongate, and hence must develop laterally, thus destroying the normal symmetry. Hypertrophied structures always increase in *size* and *weight*.

Causes. The causes of hypertrophy are such as increase nutrition, the principal of which are functional activity and increase of the nutritive fluids.

1. *Functional activity* as a cause of hypertrophy is daily exemplified in the muscular development of artisans, etc. Certain groups of muscles, if persistently and systematically exercised, invariably become hypertrophied. Instance the brawny arm of the blacksmith, the general muscular development of the athlete, and the development of the muscles of the leg in ballet dancers.

The heart becomes hypertrophied in cases of obstruction to the circulation. The stomach and bowels, when an obstruction exists lower down in the alimentary canal; the bladder, in stricture of the urethra. Glandular organs enlarge when an increased labor devolves on them, as is seen in the kidney when its fellow is disabled. Even bones will hypertrophy when an increased burden is imposed on them, as evidenced by enlargement of the fibula in cases of ununited fracture of the corresponding tibia. In short, the law of compensation extends to every structure of the body, the development within certain bounds being coextensive with the demands for increased energy or power.

2. *Increase of the Nutritive Fluids.* Aside from the influx of nutritive fluids determined by functional activity, a superabundance of them sometimes occurs in parts, from various causes. Arterial excitement, venous obstruction, damming of

the lymph channels, each and severally, serve to inundate the tissues of the affected region with nutritive fluids, by which the tissues become overfed and, as a result, overgrown. This is strikingly illustrated in the disease elephantiasis arabum, in which there is an overgrowth of connective tissue, due, in the majority of instances, to an obstruction of the lymph channels.

Functional Capacity. The functional capacity of an hypertrophied organ is usually increased correspondingly with the increase in size. In spurious hypertrophy this is not so; the functional capacity, so far from becoming increased, is diminished in proportion as the essential constituents are crowded upon and destroyed by the adventitious growth. True hypertrophy is beneficial in that it enables the organ, despite of obstacles, to properly perform its functions.

Were it not for the increased capacity secured by increased development as it occurs in hypertrophy, the economy would inevitably suffer from inadequately performed functions. Thus, in circulatory obstruction, the result would be disastrous if it were not for the compensatory enlargement and increased power of the heart, which secures an efficient distribution of the blood.

Morbid Growths.

All deviations from the normal measure and character of growth are included under the head of morbid growths. As the term is generally used it implies something added to, or grafted on, the natural or healthy growth, but quite frequently, also, an exuberance of growth in the place of the healthy. The elements constituting morbid growths, the tissues formed by them, and the combinations of tissues evolved from these, all have their counterparts in some one or other of the elements, tissues, or organs of the natural body. If we examine a morbid growth critically, whatever its nature, we shall find it composed of cells and intercellular substance analogous to

those found constituting some one or more of the various healthy tissues; epithelial, connective, muscular and nervous. We find, furthermore, that the elements spring from the same source—pre-existing cells—and originate in the same manner —by simple division, vacuolation, gemmation—as do those of the healthy organism. Indeed, a large proportion of the morbid growths have their beginning in a rather too rapid cell production of the natural tissues. *Hence, every abnormal growth has its type in some one or other of the normal tissues.* The abnormal differs from the normal in being excessive, sometimes misplaced, and in having tendencies somewhat peculiar, and which will be alluded to further on. Increased growth implies an increased production of histological elements, with all the concomitants of an increased nutritive activity. These are:

1. *Increased blood supply*, either from a local increase in the vascularity, by the formation of new vessels or the dilatation of existing vessels, or from an increased activity of the circulation.

2. *Nutritive excitation of the cellular elements*, by which they are incited to take up more, and more rapidly dispose of, the nutritive material furnished by the blood. A cell under the influence of nutritive excitation retracts its processes and tends to assume the globular form; it increases in size, becomes clouded or granular, and eventually divides into two or more cells.

3. *Increased Waste.* In proportion to the rapidity of nutritive changes molecular disintegration is accelerated and the excrementitious principles are augmented. These are carried away by the lymphatics and blood-vessels. It is owing to the increased quantity of nutritive fluids and excrementitious products in the vicinity of proliferating parts that they are usually so œdematous. *The vitality* of new growths is, as a rule, of a low order in those of rapid development,

and increases in proportion to the slowness and completeness of the organization. Hence, in those rapidly proliferating growths, such as cancers and sarcomas, the individual elements are short-lived, and quickly lapse into degeneration and death. The older and central part of such growth is always found degenerated, even while the peripheral portion is enlarging its borders by extension into the surrounding territory. On the other hand, the slow progressing growth, in which there is ample time to perfect an organization and make arrangement for blood supply and other nutritive processes, is characterized by stability. Of such are many of the osseous and, in a minor degree, other growths of the connective substances. Morbid growths are of every conceivable size and shape, and vary greatly in their color, consistence, and other physical properties. Before the days of microscopy they were classified and arranged according to these physical properties, but of late years we classify them according to the tissue elements of which they are composed. The older method of classification was very imperfect, and led to many grave mistakes, inasmuch as growths of very different character may resemble each other closely in color, consistence, outline, etc., and, on the other hand, growths of the same character may present striking variations in this respect. When the student has progressed further and learned of the secondary changes, the accidents, the retrograde processes, etc., to which morbid growths are prone, he will readily see how unreliable the physical properties of a growth would be as a basis of classification.

Morbid growths are free or encapsuled, smooth or lobulated, circumscribed or diffused. The growths are said to be *centric* when they grow within themselves by the proliferation of their own elements; they are said to be *excentric* when the neighboring tissues contribute to the growth by adding new material to the periphery. They are called *homologous* when

of the same nature as the tissues in which they are imbedded or from which they spring, and *heterologous* when they differ from these. An osseous tumor growing from a bone is homologous, but a fleshy tumor—sarcoma—growing from a bone is heterologous. Malignant growths are generally heterologous in their composition, hence the mere fact of heterology in a growth excites a strong suspicion of malignancy. Many growths previously regarded as heterologous are now known to be homologous, as tissues of like nature to the growth are found in situations where they were not supposed to exist. Thus lymphatic or adenoid tissue, a tissue analogous to that of which lymphatic glands are composed, has recently been found in many situations hitherto unknown; notably in the lungs and under the surface of the peritoneum. Now, tubercles have a structure of the same kind, and were supposed to be heterologous; this discovery, however, classes them with the homologous growths. It is not at all improbable that other tissues may be found in situations as yet not suspected, and that all apparently heterologous growths are in reality homologous, in that they spring from tissues in kind similar to themselves.

Growths are *innocent* or *malignant*. The distinction between innocence and malignancy is not easy to define, as the terms apply exclusively to the *tendency* of the growth, and have no reference to its structure or composition. The most prominent distinguishing character of malignancy is *infectiousness*, as all malignant growths are infectious, by virtue of which they are capable of reproducing themselves in various parts of the system. All infectious diseases are not malignant, however, as, for instance, syphilis and smallpox. Malignancy, therefore, implies something more. A malignant growth is progressive, and tends to go on from bad to worse; to kill by an inherent viciousness. Cancer is a very common form of malignant growth, and the laity are in the habit of

looking upon all malignant growths as cancer. The terms are not synonymous. By a cancer we mean a growth that has a certain structure—that is composed of certain kinds of tissue arranged in a certain way, so that when we look at it through the microscope we may say, "This is cancer; it has the structure and the elements peculiar to the cancer formation." By a malignant growth, however, we mean a growth that tends to kill without reference to its structure. Cancers are malignant, the sarcomas are malignant, and there are other growths that constantly, or at times, show the malignant tendency, and they all have different structures. Although there is no infallible index to malignancy in the histological or physical character of a growth, yet we have learned to look with suspicion upon very rapid growths that are highly vascular and succulent, and from which a milky fluid escapes when cut into. This fluid, sometimes called the *cancer juice*, derives its milkiness from the number of young cells suspended in it.

Inflammatory and Non-inflammatory. All morbid growths are divided into two great classes, the inflammatory and the non-inflammatory. *Inflammatory* growths are such as result from inflammation. They are all dependent on an irritation, and are evanescent in their nature; either speedily subsiding by degeneration and absorption after the cause is removed, or resolving into a tissue or structure closely resembling that from which they sprang. The cicatricial tissue as a product of connective-tissue inflammation, and the osseous tissue resulting from inflammation of bone, are common examples of the latter.

Non-inflammatory growths are more permanent in their nature, independent in their character, and either tend to develop progressively, or having attained a certain magnitude, maintain themselves indefinitely. They lead an independent life, uninfluenced by the general organism; luxuriating, per-

haps, while it is wasting, and on this account they are called *parasitical.*

Causes. The essentials to all growth, morbid or natural, are a sufficient quantity and proper quality of the nutritive fluids, and an ability and disposition on the part of the tissue elements to appropriate the cause. The blood is the mixed food from which all the tissues derive their subsistence; each selecting for itself that which is necessary for its well being and discarding that which does not concern it. The blood is, therefore, the natural stimulus to normal growth. Other agencies, though not directly contributing to it, may yet give an impetus to growth by irritating the tissue elements, and inciting them to an increased nutritive activity. These may consist of mechanical or chemical irritants, or specific poisons. If the nutritive fluids be in excess, or the cells be awakened to inordinate activity by the presence of an irritant, the growth is apt to transcend the bounds of health, and a morbid growth results.

This morbid growth may consist of a simple increase of the tissue elements without peculiar characters or tendencies —non-specific—such as results from ordinary inflammation, or it may be endowed with those peculiarities, infectious or malignant, which characterize the growths of blood poisoning, cancer, etc. These latter are known as *specific* growths. The growths of scrofula, of syphilis, of leprosy, and others of like nature, belong to the same category. They depend on a constitutional state, inherited or acquired, which predisposes to their development, and which may be aroused to activity by ordinary or indifferent irritants; or upon a specific poison being brought in contact with otherwise healthy tissues. In order, however, that a specific poison may lead to a specific growth, there must be a susceptibility to the action of the same, which, though usually present in the mass of the people, is sometimes wanting. We know of people who will not

contract smallpox, or some one or other of the contagious diseases, because, as we say, they are not susceptible to the action of these poisons—the poison does not find a suitable soil in which to grow. Agriculturists recognize the fact that different kinds of soil are adapted to the production of different kinds of vegetation, and some soils will utterly fail to produce certain kinds of growth. The principle is the same as applied to the animal economy. Cohnheim has recently propounded the theory that all morbid growths of the nature of tumors originate, not in the proper elements or constituents of the formed tissues, but in certain embryonic cells which were left over, or not used in the make-up of the same, and which remain quiescent, ready to take on renewed growth under extra stimulation. These cells, when aroused to growth, produce a tissue analogous to that for which they were originally intended, and which will sometimes differ from the tissues in which they are imbedded, because these latter have undergone a series of developmental changes in the meantime, and are now very unlike the original from which *they* started. In such cases the new growth, though apparently heterologous, is in reality not so,—it is like unto that from which it sprang, and in which it is imbedded.

Origin of Malignant Growths. The manner in which malignant growths originate is a much disputed question, and has given rise to a great deal of earnest and vehement discussion. The disputants are arranged in two opposing factions, and known respectively as the *constitutionalists* and the *localists*. The former believe that a malignant growth always depends on a constitutional taint or predisposition, without which it is impossible for it to occur, and that the growth, cancerous or sarcomatous, as the case may be, is the local manifestation of the constitutional taint. The localists, on the other hand, believe that malignant growths are always at first local in origin, and that the system becomes affected secondarily

by the dissemination of the infectious elements from the point of primary infection. It is probable that, as is usual in such cases, the truth lies at both ends; that the growth depends in some instances on a constitutional bias, and in others, has its inception in a local outbreak. If the taint be constitutional, it must depend either upon a generally disseminated morbid material, a taint of the blood, or *dyscrasia*, or upon an inherent vice or weakness of the tissues, by which they are rendered prone to specific proliferation. The theory of a constitutional taint is based on—

1. *Multiplicity of growth*, which, occurring simultaneously in different parts of the organism, evidences that it is not due to secondary infection, nor yet to direct injury or irritation. The malignant growths, however, are not the only ones that exhibit a tendency to multiply in the system, as several of the innocent growths—fatty, osseous and cartilaginous—are even more frequently multiple than they. The majority of malignant growths are, furthermore, single in the beginning, and subsequent growths may be the result of infection from this primary growth.

2. *Hereditary Transmission.* The very frequent instances of cancer and other malignant growths being transmitted, as well as many of the innocent growths, from generation to generation, are altogether too common to be ascribed to coincidence, and must be referred to a constitutional bias. The objection that individuals, as a rule, give no evidence of a constitutional depravity prior to the outbreak of the growth, and that examination of the blood and tissues has failed to reveal any special characters, is untenable. Who, for instance, would undertake to distinguish the pus corpuscle of syphilis from that of ordinary pus, by its physical or chemical properties, and who does not know that the syphilitic taint may repose quiescent in the system for long periods without anything to indicate its presence, until, of a sudden, it manifests unmistakably?

If, then, a syphilitic corpuscle is so indistinguishable from the normal, how are we to judge of the cancerous diathesis?

3. *Recurrence after Removal.* The tendency to recurrence, either at the seat of growth or elsewhere, after extirpation, is another evidence of constitutional origin. True, the recurrence may be due in some instances to the dissemination of the seeds of original infection, but in cases where a limb is amputated early in the disease, before the involvement of the adjacent lymphatic glands, it is difficult to account for it in this way. Such cases are on record.

As to the local origin of malignant growths, it is believed that in some instances, as the result of a continued irritation, a growth with malignant propensities may originate *de novo*. Virchow adduces as evidence of this, that cancerous growths are most prone to occur in situations subject to constant fretting, as, for instance, in the mammary gland, the stomach, the uterus and the rectum. Cancer, consisting, as it does, of epithelioid elements, imbedded in a connective tissue stroma, is sometimes supposed to originate by a downward growth of the surface epithelium into the subjacent connective tissue. This is most likely to occur, and probably only occurs, when, owing to prolonged irritation, the epithelial cells are driven into a condition of great nutritive excitation. Under these circumstances the cells not only multiply themselves but acquire the power of infecting other cells with which they come in contact, thus converting them into cells of like nature.

The diffusion of malignant growths takes place by the blood and lymph channels and by wandering cells. In cancer the nearest lymphatic glands in the line of the lymphatics proceeding from the growth become first involved, followed in time by the involvement of the next nearest group, and so on successively until the infection becomes general. In other instances, as in the case of sarcoma, the diffusion takes place by the way of the blood vessels; the particles of morbid

matter being carried on the current, until becoming arrested in the capillaries or elsewhere, a new focus of disease is implanted. The wandering corpuscles may pass in various directions independently of the blood and lymph channels, and, finding lodgment in a congenial soil, there proliferate. The manner in which the proliferation is accomplished is twofold: first by multiplication of the infectious elements themselves, and second by infecting other cells with which they come in contact, causing them to multiply and to bring forth progeny the same in character as the infecting cells.

In the foregoing general considerations of both natural and morbid growths as they stand side by side, the student will hardly fail to apprehend the intimate relationship that subsists between them, and to appropriate to himself that fundamental doctrine of pathology which teaches that all morbid processes have their types in the healthy. In the natural order of things construction must precede destruction, and for this reason we have given the general plan of the constructive processes, both healthy and morbid, before the destructive. But in the tissue changes incident to life, we are continually brought face to face with the evidences of destructive metamorphosis. This is conspicuously the case in those rapid proliferations included under the head of morbid growths and a knowledge of such changes, their characters and manner of production, is absolutely necessary as a preliminary to the study of individual growths of a morbid character. These are treated of under the head of retrograde changes or *destructive processes in disease.*

CHAPTER IV.

DESTRUCTIVE PROCESSES IN DISEASE.

The destructive processes in disease consist of *atrophy*, *degeneration*, and *death*.

Atrophy.

Atrophy is a term used to indicate the waste of tissues, and is, therefore, a condition resulting from destructive processes. Atrophy implies a diminution in the size and weight of the parts affected, and depends upon a diminution in the size, or the number, of the histological elements of which it is composed.

Simple and Numerical Atrophy. When the atrophy depends on a diminution in the *size* of the histological elements—cells, fibres, etc.—it is called *simple atrophy;* when on a diminution in the *number* of the same, *numerical atrophy*.

In numerical atrophy the tissue elements are destroyed; cells die and disappear, so that they are not so numerous as before, and in this way reduce the size of the tissues. Cell death is constantly occurring in the healthy state of the organism, where old cells die and are replaced by young and vigorous cells. This latter form of cell death, known as *necrobiosis*, does not entail any loss of substance, because of the immediate substitution of new elements, and therefore differs in its effects from numerical atrophy. Numerical atrophy is always preceded and accompanied by simple atrophy, and may be regarded as a more advanced stage of the same.

General and Partial Atrophies. An atrophy is said to be *general* when it affects the entire organism, as in general ema-

ciation. It is *partial* when limited to certain organs or structures. Any organ or tissue may suffer from atrophy, though it is most commonly observed in the adipose tissue, the secreting cells of the glands, and in the muscular and nervous tissues. While connective tissue may, and frequently does, atrophy, yet, on the other hand, it quite frequently increases as the other elements diminish, and thus comes to constitute an unnatural proportion of the atrophied structures. Sometimes, owing to this increase in the connective tissue elements, organs do not diminish in size at all proportionate to the loss of their proper histological elements. Thus the muscular fibres of muscles, or the secreting cells of glandular organs, may atrophy, but owing to the coincident increase of connective tissue, the muscle or the gland may retain its size and weight. The consistence and other physical properties of the organ are, however, altered, and the functional activity impaired in proportion to the loss of these proper constituents.

Tissue Changes from Atrophy. The several tissues mentioned above present the following phenomena under the atrophic process: *Adipose tissue*, which consists of connective tissue, the cells of which are filled with large globules of fat, manifests the atrophic change by a breaking up of the larger globules into innumerable smaller ones, and their subsequent disappearance in whole or in part. The cell so vacated either returns to its primitive form, displaying protoplasm and nucleus, or becomes filled with serum. It is not unusual to find a fat vesicle occupied partly by fat and partly by serum, the latter having come in to occupy the place made vacant by the loss of fat. The *secreting cells* of glandular organs decrease in size, *muscular fibres* become soft and friable, and lose their transverse marking, and in *nerves* the medullary substance breaks up and disappears.

An atrophied structure is, as a rule, reduced in size and

weight, is firmer and dryer than natural, and comparatively bloodless. Exceptionally, it is filled with serum or venous blood; with fat or other products of degeneration. Its function is impaired.

Causes. The causes of atrophy are to be sought in those disturbances of nutrition in which the destructive overbalances the formative processes. This may depend upon: 1. Insufficient nutritive material. 2. Inability to appropriate the same. 3. Inordinate destructive changes in the tissues. In order to maintain the physiological integrity of the tissues, food of a proper kind and in sufficient quantity is necessary; there must be no obstacle to its entrance into the stomach, the functions of digestion and assimilation must be properly performed, the blood must be charged with the alimentary principles, and circulate freely, and, lastly, the tissue elements must be in a condition to appropriate to themselves that necessary to their sustenance. Either of these failing, atrophy supervenes. So, also, if, from wear and tear, the destructive changes overbalance the constructive, as in individuals who are overworked, and in certain exhaustive diseases. Atrophy frequently results under the following circumstances:—

From Functional Inactivity, as in parts long diseased, in the end of bones after amputation, in the bones of the orbit after extirpation of the eyeball, and in the muscles and nerves of paralyzed parts.

From Excessive Use or Violence, as in muscles which have been strained, and in the testicles, from excessive onanism.

From Pressure, as in the atrophy of the kidney in hydronephritis, in the bones of the skull, from hydrocephalus, and in the sternum and vertebræ, from the pressure of an aneurism.

From the Use of Drugs. Phosphorus will produce atrophy and fatty degeneration, by destroying the red blood corpuscles, and thus depriving the tissues of oxygen. Ergot produces

atrophy by constringing the smaller arteries, and thereby interfering with the blood supply. Iodine and bromine produce atrophy of the lymphatic glands and other glandular structures, in a way not well understood. It will be seen from the above that a great many atrophies are traceable directly to an insufficient quantity or quality of the blood, as this is the source from which the tissues derive their support.

Atrophy, as a physiological process, occurs in parts that have served their purpose, and are no longer needed. Thus, certain essentials of fœtal life disappear at birth, such as the ductus arteriosus and venosus and umbilical cord. Soon thereafter the Wolfian bodies, the thymus gland, and the milk teeth undergo atrophic change, and later in life the lymphatic glands, the ovaries and testes. The involution of the uterus after parturition is another example of physiological atrophy.

Consequences of Atrophy. Simple atrophy may result in recovery. Under proper conditions of nutrition the histological elements regain their substance and the tissue is restored to its normal condition. This failing, and the cause continuing, cell death results. Atrophies occurring in the fœtal state sometimes leave indelible marks. The growing tissues are moulded and formed in an unnatural direction. Thus result hare-lip, cleft palate, etc. Atrophy affecting morbid growths is often beneficial; it is one of the modes of cure.

CHAPTER V.

DEGENERATION.

Degeneration is a destructive process, characterized by a change in the *quality* of tissues. This change takes place in the tissue elements, and is, as its name implies, a degradation from the normal standard. The distinction between an atrophy and degeneration is, that the former has reference to the quantity and the latter to the quality of tissue substance. Two widely different processes are included under the head of degeneration ; both, however, agree, in that the quality of the tissue is altered. These different processes are known respectively as *infiltration* and *metamorphosis.*

Infiltration. Infiltration consists in the adding of something to the tissue which does not properly belong there, and which thereby alters the constitution of the same. The infiltrate is deposited from the blood or other circulating fluids in their passage through the tissues, and it takes its place in them, but does not become assimilated to the nature of the cellular or intercellular substance. The proper albuminoid substance of the tissue elements is displaced, separated, and crowded out by the infiltrate, and by this means the standard of the tissue is lowered—it is changed in quality by degradation. The forms of infiltration are the *fatty*, *calcareous*, *pigmentary* and *amyloid.*

Metamorphosis. Metamorphosis is altogether different from infiltration. Here there is no adding of extraneous matter to the proper tissue elements, but a *transformation* of the same, by which they become changed into another substance. Thus, an albuminoid substance may become changed into fat, not by displacement, but by an actual going over into fat. The forms of metamorphosis are the *fatty*, *mucoid* and *colloid.*

Structural Changes in Degeneration. The structural changes occurring in degeneration vary according to the particular form of the same, and will be alluded to in detail hereafter. In general terms it may be here mentioned, that the infiltrations are far less prejudicial to structure than the metamorphoses. In the former the histological elements are permeated and thrust aside by the adventitious material, possibly also atrophied, but rarely destroyed. In the latter, these elements are destroyed; converted into something else which has neither the semblance nor the properties of the original. Parts undergoing metamorphosis are usually increased in bulk, rendered softer and absorbable. Infiltrated elements are enlarged, distorted and less sharply defined than before.

Functional Capacity. The functional capacity of degenerated parts is impaired in proportion to the anatomical changes produced by it. As these changes are less pronounced in the infiltrations than in the metamorphoses, it follows that function is less impaired in the former. A complete abolition of function frequently results from metamorphosis.

Causes. The proximate cause of all degeneration is an impaired nutrition. Anything tending to impair nutrition may operate as a cause. Each form of degeneration has its peculiar cause.

Cloudy Swelling.

Cells under the influence of irritation frequently become clouded and swollen. This is known as *Cloudy swelling.* Little granules make their appearance in the interior of the cell and render it opaque and clouded. Cloudy swelling comes on suddenly, and varies in degree, from a few minute granules scattered here and there, to a perfect cramming of the cell, whereby the nucleus is obscured. The nucleus is in like manner affected, though secondarily to the cell protoplasm.

Cells so affected are opaque, swollen, indistinctly outlined and distorted, from mutual pressure. In the clear tissues, as the vitreous body of the eye, the cornea, etc., cloudy swelling is recognizable to the naked eye by the opacity which it produces.

Nature of Cloudy Swelling. The chemistry of cloudy swelling proves the minute granules which infest the cells to be an albuminate. They are easily distinguishable from fat granules by being soluble in acetic acid. Whether or no cloudy swelling is entitled to a place among the degenerations is unsettled. By some it is regarded as an albuminous infiltration, and assigned to the category of infiltrations. Others think they see in cloudy swelling an increased nutritive activity, whereby the cell is incited to take up more nutritive matter than it can dispose of. Others, still, regard it as a retrograde process in which, as the result of chemical action, the influence of heat, or diminished vitality, the coagulable principle of the cell solidifies, as in rigor mortis. Cloudy swelling does not long continue. The cell either returns to its normal state, the granules being redissolved, or it passes quickly into fatty degeneration. This latter fact would seem to give color to the opinion that it is a retrogressive change, or a transition state between the normal and that of fatty degeneration.

Causes. Cloudy swelling results from the contact of various irritants, as the mineral acids, arsenic, phosphorus; also from the presence of dropsical fluids, inflammatory transudates and septic matters. High temperature, as in fevers and inflammations, also produce it.

Examples of cloudy swelling are found in the tubal epithelium in acute nephritis, and the hepatic cells in acute atrophy of the liver, and in the epithelium of other parts under conditions of inflammation.

CHAPTER VI.

INFILTRATIONS.

Fatty Infiltration.

In fatty infiltration the cells are occupied by globules of fat which have penetrated into them from without. In the beginning a few, not to exceed two or three, minute granules of fat are seen in the immediate vicinity of the nucleus. Gradually, and by degrees, these augment in volume by the continued infiltration, until, meeting, they fuse into one large drop. By the continued increase of the fat the nucleus and protoplasm are pushed toward the periphery until the cell assumes the appearance of a vesicle filled with fat. As a rule the fatty infiltrate consists of one large globule, but occasionally it consists of two or three smaller ones.

Physical Characters. A fatty infiltrated cell does not suffer structural violence. The cellular constituents are neither disorganized nor destroyed; they are merely pushed aside and altered in form. The cell is enlarged, opaque, and tends to become spherical. When filled to repletion it appears to have lost its nucleus and protoplasm; both, however, reappear when the fat is reabsorbed.

Tissue Changes in Fatty Infiltration. Tissues that are fatty infiltrated are increased in volume and weight, but are diminished in specific gravity. They are anæmic, less elastic and doughy. When cut into they are of a light yellow color, or when the infiltration is not uniform, mottled in appearance. Oil accumulates on the knife, or may be scraped from the cut surface.

In less marked cases, unrecognizable by the naked eye, the microscope reveals the fat globules. These are black and

sharply outlined by transmitted light, white by reflected light. Ether dissolves them.

Functional Capacity. In ordinary cases the functional capacity is not materially impaired. So long as the integrity of cell constituents is preserved it matters little into what shape they are thrown. Exceptionally, a very serious impairment of function results. Such cases are due to injurious pressure.

Causes. Fatty infiltration may result from an over-production of fat or a deficient consumption of that normally produced.

How Produced. The fat of the system is produced from actual fat taken with the food, from starchy and saccharine matters, and from albuminous substances. The evolution of fat from albuminous substances, though complicated, nevertheless takes place, both in the constructive and destructive processes.

How Destroyed. Fat is destroyed by oxidation. The red blood corpuscles are the carriers of the oxygen to the tissues by which this oxidation may be effected.

It follows, then, that fat may accumulate from over-feeding, more especially if the individual be of indolent habits, as in such the circulation is less active and the oxidation of the tissues less complete. Fat in any situation may be accounted for on the score of *a relative deficiency of oxygen to the oxydizable matter.*

Physiological Fatty Infiltration. Fat is a never failing constituent of all animal bodies. In the form of adipose tissue it occurs under the skin, between the muscles, surrounding organs. It is also found in the secreting cells of the liver. Certain tissues are much more prone to fatty infiltration than others. The subcutaneous connective tissue stands pre-eminent in this respect. The sub-mucous, sub-serous and interstitial connective tissue of muscles are susceptible in the

order named. Fat is very liable to accumulate about the kidneys and heart.

Pathological Fatty Infiltration. The mere presence of fat in the tissues is, therefore, not necessarily of pathological import. It is only when it occurs in situations in which it does not naturally exist, as between the individual muscular fibres, or interlacing the individual elements of most organs, or when it is excessive in quantity, that it becomes pathological. A general excess of fatty infiltration constitutes the disease obesity.

Calcareous Infiltration.

Calcareous infiltration, otherwise known as *Calcification*, consists in the impregnation of the tissues with lime salts. It also embraces the deposition of magnesian and other salines as well. It occurs physiologically in the pineal gland, the choroid plexus, and questionably so in the cartilaginous ossification of old age. The most notable type of calcification is found in the development of bone. So far as the infiltration is concerned, the physiological process, as it occurs in bone formation, and the pathological, as it occurs elsewhere, are identical. Otherwise an essential difference obtains. The development of bone is characterized by a nutritive activity, increased vascularity, cell proliferation and methodical arrangement of parts, with a view to its future nutrition, etc. ; whereas in calcification the tissues are quiescent, and simply become a receptacle for the deposit.

All parts are susceptible to calcareous infiltration. Cells and intercellular substance alike are affected, though by no means equally. It is in the inter-cellular substance that we look for the most frequent and pronounced changes. The infiltrate appears first in the form of minute granules, irregularly scattered through the basis substance. These enlarge and multiply, often running together so as to form patches. In this way the cells are surrounded, become obscured and

lost to sight. The cells may or may not participate in the change. More frequently they do not, but are encased by the infiltrate. The degree of infiltration varies from that in which it is barely perceptible, to that in which the entire structure is converted into a calcareous mass.

Calcareous infiltration manifests most frequently in the hyaline cartilages, in the valves of the heart, the walls of arteries and capillaries. It is also frequent in the placenta, in extravasations, exudations, in thrombi, and in new formations of every kind, but especially the connective tissue new formations. It is less frequent in the skin, mucous and serous membranes, and in muscular tissues.

Physical Characters. The initial appearance of a part being infiltrated is as though it were dusted with granules. These granules are black, by transmitted light, and of various shapes. The patches subsequently formed are opaque, irregular in outline, black at the margin and brilliant toward the centre. By reflected light these bodies are of a peculiar white, in the midst of which the dim outlines of cells are discernible. After complete fusion the opacity gives way to more or less transparency. This latter effect is in accord with a well-known principle of refraction, wherein transparent matter, broken into fragments and thrown into a mass, so breaks and deflects the rays of light in their passage through it that none reach the eye; whereas, if fusion take place, and the individual particles unite to form a homogeneous whole, the transparency again returns. Pounded glass is opaque, plate glass transparent.

The chemical reactions of calcareous matter serve to distinguish it from all other substances. The stronger acids, especially the nitric and hydrochloric, dissolve it out, leaving the matrix. The presence of carbonate of lime is indicated under this test by bubbles of gas—carbonic acid;—and the bubbling is proportionate to the amount of that salt present.

The size of the infiltrated part undergoes no change, showing that the infiltrate does not displace, but enters into intimate union with, the normal elements. The density is increased, and may attain the hardness of bone.

Functional Capacity. The functional capacity of calcified parts is reduced in proportion to the amount of infiltration. The albuminous constituents are not only jugulated, but also cut off from their nutritive supplies. Aside from the devitalizing influence of calcareous infiltration, the properties of tissues are otherwise altered, so as to greatly interfere with their usefulness. Thus, in soft, pliable parts, such as cartilage, muscle; in transparent parts, such as the cornea; in elastic parts, such as the blood vessels, calcification materially interferes with function by altering the properties. Especially is this to be observed in the vascular system, because so common, wherein the vessels are converted into rigid, unyielding tubes, causing embarrassed circulation and hemorrhages, and leading to atrophies, degenerations and gangrene of the dependent tissues.

Occurring in abnormal growths, extravasations, exudations, and in the fœtus of extra-uterine pregnancy, it is beneficial, in that it arrests further development and prevents further changes.

Causes. The causes of calcareous infiltration are:—

1. *An Excess of Calcareous Salts in the Blood.* This occurs in some forms of rapid disintegration of bone tissue—caries, osteo-malacia, osseous cancer—in which the lime salts are first taken up by the blood, but being arrested in their transit through the tissues, are left as a filtrate. In this form of infiltration the blood vessels and their immediate surroundings are most frequently and most densely impregnated; the process seldom extending beyond the immediate confines of these. This form is much less common, but more generally diffused, than the next.

2. *Retardation of the Circulation.* The lime salts are held in solution by the free carbonic acid of the circulating fluids. Other acids, such as the lactic, volatile fatty and the glycerine-phosphoric, also serve the same purpose. If new combinations are formed, by which these acids are removed, the lime salt precipitates. Certain conditions of the tissue, of the intimate nature of which we are in ignorance, conduce to these changes. Such conditions are in some way associated with those nutritive impairments which predispose to fatty degeneration. Hence it is that fatty degeneration and calcification are so often associated; the latter often terminating the series of changes introduced by the former. Atrophy, old age, chronic inflammation, gangrene, for the same reason, presage calcification.

The selective point for this form of infiltration is in the extra-vascular territories; either in tissues not supplied with blood vessels, or in the spaces included between the capillary vessels. With a sluggish circulation the nutrient fluids outside the vessels also move slowly, or become stagnated in their transit through the tissues. The carbonic acid, being diffusible, leaves them here, and allows the now no longer soluble salts of lime to precipitate. This form of infiltration, as will be seen, differs from the preceding as regards the site of the deposit, being in this instance in the regions beyond the vascular limits, and in that, confined to the vessels and their immediate vicinity. This is also the most common form of calcareous infiltration.

Pigmentary Infiltration.

Pigmentary infiltration or *pigmentation*, consists in the impregnation of tissues with the coloring matter derived from the blood.

All the coloring matters of the body are derived from the hæmoglobin of the blood. This coloring matter, variously

modified, exists physiologically in the bile and urine, imparting to them their characteristic tints.

The choroid coat of the eye, the rete mucosum of the skin, the sheaths of the cerebral vessels, the epithelial cells of the choroid plexus and the rich yellow of the corpus luteum, are all examples of physiological pigmentation. The excess of pigmentary matter finds its way out of the system in the biliary and urinary secretions. Normally pigmented structures appropriate pigment matter from the blood as a part of the general nutritive process, in which respect the physiological differs from the pathological process, wherein the pigment matter is thrust upon the tissues. Pathological pigmentation may, however, result from an excess of the normal process, or from an inherent tendency of morbid structures to appropriate pigment.

Pigment occurs in the form of granules, crystals, and in a state of diffusion. It was formerly supposed that the coloring matter of the blood became dissolved in the liquor sanguinis, and diffusing among the tissues, stained them, thus giving rise to diffuse pigmentation as the first stage of the process. It was furthermore believed, that as the liquor sanguinis disappeared by absorption, the coloring matter left behind gathered into granules and crystals, and constituted the last stage of the process. Recent investigations have shown that hæmoglobin never dissolves in the blood serum except after the death of the blood corpuscle, and that, so far from diffuse pigmentation being the first stage of the process, it is in reality the last, and results from the breaking down of the granules and crystals preparatory to their disappearance. It seems that pigmentation occurs in the following manner. Certain cells, epithelial or other, take into themselves a limited number of red blood corpuscles; these red corpuscles in time become dried and mummified, and the coloring matter remains in the form of granules or crystals.

In this way it remains indefinitely, or becoming pulverized and disseminated, gives rise to diffuse pigmentation.

The period required for the transformation of hæmoglobin into granular or crystalline pigment—*hæmatoidin*—varies from a few days to several weeks. Pigmentary infiltration occurs for the most part suddenly. It affects both cells and intercellular substance, but much more frequently and most markedly, the cells. Even in the cells a predilection exists for certain parts, the nucleus and cell wall escaping while the protoplasm is thickly bestrewn. Exceptionally, the nucleus is the exclusive seat of the deposit, but the cell wall never. All vascular tissues are subject to pigmentation; those parts in proximity to the vessels more so than those further removed. The reason for this will be apparent when the cause is considered. Pigmentation is frequently witnessed in epithelial, endothelial, and gland cells, in connective, muscular, and nervous tissues, also in many morbid growths. The cells of new growth often show a selective affinity for pigment, taking it directly from the blood. In the majority of instances, however, the pigment is derived from extravasated blood or exuded blood corpuscles.

Physical Characters. *Granular* pigment occurs in finer or coarser granules, which are irregular in shape, sharp in outline, and highly refractive; the larger granules being somewhat bright and the smaller dull and opaque. The color varies, being at times yellow, red or black, or of various intermediate shades. The granules which may be grouped or isolated are usually angular, or elongated, in form.

Crystalline pigment is in the form of regular, oblique, rhombic prisms, rarely acicular. The crystals are, for the most part, exceedingly small. They are sharp cut, strongly refractive, somewhat glistening, and more or less transparent. *Diffuse* pigment produces a more or less uniform coloration of the tissues, the color being yellow or reddish yellow.

The color of the pigment depends in part on its age, and in part on the chemical influences to which it is subjected. As a rule, the older the infiltrate the darker it becomes; very old deposits being quite black. On the other hand, the tissues into which the infiltration occurs govern, to a great extent, its color, probably by chemical influence. This is strikingly manifest in physiological pigmentation, wherein the pigment is wont to assume a definite color owing to local causes. The form in which pigment occurs, whether granular or crystalline, also seems to depend on local influences, as it is almost invariably crystalline in the brain and ovaries, and as constantly granular in the lungs.

Tests for Pigment. Hæmatoidin is insoluble in water, alcohol, ether, and the dilute acids and alkalies. Treated with concentrated mineral acids a play of color is produced, commencing with a brownish red and shading off into green, blue, rose, and finally a dirty yellow. This will be recognized as being similar to the reaction of biliary coloring matter treated in like manner.

Causes. Pigmentation occurs in two ways. The tissue elements select the coloring matter from the blood, or the coloring matter is thrown out into the tissues by extravasation or otherwise. The first method is not common in pathological pigmentation. The manner in which the hæmoglobin finds its way into the tissues differs. By far the most common method is by rupture of the vessels and extravasation of blood. Occasionally, under pressure, the red blood corpuscles traverse the walls of the vessels by diapedesis, or even free coloring matter may do the same. The condition of the vessels and circulation in inflammation is favorable to the process; hence the frequency of pigmentation following inflammation. All conditions favoring extravasation of blood, distention of the vessels, or weakness of their walls, act as accessory causes of pigmentation. Pigmentation often occurs

in the course of nervous diseases, and is probably referable to some derangement of the vaso-motor system, and the consequent weakening of the vascular walls. Extravasations of blood are not always followed by pigmentation, because the hæmoglobin being absorbable, is removed before it becomes transformed into hæmatoidin, or true pigment. Thus do rapidly disappear the effusions beneath the skin. Once formed, however, it is very persistent, often remaining for years. Its stability depends much on the situation and character of the infiltrated part, owing to the facility with which chemical influences and reabsorption can be brought to bear. Pigmentary deposit is a valuable indication of a preëxisting hemorrhage, or an inflammatory stasis, and is sometimes the principal landmark which leads to their recognition.

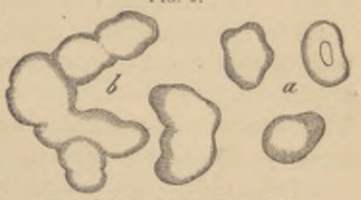
Amyloid Infiltration.

Amyloid infiltration consists in the infiltration of the tissues with a colorless, translucent, homogeneous, albuminous substance, of the consistence of solidified lard or wax. It is known as *lardaceous*, *waxy*, and *vitreous* infiltration. It affects both cells and inter-cellular substance, and though not confined to any set of tissues, is much more frequent in some than others. The spleen, liver, kidneys and lymphatic glands stand foremost in this respect, whereas other tissues and organs are only exceptionally, and for the most part secondarily involved. It is extremely rare in ordinary connective tissue and bone. Next to fatty degeneration it is the most common of all the degenerative changes. The process commences in the smaller arteries and capillaries, first affecting the innermost coat, and extending thence outward in ever-widening circles until a zone of infiltration embraces the vessel and its surroundings. By the meeting and blending of these zones, an entire organ may be involved, though, as a rule, such is not the case; the infiltrate being disposed in

tracts representing the course of the vessels, or in areas of greater or less magnitude. Tissues and organs widely separated are simultaneously affected, and as the deposit occurs in the course of the blood vessels, the indications are strong in favor of an hæmatogenous origin.

Physical Characters. The infiltrating substance is colorless, translucent, homogeneous, and slightly opaline. Cells affected swell up, become less angular, more plump and squabby, and tend to become spherical. They sometimes attain a size equal to twice that of the normal. If two or more are in contact they fuse and lose their individual identity. The inter-cellular substance suffers a like change, whereby it becomes homogeneous and waxy. The appearance of amyloid infiltrated tissues under the microscope is quite characteristic, but may be made yet more convincing, by the addition of reagents. A thin section, washed so as to deprive it of blood, and subjected to the action of an aqueous solution of iodine, turns reddish brown or a mahogany red. This, in itself, is decisive, but if, now, a drop of sulphuric acid be gradually and carefully added, the color changes to a blackish blue or violet. Much care and repeated trials are sometimes necessary to insure the success of the last-named test, and even then it is sometimes long delayed. As the first test is all-sufficient to differentiate it from all other known substances, the second or complementary test is seldom resorted to. The color thus produced is sometimes evanescent, sometimes lasting.

FIG. 2.



AMYLOID INFILTRATED CELLS.

Naked-eye Appearances. Tissues densely and extensively infiltrated may be recognized by the naked eye. They present on section a waxy, more or less lustrous appearance,

devoid of color, and homogeneous or mottled, according as the deposit is uniform or in patches.

Organs thus affected are larger, plumper, denser, heavier, tense and doughy. They are notably bloodless. An aqueous solution of iodine being poured over the cut surface develops the characteristic mahogany red.

Functional Capacity. The functional capacity of an organ is impaired according to the extent and situation of the infiltration. The causes of this impairment are:

1. *Interference with the blood supply.* Inasmuch as the process of infiltration commences in the walls of the smaller arteries and capillaries, these are the first to manifest changes. They become swollen and diminished in calibre, and in extreme cases entirely occluded. The circulation is still further interfered with by the pressure of the extra-vascular deposits. Hence the greatly reduced blood supply, and the consequent anæmia, so characteristic of amyloid infiltration.

2. *Displacement of the proper living elements.* The pressure of this lifeless material in and around the cells serves greatly to impede and embarrass them in their functional activities. Owing to the impaired nutrition, amyloid infiltration is often accompanied by other degenerative changes, especially the fatty. By some the amyloid change is regarded as a transition state between healthy tissue substance and fatty metamorphosis.

Nature and Causes. Little is known as to the intimate nature and cause of amyloid infiltration. It seems in some way to be dependent on a dyscrasia, inasmuch as it occurs so generally as a secondary affection in the course of exhausting diseases.

So frequently, indeed, is it associated with long continued suppuration, as to impel to the belief that it is, in some way, dependent on the same. Especially is this evident in those affections of bone which extend over such long periods of time, and which are attended by such profuse and long con-

tinued suppuration. Other degenerative processes, such as chronic pulmonary phthisis, chronic intestinal ulceration, chronic pyelitis, pyæmia, and in fact any and all slowly progressing and profuse suppurations, frequently lead to amyloid infiltration.

Prominent in the list of causes must be placed syphilis, and especially those deeper forms of it which are attended by destructive changes.

It has already been intimated that the infiltrate of this affection is not, as its name implies, a starchy substance. Neither is it fatty, nor waxy, but, on the contrary, an *albuminous substance.*

That it is not of the nature of starch, fat, or cholesterine, or of cellulose, as once supposed by Virchow, its reactions fully attest.

Starch treated with iodine becomes blue; cholesterine treated with sulphuric acid becomes reddish brown, but neither is starch affected by sulphuric acid, nor yet cholesterine by iodine. Cellulose treated with iodine and subsequently with sulphuric acid becomes blue, and in this respect more nearly approaches the amyloid reaction than either of the others. But amyloid substance first becomes *mahogany red* upon the addition of iodine, and subsequently blackish blue, or violet, upon adding the sulphuric acid.

Until quite recently the most plausible theory with reference to the nature of the amyloid material was that advanced by Dickinson, who based his theory upon the following premises: 1. Fibrin, extravasated and left at rest in the tissues, is prone to take on the physical characters and chemical properties of amyloid substance. 2. Fibrin, deprived of its alkaline salts, likewise attains these properties. Now, as pus is rich in alkaline salts, especially the salts of potassa, and as amyloid infiltration follows so constantly in the wake of prolonged and profuse suppuration, it is an easy step to the fol-

lowing conclusion: Amyloid material is indistinguishable from fibrin deprived of its alkaline salts. Amyloid infiltration follows suppuration, in which these salts are drained off from the blood; hence the amyloid infiltrate consists of dealkalized fibrin. Very recently, however, Budd has pretty effectually disproved the above theory, and substitutes the following: There exists in the blood normally a substance—*distropodextrine*—"which agrees with amyloid material in its most specific characteristic," and all that is necessary to an amyloid infiltration is that this substance becomes insoluble and deposited in the tissues.

It has been assumed that amyloid degeneration is an infiltration and not a metamorphosis. The principal reasons for believing it such are: 1. It occurs primarily and constantly in the track of the nutrient fluids in their passage from the small vessels to the tissues. 2. It manifests simultaneously at many different points in widely separated structures, and when the local conditions are extremely unlike. 3. It follows in the course of diseases, in which there is much reason to believe blood changes must occur.

CHAPTER VII.

METAMORPHOSES.

Fatty Metamorphosis.

Fatty metamorphosis consists of a change of the proper substance of histological elements into fat. The fat here is not derived from the blood or any other external source, as is the case in fatty infiltration, but originates within the part by an absolute transformation.

The albuminoid matter that constitutes the tissues represents so much fat intimately combined with other matters. In fatty metamorphosis this union is broken up, the fat going to itself and the other matter to itself. The exact nature of this change is not definitely known. For facility of description fatty metamorphosis may be divided into stages :—

First Stage—Cream. In this, as in fatty infiltration, a few minute granules or globules of fat appear in the interior of the cell, around the nucleus. These, as the process advances, multiply in numbers, but do not fuse into large drops, as in that instance. When, at length, the process is complete, the entire cell, including the nucleus and cell wall, consists of these little globules of fat, partitioned off one from another, and yet held together by an intermediate albuminous cement. The cell has now a mulberry-like appearance. In this condition it is known as the *granular corpuscle*, because of its appearance. It was formerly known as the inflammatory corpuscle, because having been found in inflammation, it was supposed to be pathognomonic of the same. We now see in it a fatty metamorphosed cell, that may accompany inflammation,

Fig. 3.

GRANULAR CORPUSCLES.

in common with divers other processes. The granular corpuscle is found in the first milk of the mother—colostrum—and indicates that the process of milk-making is not thoroughly established. If colostrum is allowed to stand the granular corpuscles arise to the surface as a cream.

Second Stage—Milk. The next step is the solution of this cement that binds these little globules together. The alkaline fluids in which the tissues are bathed are all-sufficient for this purpose. As this solution is accomplished the little globules are liberated, and one by one, or in clusters, leave the granular corpuscle and distribute themselves in the surrounding fluids. Finally the granular corpuscle disappears; but the fluid, impregnated with molecular fat, has now become an emulsion. This emulsion, like all fatty emulsions, is white and milky. Indeed, milk is a fatty emulsion, and the process of its formation tallies perfectly with the description given above. The secretion of the mammary gland depends upon the fatty metamorphosis of the epithelial cells lining the acini, which at first assume the characters of granular corpuscles, but subsequently being dissolved in the serum, constitute true physiological milk.

The cerumen of the ear, the sebaceous secretion, and the meibomian secretion of the eyelids, are other examples of fatty metamorphosis for physiological purposes. Fatty emulsion is capable of resorption. This is proven by injecting milk into the peritoneum of a rabbit or other animal, when it will be observed to quickly disappear by absorption. It is only by fatty metamorphosis and conversion into pathological milk, that pus and many other products of inflammation and degenerative change are rendered capable of absorption, and disposed of through the vascular channels. But the conditions may not be favorable to absorption. The surrounding parts may be in a state of inflammation, which precludes absorption; they may be illy provided with blood

vessels or lymphatics, as when enclosed with a dense fibrous membrane. The circulation may be impeded by obliteration of the lumen of the vessels, as in tuberculous deposits, or there may be such a massing of cells that those in the interior are shut out from the circulation, as in tubercle and cancer. In either event other changes await the fatty degenerated mass, and this brings us to the

Third Stage—Cheese. Gradually the moisture departs, and the mass becomes dryer, firmer, smeary or unctuous; in short, cheesy. The process by which this is brought about is called *caseation*, because it is a veritable cheese-making process. Caseous matter used to be regarded as tuberculous matter, because so often found in tubercular deposits. We now know it to be fatty degenerated matter that has dried up, and look for it in all cases of fatty degeneration in which the detritus is not amenable to speedy removal, and in which it is deprived of its moisture. A caseous mass may undergo resolution. This can occur only from the presence of moisture, which is either absorbed or evolved by chemical change in the caseous mass. The resultant matter is fluid, curdy, and much resembles pus. It is to some extent absorbable, but usually finds its way to the surface through destructive inflammation, or is liberated by the knife. The discharge from scrofulous lymphatic glands is a familiar example of softened caseous matter.

Under the microscope it presents broken-down cells, fatty debris, and cholesterine crystals. This softening takes place much more rapidly in situations exposed to the action of air and moisture, as in deposits along the alimentary canal, the air passages, or any of the cavities of the body communicating with the surface. Caseous matter environed by dense and non-vascular tissues, or encapsuled, as it sometimes is, by fibrous tissue, may exist indefinitely without further change. Exceptionally, another change is inaugurated

Fourth Stage—Soap. The fat here combines with the free alkaline ever present in the body, to form soap. In so doing the cholesterine held in solution by the oil globules is thrown down in the form of imperfect rhombic plates, which are soluble in sulphuric acid. Finally a dirty white pulp, or if more thoroughly dessicated, a brain-like deposit, is all that remains.

Physical Characters. The physical characters of fatty metamorphosed elements and tissues vary according to the stage. These have been adverted to under their separate heads. The cell, as in infiltration, is enlarged, opaque and spherical. Cells firmly fixed in a basis substance, as in certain connective tissue substances, do not become spherical or retract their processes, but retain their natural form. Disorganization and loss of structure attend fatty metamorphosis and are proportionate to the extent of transformation. The tissue changes are very similar to those described under infiltration, but exhibit more friability and less cohesion. The principal distinction between fatty infiltration and fatty metamorphosis lies in the number and size of the globules which the cell contains. These being few in number and of large size in infiltration, numerous and small in metamorphosis.

Functional Capacity. The functional capacity is impaired in proportion to the extent of the metamorphosis, being totally extinct in advanced cases.

Causes. The primal cause of fatty metamorphosis lies in imperfect oxygenation of the tissues, and of nutritive disturbances of a nature not well understood. Oxygenation of the tissues may be interfered with in one of several ways :—

1. The circulation may be impeded, by which the blood fails to reach the tissues in adequate quantities.

2. The aeration of the blood may be imperfect, and the red blood corpuscles themselves not being properly oxygenated, cannot impart sufficient oxygen to the tissues.

3. The red blood corpuscles may be deficient in numbers, from having been destroyed or lost.

As an example of the first, we have embolism, say of one of the cerebral arteries;—as a result, fatty degeneration of that part of the brain deprived of its blood.

As an example of the second, pulmonary phthisis, in which the diminished lung capacity is inadequate to the proper oxygenation of the blood;—as a result, fatty degeneration of the liver and other structures.

As an example of the third. Destruction of the red blood corpuscles by phosphorus, or their loss by hemorrhage;—as a result, fatty degeneration of various organs.

Mucoid Metamorphosis.

This is a transformation of the proper constituents of the tissue into *mucin*, a substance identical with that found in the secretion of the nose and other mucous passages. This secretion is the result of a mucoid degeneration of the secreting cells. Its type is found in the tissue which abounds in the fœtus, and, indeed, is the primitive state of all connective tissue substances before the hardening of the inter-cellular substance.

The umbilical cord, at birth, presents a beautiful example of mucous tissue in the gelatine of Wharton. The vitreous humor of the eye also consists of the same. This latter is the only physiological example of mucous tissue in the adult. Mucoid metamorphosis affects more especially the inter-cellular substance of tissues. The cells are, however, occasionally affected in like manner. It affects principally the connective tissue substances, such as cartilage, serous membranes, bone, also fibrinous exudations, especially those occurring in the air passages; also new growths, such as enchondroma, lipoma, sarcoma and syphilitic nodes. The inter-cellular substance of cartilage and bone first becomes fibrillated or broken up into shreds and then passes over into mucin. In bone the lime salts are re-absorbed previous to, or coincident with,

the fibrillation. This fibrillation of the inter-cellular substance, together with its subsequent conversion into mucin, stamps the changes as purely retrogressive, and indicates that the tissues are returning, step by step, to the primordial state as found in the fœtus. It is an interesting fact in this connection that the articular and costal cartilages of very old people are prone to this change, and accords with the common sentiment that man in his dotage is remanded to a second childhood. Mucoid metamorphosis affects either the surface of structures or may be deeply imbedded in their substance; in the latter event a circumscribed mucoid softening in the midst of unaltered tissues presents the appearance of a cyst; for which it is often mistaken. This form of degeneration is comparatively infrequent.

Physical Characters. Mucin, the product of this change, very closely resembles albumen, both in its chemical and physical properties. Fully formed, intercellular substance yields, upon analysis, gelatine and chondrine. We should naturally look for these substances, or a close approach to them, in this degenerated material. Such is not the case. That change which occurred in the developmental process, by which the albuminates derived from the food became converted into the gelatin and chondrin of the tissues has been reversed, and the product is much nearer albumen than either of those substances. It resembles albumen in that it exists diluted only in alkaline fluids, and in being precipitated by dilute acetic acid. It differs from it, in not containing sulphur, in not being soluble in an excess of acetic acid, and in not being thrown down by heat, tannic acid, or bichloride of mercury. Its indifference to the two latter reagents serves to distinguish it chemically from gelatin and chondrin, both of which are precipitated by them. Mucin is colorless, transparent, homogeneous and viscid. It possesses remarkable hygrometric properties. The avidity with which it imbibes

water greatly affects its consistence. Deprived of fluid, it is of the consistence of half-set glue or jelly, but just in proportion as fluid is admitted to it, it absorbs the same, swells up, and becomes diffused. It may now be mucilaginous or quite fluid, possessing a little viscidity. Though capable of indefinite dilution, it never dissolves. It is incapable of absorption, and cannot pass through animal membranes. If, therefore, it form in the depth of tissues, it remains permanently imprisoned until it is either liberated artificially, or suffers a further chemical change by which it becomes absorbable. As it is never found in the blood and cannot transude the tissues, it must be formed on the spot where found, and cannot, therefore, be an infiltration. Parts affected by mucoid softening are tumid and formless. Cells either undergo no change, are destroyed, or stimulated to proliferation.

Functional Capacity. This suffers either from a destruction of the cellular elements, or from a loss of consistency in the intercellular substance, where this is essential to the well-being of the part, as in cartilage and bone. Otherwise, there may be no impairment of function.

Causes. Nothing is known as to the cause of mucoid degeneration.

Colloid Metamorphosis.

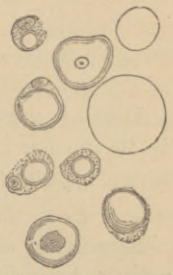
Colloid metamorphosis is the transformation of the albuminoid constituents of cells into *colloid* matter; excepting in those cases where the entire cell contents simultaneously go over to the colloid state, it commences as a small lump of colloid matter in or near the nucleus, which gradually extends its borders until the cell wall is reached. This crumbles and liberates the colloid mass. Sometimes a number of foci appear, scattered throughout the cell, which subsequently enlarge and coalesce. The liberated colloid material melts and fuses with that from other cells, and thus may be formed a mass appreciable to the naked eye. In connective

tissue substances the inter-cellular substance serves, for a while, to keep apart the degenerated cells, but usually liquefies and is absorbed, or undergoes the mucoid change. When the partition is not entirely abolished it is frequently broken through in such a manner as to form a system of communicating channels between the degenerating cells. Fatty degeneration often goes hand in hand with the colloid change. In course of time the colloid matter liquefies and forms watery fluid. This, if encysted, may deceive as to its nature and origin. The colloid change is seen with greatest frequency in the thyroid gland, but seems to show a predilection for ductless glands in general. It occurs, however, in the choroid plexus, in muscles, in serous and mucous membranes, and the secreting glands. In short, it may occur wherever cells exist. Many morbid growths, especially those of the connective tissue type, are prone to the colloid change. Some growths exhibit this tendency so early as to win for them the title of colloid growths. Such is colloid cancer. It is always, however, a secondary change, and the result of transformation of the proper cell substance into colloid matter.

Physical Characters. So great is the resemblance of colloid to mucoid metamorphosis, and so frequently are they associated, that they long passed as one and the same. They are nevertheless distinct. The principal points of difference are: The colloid change affects the *cells;* whereas the mucoid affects chiefly the *intercellular substance;* colloid matter contains sulphur, the mucoid does not; colloid matter is not affected by acetic acid, the mucoid precipitates. Otherwise these two substances bear a remarkable resemblance to each other. They are both homogeneous, colorless, somewhat translucent and jelly-like. They both imbibe fluids with great facility, swell up and become diaphanous, and approach to the character of liquids. Both reside in alkaline fluids.

In heaps of colloid changed cells an amber tint is conspicuous; such a mass is at first firm and glue-like, strongly refractive and glistening. It subsequently loses its tint and liquefies. The exact nature of colloid matter is not known. Some have supposed it to be albumen surcharged with chloride of sodium, by which it is rendered insoluble in acetic acid. It is better known by what it is not, than by what it is. Thus it is distinguishable from amyloid matter by its indifference to iodine and sulphuric acid; from mucin from its want of coagulability by acetic acid; from albumen by the same.

FIG. 4.



COLLOID CHANGED CELLS.

Functional Capacity. As colloid changed cells are always destroyed, so also are their functions.

CHAPTER VIII.

DEATH.

Death is the extinction of life. It may be *general* or *local*. In the former instance it affects the whole organism; in the latter, a part of it.

General Death.

General or somatic death occurs either suddenly or gradually. It is rarely instantaneous throughout the whole organism. Usually it passes over the body like a wave, affecting successively different systems or apparatuses. The cerebral functions, circulation or respiration, may either be the first to signal the approach of somatic death. This has given rise to the classical arrangement of death commencing at the head, heart, or lungs. In the vast majority of cases the heart continues to act after respiration and cerebration have ceased. The order of succession in which functions disappear varies. The mind may go out early or be retained to the last. Motion and sensation may be abolished together, or either may be abolished long before the other. The following is the usual order in which the phenomena of approaching death present: The voluntary muscles yield before the involuntary. The sphincters cease to offer resistance to the propulsive power behind, and permit involuntary discharges. Liquids introduced into the throat, fall into the stomach with a rumbling noise—this, on account of the paralysis of the muscles of deglutition. The arteries retain their contractility longer than the heart, and force the blood through and out of them into the venous system. The arteries are empty in death. Of the senses, hearing and touch linger longest. The dying man hears when he can neither see nor speak. As a rule the

approach of death is signaled by unconsciousness, slow, laborious, and irregular respiration; by rapid, feeble, sometimes intermitting, pulse; by muscular flaccidity, sunken features, dilated pupils, coldness, great pallor, or even purple suffusion of the skin, tracheal râles, clamminess. The temperature generally rises, in the last moments of life, from one-half to two degrees. Exceptionally it falls below normal, as in cholera or collapse.

Local Death.

This is the death of a part of the organism. It may affect the structures in bulk—*gangrene*, *mortification*, or *necrosis*—or may be confined to the cells or elementary parts of tissue—*molecular death*, *necrobiosis*. The dead part, if it consist of bone, is called a *sequestrum;* if of soft tissues, a *slough*.

Structure in Death. A dead part retains its structural characters for a variable period. Not only are the physical characters preserved, as color, consistence, form, but also its anatomical characters, and more intimate composition. It is because of the preservation of structure after death that we are enabled to dissect and recognize the different parts. Sooner or later changes occur, as a prelude to which we have—

Rigor Mortis. Rigor mortis, or cadaveric rigidity, is the stiffness that ensues after death. Its most prominent feature is a firmness and shortening of the muscles. This is similar to that witnessed in muscular contraction. The period at which it manifests is from six to twelve hours after death, and it continues from twenty-four to forty-eight hours. It may come quickly; in a few moments after death, and disappear rapidly. It may be well marked, or scarcely recognizable. The time of its appearance, its intensity and duration, depend much on the cause of death, and the state of muscular nutrition at the time of death. Generally speaking, in death from exhaustion, from sunstroke, lightning, or carbonic acid, there is little disposition to post-mortem rigidity.

Though sometimes inappreciable, it is probably never absent. It has come and gone quickly, and been slightly marked. In death from acute diseases, or in those stricken down in health, it is strongly marked; in such it comes tardily and disappears slowly.

Nature of Rigor Mortis. The rigor after death is due to a coagulation of a coagulable principle in the muscular tissue —*myosin.* It occurs in both the voluntary and involuntary muscles, and, in fact, is not confined to the muscular tissue. The protoplasm of all tissues undergoes a like change. It is the first step towards disintegration, and occurs immediately nutrition ceases. A stiffness similar to, if not identical with, cadaveric rigidity, takes place in muscles from which blood has been excluded. It has been witnessed after ligation, and after long exposure to cold. If not continued too long the normal condition is restored again by admitting the blood.

Disintegration. After death comes disintegration. The vital powers being withdrawn, there is nothing now to oppose the mechanical and chemical agencies that prey upon all inanimate matter. Life has been defined as a state of chemical tension, in which the chemical elements are forced into unnatural combinations; with death this order of things ceases and the elements seek their natural affinities. The conditions favoring decomposition are *heat*, *moisture* and *atmospheric air.* In the absence of heat decomposition cannot progress. The dead bodies of animals found imbedded in the ice banks of the frigid zone, unaltered after many years, strongly attest this. In the absence of moisture decomposition is arrested and dead parts dry up, or become mummified. This sometimes occurs in tissues from which the fluids have been withdrawn, and in tissues exposed to rapid evaporation by the destruction of the epidermis and the application of dry heat. The blood, the lymph, and the residual fluids of the

body constitute about eighty per cent of its entire weight. These are in themselves sufficient to dissolve its structures. Exclusion from atmospheric air will also retard decomposition. A dead body *in vacuo* will preserve indefinitely provided the process of decomposition have not already begun. The air furnishes oxygen to hasten chemical changes and lowly organisms which facilitate putrefaction. Soft tissues disintegrate more rapidly than denser ones, because they contain more fluid. The same may be said of the tissues surcharged with blood or lymph, or bathed in serum. The epidermic covering of the skin being impervious to fluids, retains the moisture and facilitates decomposition. On the other hand, very hard tissues, such as teeth, bone, cartilage and tendon, yield slowly to disintegration, because of the absence of moisture.

FIG. 5.

GANGRENOUS DISINTEGRATION OF TISSUES.

a. Blood-corpuscles. *b*. Smooth muscular fibres. *c*. Striated muscular fibres. *d*. Breaking up of the same.

Order of Decomposition. The order of decomposition is as follows: The blood-corpuscles, fat cells, gland cells, and epithelium first, next the muscles and nerves, after these, connective tissue and cartilage, finally elastic tissue, bones and teeth.

Ultimate Changes. With the destruction of blood corpuscles the coloring matter is liberated, and becoming dissolved in the liquor sanguinis, permeates the surrounding tissues, staining them. This staining, first noticeable in the lining of the heart and vessels, next appears externally in the course of the vessels, and thence becomes generally diffused. The intensity of staining is proportionate to the amount of blood in the gangrenous part. Tissues undergoing decomposition become clouded and swollen, then break up into

colorless particles—*gangrenous detritus*. As a result of decomposition we have the *gangrenous ichor*, consisting of water, in which is suspended the detritus of tissues, and finally gases,—ammonia, carbonic acid, nitrogen, and sulphuretted hydrogen.

Physical Characters. Gangrenous parts are devoid of motion, sensation, and muscular tonicity. The skin is cold and dry, the underlying parts flaccid and boggy, and, according to the amount of fluid contained, tumid or shriveled. As decomposition advances discolorations occur, which may be ashy, or of a reddish, brownish, or greenish-black hue. They may follow the course of the vessels, or, being diffused, present a mottled surface, or a uniformly diffused staining. As the fluids accumulate the tissues become sodden and œdematous, and the cuticle is raised into blisters or blebs; the contents of which are more or less highly colored. As gases form, a disagreeable odor is given off, and on pressure, emphysematous crackling is elicited. In *dry gangrene* the parts are hard, dry, wrinkled and charred.

Causes. Gangrene is due to an arrest of nutrition. Two things are essential to nutrition: 1. That the nutritive material be furnished the tissue elements. 2. That the same be appropriated by them. Either failing nutrition is not accomplished. We then seek for the causes of death in one or both of these conditions.

Supply of Nutritive Material. Nutritive material is carried to the tissues by the blood. As it is essential that the blood not only carry to, but also from, the tissues, therefore, as an agent of nutrition, *the blood must be in circulation*. A stagnation of the blood in any part, if long continued, is equivalent to an arrest of nutrition in that part, and is necessarily followed by death as soon as the nutritive materials on hand are consumed. Impediment to the circulation of the blood may arise in the heart, the arteries, the capillaries, or veins. The

heart may be weakened from degenerative changes, or its propulsive power interfered with by valvular lesions. The *arteries*, *veins* and *capillaries* may be pressed upon from *without* by morbid growths, exudations, hemorrhagic extravasations, bandages, ligatures. They may be plugged *within* by thrombi, foreign bodies, emboli. Their walls may be thickened, or their calibre diminished, by inflammation, degenerative changes, etc.

Ergot, for instance, produces a tonic contraction of the arterioles, thus reducing their calibre, and impeding the onward flow of the blood. The vessels may be cut or lacerated, thus allowing the blood to escape before reaching the tissues. But, by what means or manner soever a stoppage of circulation is effected, if it be complete and permanent, the effect on the tissues is the same—they are deprived of nutrition ;—they die. A weakened heart power is seldom in itself sufficient to cause local death. This, conjoined with arterial or capillary obstruction, is a frequent cause. If the obstruction appear in the arterial tree, and the influx of blood be prevented, the outflow being free, *dry gangrene* ensues. A venous obstruction seldom suffices to produce gangrene, inasmuch as the nourishing fluids reach the tissues through the arteries, and find exit through the many collateral branches of the venous system and the lymphatics.

In parts connecting with the general system by an isthmus, as in strangulated hernia, or a pendulous growth, this is possible. Also where a bandage encircles a member or part.

Appropriation of Nutritive Material. If, from any cause, a disability on the part of the cells to appropriate aliment exists, nutrition is not accomplished. This may be due to disease or injury, by which they are directly deprived of life; as in crushing, tearing, cutting, or through the influence of heat, cold, or chemical agencies.

Arrest of Gangrene. A gangrene becomes arrested the instant it reaches a point accessible to the nutritive fluids, and where the histological elements are in a condition to appropriate the same. The dead part then becomes as a foreign body, and measures are instituted to effect its riddance. This is done by throwing out a wall of partition between the living and the dead; *the line of demarcation.* It consists of inflammatory products, which have undergone more or less organization. This line is red, swollen, and sensitive; and being removed by ulceration and suppuration, allows the slough to drop off. When the gangrenous part is deep-seated, as in bone, a track or sinus is opened to the surface through which it is discharged. The line of demarcation, instead of dissolving sometimes develops into a fibrous substance which envelops and fences off the dead from the living. The encapsuled mass may gradually undergo changes, and in the end becomes absorbed or calcified. Gangrene arrested by a line of demarcation is called *circumscribed gangrene*, in contradistinction to *diffused gangrene*, in which there is no tendency to arrest.

Senile Gangrene. This is the gangrene of old age, and is dependent on weakened heart action and degeneration of the arterial walls. It occurs, for the most part, in the remote parts of the body; the toes or feet, and generally follows some trivial injury, such as the paring of a corn, a slight abrasion, or the irritation from an ingrowing toe nail. It is usually of the dry variety.

To Distinguish Real from Apparent Death.

Individuals sometimes lapse into a state of vital torpidity, the very semblance of death. The horrible possibility of being buried alive stimulates to the inquiry of differentiation between this and real death. *The only sure sign of death is decomposition;* the only safeguard, to hold the subject un-

til this has declared. Other diagnostic criteria, of greater or less value, are cited below. The apparently dead have circulation and respiration, though these functions are performed so quietly as to escape observation, and, indeed, often to baffle detection by the closest scrutiny. Patients thus affected often hear and are conscious of all around them, but are totally unable to manifest any signs of life. This state may continue for days.

To Determine Respiration. Place a feather or lighted taper over the mouth, or a glass of water upon the epigastrium ; respiration will be indicated by motion communicated to these. A cold mirror held before the mouth will become tarnished, if the patient breathes.

To Determine Circulation. Try careful and prolonged auscultation of the heart; thrust a fine long needle into the ventricle and observe if any motion be communicated to the same. The sphygmograph may reveal arterial circulation. The arteries being empty in real death, bleeding from a cut temporal artery will indicate life. A thread tied tightly around the finger will indicate circulation by redness or turgescence at the end of the finger.

To Determine Muscular Excitability. Apply irritants to the skin ; mustard, burning sealing-wax ; sternutatories, tintillation to the mucous membrane of the nose and eyes; cringing, sneezing, or motion of the eyelids, indicates life. Try electricity. The electro-muscular excitability disappears in from one and a half to three hours after death.

To Determine Nutritive Action. Destroy the epidermis by rubbing, burning, or by irritants ; if redness supervene, if the parts become covered with moisture, or vesicles form, nutrition is not abolished ; the patient is not dead. A dead part denuded of epidermis becomes dry, leathery, and if burned, charred. The failure of any of the above measures

to evoke signs does not necessarily indicate death; rather their success indicates life.

The eye is the best indicator of commencing decomposition. If this be dull, dry, flaccid; if dark spots or dark rings form in the sclerotic, around the cornea, decomposition is in progress.

CHAPTER IX.

MECHANICAL AND FUNCTIONAL DERANGEMENTS.

Diseases in running their course are characterized by certain manifestations, symptoms and signs, by which we are enabled to recognize them, to obtain some insight into their nature and tendencies, and to differentiate one from another. Some of these are of such frequent occurrence and so conspicuously prominent in so many disease processes as to entitle them to separate consideration. The more important of these will be considered under the head of mechanical and functional derangements.

Hyperæmia.

Hyperæmia is an over-filling of the blood vessels. It affects either the arteries or the veins, and in limited regions, sometimes both at once. The surplus of blood in hyperæmic parts is derived from that of other parts, consequently hyperæmia is never general, but implies a disturbance of circulation. It is divided into active or arterial, and passive or venous.

Active Hyperæmia. Active hyperæmia signifies an increased *inflow* of blood to a part. In this the circulation is generally accelerated. It is also called *arterial* hyperæmia, because of the increased arterial circulation.

Causes. The causes of active hyperæmia are such as to tend to increase the afflux of blood to a part, and are grouped under two heads: Those which increase the force of the circulation, and those which diminish the resistance to it; of these the latter is by all odds the most influential.

We find active hyperæmia occurring under the following circumstances: 1. As a turgescence of collateral vessels after

the obstruction of some important vessel, as, for instance, after the ligation of one of the principal arteries of a limb. Here we find the collateral vessels enlarging, becoming turgid with blood, which moves with increased velocity through them, in order to supply the region fed by the obstructed artery. This is known as *compensatory* hyperæmia, and the process is spoken of by surgeons as the establishment of the collateral circulation. 2. As the result of injury or irritation —slapping, friction, the application of mustard or other irritants to the skin. The foregoing applies as well to the hidden parts of the body as to the skin, where the evidences are so conspicuous. 3. As the result of mental perturbation—anger, shame, and the exciting emotions in general; the flushed and mantled cheek, which betrays emotional excitement, affords a familiar example. 4. As the result of sudden removal of pressure, especially from vessels accustomed to support. This is evidenced in the sudden withdrawal of fluids from the natural cavities, as after tapping for dropsy, also after the removal of tumors, the division of cicatrices, etc. In all such instances the vessels from which the support has been withdrawn become distended with blood and the circulation accelerated. In nearly all of the above instances the proximate cause of the hyperæmia is the diminished resistance to the blood current. In other words, the vascular walls relax and allow the blood to enter the vessels with greater facility. This relaxation of the vascular walls is ascribable either to a disturbance of the nervous influence which controls the calibre of the vessels—the vaso-motor nerves—or to injury of the coats of the vessels direct.

Vaso-motor Disturbance. Vaso-motor disturbance may occur as a result of irritation or injury in the course of the nerve; as a result of the same affecting the vaso-motor centres; or in a reflex manner; the impression being received at the periphery by sensitive nerves and conveyed to the vaso-motor

centre, whence it is reflected along the vaso-motor branches. The effect of stimulating a vaso-motor nerve is to cause contraction of the vessels supplied by it, while an over stimulation or a severe injury of the same produces paralysis of the nerve, and consequent relaxation of the vessels. Whether there be such a thing as an active dilatation of blood vessels through nervous influence, as opposed to mere relaxation from the withdrawal of nerve force, is not yet settled, though there is much to support this view. In hyperæmia, therefore, the vaso-motor nerves are either paralyzed, with a consequent relaxation of the vascular walls, or the nervous influence is modified in such a manner as to cause active dilatation of the vessels. As it is plainly evident how an irritation or injury of the vaso-motor centres, or the nerves themselves, may lead to excitation or paralysis, according to its severity, it will only be necessary to cite some examples of reflex vaso-motor disturbance. This is evinced in compensatory hyperæmia, wherein the sensory nerves of the region deprived of blood waft the impression to the vaso-motor centres, whence it is reflected out along the vaso-motor branches, distributed to all the smaller vessels supplying the same region, causing them to enlarge commensurate with the demands of the occasion. So also in slapping or friction of the surface, it is the sensory nerves that convey the impression inward, and the resulting hyperæmia is because of the reflex disturbance of the vaso-motor nerves. It is significant that reflex hyperæmias occur for the most part at the spot irritated.

Injury to the Vascular Walls. As examples of hyperæmia occurring from injury to the vascular walls, mechanical and chemical violence and the effects of severe and protracted cold are frequent. The erythemas of Spring and Autumn, after the cold of Winter or the heat of Summer, are instances of the direct effects of heat and cold on the vascular walls.

Passive Hyperæmia. Passive hyperæmia is that over-filling

of the blood-vessels occasioned by a diminished *outflow* of blood from a part. In this the circulation is usually retarded. It is also called *venous* hyperæmia, because it mostly affects the veins.

The Causes of venous hyperæmia are such as tend to retard the onward movement of blood. These causes may consist in a diminished propulsive power, or an increased resistance, either or both. The first condition is found in the weakened heart, arising from degeneration of its muscular fibres, so often encountered in the exhaustive diseases; in the various valvular derangements and in a diminished tonicity of the vessels. This latter diminishes the outflow by allowing the vessel walls to yield before the blood pressure and their failure to exert that lateral pressure which will direct the blood current forward and onward. The most frequent cause of passive hyperæmia is some obstruction to the circulation. This may occur from pressure on the outside of a vein, from thickening of its walls, or from impaction of its lumen. It also occurs where the valves of the veins are faulty, where there is trouble in the heart, either obstructive or regurgitant, by which the blood becomes backed up in the venous system, and, in short, where there is a deficiency, or want of the natural forces which contribute to the circulation—heart power, arterial resiliency, perfect valves, muscular action, the aspiratory force of chest expansion. Passive hyperæmia not infrequently occurs as the result of obstruction in the capillaries—compression, embolism, spasm. The application of cold to the surface of the body will produce an immediate contraction of all the smaller superficial vessels with a consequent hyperæmia of the deeper ones, and thus serious congestion of the internal organs sometimes occurs.

Symptoms. The symptoms of hyperæmia are heat, redness and swelling for the *active* form, and redness and swelling for the *passive* form. The *heat* is the result of the increased

quantity and velocity of the blood, together with the more rapid tissue changes incident to the same. The *redness* is due to excessive quantity of red blood corpuscles in the part, and the *swelling* to the increased volume of blood in the vessels, to serous effusions, and sometimes to hemorrhage. The color in active hyperæmia is bright red. It may be diffused and uniform, mottled, streaked, or in spots In passive hyperæmia it is of a darker hue, sometimes livid, and may assume any of the forms mentioned above.

In both active and passive hyperæmia the color disappears when the vessels are emptied by pressure, to immediately reappear when the pressure is removed. In cases of extravasation of blood the color is not effaced by pressure. The swelling in passive hyperæmia is usually much more marked than in the active form. This is owing to the greater number and larger capacity of the veins, and to the greater amount of transuded serum.

Function. Secretion and nutrition are generally augmented in active, and diminished in passive hyperæmia.

Effects of Hyperæmia. In hyperæmia the vessels are distended and elongated. The blood corpuscles occupy the vessel in disproportionate quantities, sometimes completely filling the vascular lumen, to the exclusion of the plasma which has escaped into the perivascular parts. The transuded serum leads to œdemas and dropsical accumulations. Hemorrhagic extravasations sometimes occur, and occasionally the over-nourished tissues take on rapid growth, giving rise to various forms of hypertrophy. It is notably the connective tissue that is prone to overgrowth, being, as it is, inundated by the nutritive fluids. Of the two forms, active hyperæmia comes quickly and goes quickly, or terminates in inflammation, whereas passive hyperæmia is usually of slow coming and equally tardy declining, and, as a rule, is much more extensive than the active form.

Ischæmia.

Ischæmia is a local anæmia; like hyperæmia it implies a disturbance of the balance of circulation, wherein certain parts are deprived of their due allowance of blood. It often happens, therefore, that ischæmia affects one part, while hyperæmia affects another. This will readily appear when we consider that the vascular apparatus contains a specific amount of blood; therefore any excess of blood in one part must be at the expense of that in some other part.

Causes. The causes of ischæmia are such as hinder the inflow, or increase the outflow of blood: those which hinder the inflow are—

1. Inefficient heart action and diminished tonus of the arteries, in which the more remote parts suffer, because the blood is not impelled with sufficient momentum to reach them.

2. Pressure exerted on the walls of the arteries and capillaries, whereby the blood is prevented from entering and flowing through them in sufficient quantity. This pressure may be exercised by tight clothing, bandaging, muscular contraction, cicatrices, accumulation of fluid and plastic matter, and by new formations.

3. Spasmodic contraction of the vessels from vaso-motor disturbance, and from direct irritation of their walls, as in certain emotional states. Instance the blanching of the face in fear, also the blanching from the application of electricity and of cold.

4. Impaction of the vessels from embolism and thrombosis.

Those which increase the outflow of blood are—

1. Hemorrhage, in which the blood escapes more rapidly than it can be supplied.

2. Deflection of the blood current, by which blood designed for one region is drawn off into another. Hyperæmia of the thyroid gland may cause anæmia of the brain by the

blood being drained off from the carotids before reaching that organ. Also hyperæmia of the splanchnic and other viscera often cause extensive and prolonged ischæmia of the surface, and *vice versa*.

Symptoms. The symptoms of ischæmia are, blanching, coldness and diminished functional activity. Ischæmia long continued leads to atrophy and degeneration.

Transudation.

Transudation is the passage of a serous fluid through the vascular walls into the cavities and tissues of the body. This fluid resembles, more or less closely, the serum of the blood, but varies according to cause, situation, etc., as to the relative proportions of its constituents. It is usually less rich in albumen than the serum of the blood, clear, colorless, or slightly amber tinted, and alkaline in reaction. Occasionally it is red, from the presence of hæmoglobin, or opaline, from the presence of fatty matter. The transudation occurs chiefly into the serous cavities, or into the meshes of the areolar connective tissue; but also on the mucous surfaces and in other situations. Transudations into closed cavities or into the interstices of tissues produce dropsies. Occurring from mucous surfaces, they produce fluxes. Dropsies are *general* or *local*, and have received various names, according to extent and situation. A general dropsy is called *anasarca*, an interstitial dropsy is called *œdema*, and dropsies into serous cavities are designated by the term *hydrops*, or the prefix *hydro* in conjunction with the proper name of the part. Thus we speak of œdema of the extremities, of the face, of the scrotum, and of the glottis. We also speak of œdema of the lungs, but here the effusion is into the air vesicles, and not being interstitial, makes an exception to the rule. With reference to dropsy of the cavities, we say hydrops-pericardii, hydrops-articuli, or hydro-pericardium, hydro-peritoneum, hydro-thorax, etc.

Causes. The causes of transudation are: mechanical obstruction to the venous circulation; alteration in the constitution of the blood, and alteration in the vessel walls.

1. *Mechanical Obstruction to the Venous Circulation.* This may occur in various ways, and according to its extent and situation will be the amount and location of the transudate. Impediment occurring at the heart causes obstruction throughout the entire venous system, and leads to general dropsy. This explains the anasarca so frequently accompanying valvular disease of the heart. This will be readily understood when we remember that the blood of all the veins must pass through the heart before it can go out again by the diverging channels of the arterial system. Impediment in the portal trunk, or its branches, gives rise to hydro-peritoneum, because the blood is backed up in the abdominal vessels. Thrombosis of the portal trunk, and constriction of its branches, as in cirrhosis, are frequent causes of this trouble. Œdema of the extremities, and in other situations, may be caused by obstruction of the venous trunks leading therefrom. Œdema may also arise from the obstruction of the lymphatics, but this is not apt to occur, inasmuch as the lymph, and even the transudate, if any occur, is quickly carried off by the veins. The *rationale* of transudation occurring from venous obstruction is the increased pressure of the blood caused thereby in the capillaries and venous radicles, and by reason of which the watery portions of the blood are expressed. Recent investigations make it probable that an altered condition of the vascular walls is always necessary to transudation. Increased blood pressure with accelerated circulation, as it occurs in arterial hyperæmia, does not conduce to transudation, but with retardation of the current, as it occurs in venous hyperæmia, transudations are frequent. In the latter, not only is the pressure on the capillaries greatest, but the vascular walls are also more apt to suffer from malnutrition.

2. *Alterations in the Constitution of the Blood.* This is a frequent cause of transudation. It is witnessed in some acute and many chronic diseases in which the blood has become impoverished. The cachectic state resulting from malarial infection, from tuberculosis, and from Bright's disease, furnishes familiar examples of dropsies occurring as the result of impoverishment of the blood. These are all attended by anæmia and a watery condition of the blood. This latter in Bright's disease is in consequence of the loss of the blood albumen, which escapes into the urine. Hydræmia is generally proportionate to the absence of albumen in the blood. It is doubtful, in the face of recent experiments, whether the watery condition of the blood alone suffices to produce transudation. It is more reasonable to suppose that in this, as in all cachectic states attended by transudation, the vascular walls have suffered alterations from deficient nutrition.

3. *Alterations in the Vessel Walls.* These have been alluded to as being, probably, indispensable to transudation. It will only be necessary to say further, that injury to the vessel walls, especially the capillaries, is followed by transudation, and that conversely, high blood pressure from venous stasis and from blood rendered watery, is not followed by transudation so long as the vascular walls suffer no injury. The experiments alluded to above consisted in injecting quantities of a saline solution into the blood, so as to produce artificially the hydræmic state. Neither œdema nor transudation occurred under the more moderate injections. Nevertheless, very large injections, to the extent of increasing the volume of blood several times, caused transudations in the form of fluxes from the intestinal canal and in the vicinity of glandular organs, but not in the ordinary situations. Now by the application of an irritant to any part of the body, so as to injure the vascular walls, rapid and extensive transudation occurred at that point.

Collapse.

Collapse is a term used to indicate a more or less complete prostration of the vital energies. This condition is distinguished principally by feeble, scarcely perceptible respiration and circulation, cold, clammy skin and sunken features. Collapse occurs under many and various conditions. As the result of grave injuries; of hemorrhage, of copious discharges, as in vomiting or diarrhœa; from an excess of pain, from strong impressions made on the peripheral nerves in certain situations; as of the stomach, testes, ovaries, etc; from overpowering emotions, especially of terror, and lastly, in the chill stage, or in the dehiscence of fever.

The symptoms of collapse vary according to its intensity. In the severe forms the heart sounds are scarcely audible and the pulse is preternaturally slow, sometimes rapid, often intermittent, and scarcely, if at all, perceptible at the wrist. The respirations are slow, shallow, at times gasping or suspirous. The surface of the body is cold, bathed in perspiration, pallid or livid. A pinched or shrunken appearance about the face and extremities gives the patient a death-like aspect. The mind is confused, sometimes clear, and the patient is depressed, apprehensive or actually panic-stricken; exceptionally, apathetic. There may be delirium or convulsions. There is great muscular weakness, giddiness, noises in the ears, indistinctness of vision, pericardial oppression, and a sense of impending dissolution. The surface temperature in collapse is lowered from 8° to 15° F., or even more. The internal temperature is sometimes higher, sometimes lower, than normal. There is a general disposition to lowering of the temperature, internally as well as externally, when the collapse is persistent.

Causes. The essential cause of collapse is not understood. Prominent among the phenomena of this condition are those pointing to a disturbance of nutrition; lowered temperature,

enfeebled circulation and respiration. An impaired nutrition may depend on one of three conditions: deficient supply of nutritive material, excessive waste, or a direct inhibition of the nutritive processes by the nervous system. The two first may be dismissed summarily, as, although collapse may occur from inanition, it not unfrequently happens to persons stricken down in the full vigor of health, in whom there has been no impairment of the nutritive functions. It now seems to be pretty clearly established that nutrition is subservient to a special nervous apparatus. We look upon the sympathetic system as especially concerned in nutrition, and believe that by and through it the nutritive processes may be accelerated, retarded or arrested. We can account for the sudden failure of the nutritive processes in collapse in no other way than by referring them to the inhibitory influence of this apparatus. The derangement of special functions is easily accounted for by the absence of nutrition. The instant the latter ceases, the former must also. Observe how suddenly unconsciousness and paralysis supervene on embolism of the middle cerebral artery.

Syncope, or Fainting. Syncope is a phase of collapse for the most part more sudden in its coming and going—more profound in its intensity. There are, however, all grades of intensity, from a mere faintness up to a perfect semblance of death. Owing to the transitory duration of the attack the temperature does not materially fall.

As the result of the various functional, and more especially the structural changes occurring in disease, many mechanical derangements arise, which in their turn may give rise to more serious disorders. They consist, for the most part, of compression, constriction, distention, impaction and displacement.

Compression. Compression results from enlargement and displacement of contiguous parts, from morbid growth, from

effusions, from turgescence of the blood vessels, and from muscular action. The brain is compressed in displaced fractures of the skull, in serous effusions on its surface or into its ventricles, from the development of morbid growths, or inflammatory exudations into its substance, from turgescence of its blood vessels, and, lastly, from hemorrhagic extravasations on its surface, or in its substance, as in apoplexy. Causes of a similar nature produce compression of the lungs, heart, and other organs. The shrinkage following the overgrowth of fibrous tissue compresses, jugulates, and at times destroys the functional parts of organs. Of such are *cirrhosis* of the lungs, liver, kidneys, and the *scleroses* of the brain, spinal cord, and skin. Muscular spasm compresses organs beneath—as in spasm of the abdominal muscles—emptying the blood from the organs compressed, and frequently damming it up on organs behind.

Constriction. Constriction affects more particularly the tubular organs, and is caused by thickening of their parietes, by bands or bridles encircling the same, by displacements and muscular spasm. In the vascular apparatus, the valvular orifices of the heart are constricted, as the result of inflammatory exudation. The blood vessels from the same cause. Spasm of the cerebral vessels occurs in epilepsy. The air passages are constricted from œdema and swelling about the glottis and the smaller bronchial tubes, from spasm of their muscular fibres, as in asthma. The cardiac, pyloric, and anal orifices become constricted from morbid growth. The intestinal canal becomes constricted from inflammatory and other growth, from intussusception, from twisting of the bowel, from incarceration, as in hernia, from slipping into a loop or diverticulum, and from spasm of the circular muscular fibres, as in colic. The ureters, urethra, hepatic duct, and, in short, all the ducts of inlet and outlet, of large or smaller size, may be affected in like manner, giving rise to the various strictures.

Distention. Distention results from accumulation within the natural cavities of the body. These generally consist of an increase in the natural contents, or of effusions, but also, of morbid growths and extraneous matter. The heart becomes distended from an overfilling of its ventricles with blood; the vascular tubes from the same cause. The pulmonary vesicles become distended from the increased pressure of the gases which fill them. The stomach and bladder, from accumulations of their natural contents. The pleural, peritoneal, pericardial and articular cavities, from inflammatory products, or extravasations. Cancerous and other growths may develop in any of the hollow organs, distending them. Distention often occurs from obstruction to the outflow of their contents, as from valvular troubles of the heart, venous or arterial obstruction; distended stomach, as the result of pyloric narrowing; distended bladder, from strictured urethra; distended sebaceous follicles, from closure of the ducts. Distention frequently depends on weakening of the walls of the organ, or from a want of collateral support. Distended air vesicles, known as pulmonary emphysema, is usually attributable to collapse of contiguous vesicles, whereby the lateral support is withdrawn. The results of distention, if long continued, are relaxation, permanent dilatation, or rupture.

Impaction. Impaction also affects hollow organs. They become blocked by inspissated secretions, by concretions, by parasites, and by foreign matter, thus leading to their obstruction. Hardened fæces and enteroliths obstruct the bowels; gall-stones the biliary ducts; renal caculi the ureters and urethra; salivary calculi, the salivary ducts; sebaceous matter the sebaceous follicles. Parasites and entozoa sometimes make their way into narrow channels and occlude them. Suffocation has resulted from an intestinal worm finding its way into the chink of the glottis. Coagulation of blood in the vessels gives rise to those very import-

ant forms of impaction treated of under the heads of embolism and thrombosis.

Displacement. Displacement is the result of pressure exercised by unnatural growths, by effusions, also of traction exerted on the part by its natural or unnatural connections. It also, not infrequently, results from a relaxed state, whereby the organ is unable to maintain itself *in situ*. The heart and lungs become displaced in hydro and pyo-thorax, from the presence of morbid growths in the same cavities, and the malformation of the thorax resulting from spinal curvature. Other viscera are displaced from like causes. Prolapse of the bladder and the rectum and the various mal-positions of the uterus arise from one or more of the causes enumerated above, but usually, also, from a weakness of their natural supports.

CHAPTER X.

FEVER.

Fever has been defined as an excess of body heat from internal causes. As there can be no fever without excess of temperature, this is its essential phenomenon. Other phenomena are usually superadded, which are, however, variable and inconstant, therefore not essential. The superadded phenomena embrace disturbances of the circulation, respiration, of the nervous and muscular system, of secretion, excretion, and, in short, of all the functions of the body. Associated with the functional disturbances are various tissue changes of great practical importance.

Taking the phenomena *seriatim*, that which claims first attention, as being of first importance, is—

The Excess of Body Heat. The normal standard of body heat is 98.6° F. This standard, with very slight variation, is maintained by the internal processes of the economy. Certain conditions, however, such as activity and repose, eating and sleeping, are capable of inducing a slight rise or fall in temperature. The most notable variations, however, occur with rhythmical precision at successive periods of the twenty-four hours. These, the *diurnal variations*, are distinguished by a minimum of temperature between the hours of one and seven, A.M., and a maximum of temperature between the hours of four and nine P.M. The variations are physiological, and seldom exceed 1° F. A body heat exceeding 100° F. is regarded as an indication of fever. The fever heat may range all the way from this temperature to 110° or 112° F., rarely exceeding the latter. The intensity of the fever and the attendant danger are in proportion to the height of temperature; the medium being from 103° to 105° F.,

but a temperature of 107°F., or more, is of very grave import. The fluctuations of temperature in a continued fever generally correspond in time to the diurnal variations, but are usually much more marked. Contrary to the popular belief, the cold or chill stage of fever is usually characterized by a rise of temperature, although distal parts, such as the tips of the fingers and toes, the ears and the nose, may actually show a decrease of temperature. Occasionally, as in collapse, an actual fall of temperature precedes the fever.

Circulation. The circulation is almost always accelerated in fever. The heart acts with increased frequency and power in the sthenic fevers, and diminished power in the asthenic. In cases of very profound depression the pulse is small and thready, and the systolic sound of the heart much weakened or abolished. The pulse rate is generally, though by no means constantly, proportionate to the fever heat; every degree of increase of the latter being accompanied by a rise of ten pulsations per minute.

Respiration. The respirations are usually increased in frequency, and bear a certain relation to the circulation and fever heat, though this connection is not nearly so intimate as between the circulation and temperature.

Nervous System. Pains in the head, loins and limbs, sensations of chilliness and heat, rigors and tremors, delirium, insomnia and mental hebetude, with many other perversions of sense and mind, evidence the implication of the nervous system.

Muscular System. The muscular system also betrays general debility, whereby the patient is compelled to seek rest in bed.

Secretion and Excretion. The constructive processes, including digestion, assimilation and secretion, are much impaired. The patient loathes food, and the stomach rebels against that which is introduced; the bowels are constipated,

the mouth and tongue dry and parched; the latter being loaded with dead epithelium. The absence of secretion in the oral cavity is an index of what obtains in the glandular organs throughout the system. The patient, however, is tortured with thirst and drinks large quantities of water, which only transitorily satisfies. The excretions, though diminished in volume, owing to the absence of water—and this, too, notwithstanding the enormous quantities ingested—are loaded with solid constituents, which represent the destructive processes going on in the tissues.

Tissue Changes in Fever. As indicated by the increased quantity of solid excrementitious principles, the tissues of the body undergo a more or less rapid destructive change in fever. This is obviously manifest in the loss of fat, which at times almost entirely disappears, leaving the subject thin and emaciated. The muscles also dwindle to a very marked degree, and even the more compact tissues, such as bone and cartilage, exhibit a similar, though less striking, loss. Organs and tissues undergoing the changes incident to fever are swollen, soft, and friable; the histological elements swollen, opaque, and granular. This condition, which has been more fully described under the head "Cloudy Swelling," is most strikingly manifest in the liver, kidneys, heart, muscles, and lungs. In the liver, kidneys and lungs this change is to be observed more especially in the epithelial cells; in the heart and voluntary muscles it is betrayed by a disappearance of the normal striations. The fibre, as a consequence, becomes granular, incontractile and friable. Advanced stages show, in lieu of cloudy swelling, a genuine fatty metamorphosis.

The increased temperature of fever is merely an exaggeration of the normal body heat, and the *rationale* of its production the same. For the various theories and ascertained facts relative to the production of animal heat, reference should be had to works on physiology. Suffice it to say, the evolution

of heat in the body, as well as out of it, depends largely on changes in the chemical constitution of substances. Every molecule of matter contains a certain amount of latent heat, which, under different circumstances, is increased or diminished by appropriating and transforming the sensible heat from the surroundings, or by converting the latent heat which it contains into the sensible form. The multifarious chemico-vital changes of the living body in the process of nutrition are exceedingly favorable to these transformations. The heat contained in the food and drink and the air we breathe is thus taken into the system and stored away in the constructive, to be again liberated in the destructive processes which are constantly transpiring. These changes are under the influence of the nervous system and regulated by it. Hence, in a word, we say; *the production of animal heat depends on the nutritive changes going on in the organism, and is under the direction of the nervous system.* This heat is evolved principally by the muscles and glandular organs; but also, to a less extent, by the other organs and tissues. It, therefore, arises to a great extent in the interior of the body, and would there accumulate, but for provisions for its equable dispersion. This is accomplished mainly through the circulation of the blood, by which it is distributed to the mucous and cutaneous surfaces and nether parts of the body, where much of it is expended in raising these to the level of its own temperature, and much is lost. Thus the blood returns cool to the feverish structures within, to again become surcharged with heat. The cold sensations in the chill stage of fever are not due to absolute coldness, but to the relative coldness of the surface to internal parts. We have already seen that even the surface heat is higher than normal in the chill stage. The surface is *relatively* cold, because of a spasmodic condition of the superficial vessels, whereby an adequate quantity of blood does not circulate through them to maintain the

equilibrium of temperature. As to the essential cause of those rapid tissue changes in fever resulting in the evolution of excessive heat, almost nothing is known. We satisfy ourselves by saying that a warfare is being waged between the tissues on the one hand and the germs of disease on the other, which is carried on at the expense of much molecular life, in the yielding up of which sensible heat is evolved. While increased activity of the circulation and respiration feed the fever flames, by supplying oxygen for the combustive process and expediting tissue metamorphosis, they are also conservative, in that they dissipate the heat thus engendered and set free waste products of tissue metamorphosis. The blood conveys the heat to the respiratory and cutaneous surfaces, where it is given off in the vapor, by irradiation, and by contact with the cool air which it there meets. The waste products are conveyed by the blood to the various emunctories, thereby to be expelled; the carbonic acid by the lungs, the other excrementitious principles by the kidneys and skin. The disturbances of the muscular and nervous systems, of the assimilative and secretory organs, are largely traceable to malnutrition, to waste of substance, and to the influence of the poison producing the disease, and the products of tissue waste.

CHAPTER XI.

INFLAMMATION AND INFLAMMATORY GROWTHS.

Inflammation is a condition resulting from irritation, characterized by disturbance of nutrition and derangement of the vascular apparatus. The cardinal symptoms of inflammation, according to the old writers, were *heat, pain, swelling* and *redness*. From a clinical point of view these are yet valuable diagnostic criteria ; though not infallible, as either, in its turn, may be absent. The phenomena of inflammation appertains to the vascular apparatus and to the tissue changes.

I. VASCULAR PROCESSES IN INFLAMMATION.

The participation of the vascular apparatus in the inflammatory process is best observed in the transparent tissues of one of the cold-blooded animals, in which inflammation has been artificially induced. Here, owing to the sluggish movement of the circulating fluid, and the tenacity of life under circumstances that would rapidly exhaust the vitality of a warm-blooded animal, the investigation can be conducted leisurely and in a systematic manner. For this purpose the tongue, or mesentery, or web of a frog's foot may be selected, which, being placed under the microscope, and inflammation being induced by mechanical or chemical irritation, the various phases of the process may be readily followed. They are as follows :—

Dilatation of the Vessels. This comes on gradually, and may be preceded by a contraction or by a rapid dilatation, which soon passes off ; either of which are accidental and inconstant, and therefore do not belong to the essential phenomena of inflammation. The vessel not only dilates, but elongates and becomes tortuous, thereby increasing its capacity. The dilatation affects first the arteries, and thence extends to the

veins and capillaries. When once established it is permanent and is accompanied by a—

Retardation of the Circulation. This retardation, which is usually, though not necessarily, preceded by an accelerated blood flow, is one of the essentials of the inflammatory act; because always present. It, like the dilatation, is of gradual coming, and once established is permanent. It commences in the veins and subsequently extends to the capillaries and arteries. It becomes more and more pronounced at the point of greatest intensity, until eventually a complete stagnation of the capillary circulation ensues. This, which is known as *inflammatory stasis*, affects a circumscribed area in the centre of the inflamed tract, which usually dies.

Accumulation of Corpuscular Elements in the Vessels. Consentaneously with the above phenomena, the leucocytes of the blood begin to accumulate in great numbers in the veins. These adhere to the walls of the vessel, and, piling tier on tier, greatly reduce its calibre, through which constricted passage the blood courses slowly. Behind this, and occupying the capillaries, we find a like accumulation of red corpuscles, although these do not adhere to the vessel. The next step in the process is

The Migration of Corpuscles and the Exudation of the Blood Serum. Probably the most striking phenomena connected with the inflammatory process is the migration of leucocytes. As before intimated the veins of the inflamed region are charged with these corpuscles, which, though not moving with the current, are living and active. If one of these vessels be attentively watched under the mircroscope, it will be observed that the corpuscles are escaping through its walls. First those corpuscles nearest the inner wall of the vessel are seen to gradually sink into its substance. Presently a small button-like process projects from the outer wall, which gradually increases in size, becomes pear shaped, and finally hangs by a

tender thread. This is drawn out and the liberated corpuscle, by an amœboid movement, strikes out into the extra-vascular space. Corpuscles in great numbers thus leave the vessels to accumulate in the extra-vascular parts; the number being proportionate to the intensity of the inflammation. At the same time a greater or less number of red corpuscles escape. These latter are derived principally from the capillaries where they have been accumulating, not however, from the area of inflammatory stasis, but from the belt outside of this. Thus the area of stasis is literally hedged in with red and white corpuscles, as if to throw themselves into the gap created by its death and disintegration. The red corpuscles, in great measure, escape by rupture of the vessels containing them, possibly, also, by diapedesis. Along with the corpuscles large quantities of fluid leaves the vessels and inundates the tissues. This fluid is the liquor sanguinis, somewhat altered by the changes going on in and around the vessels. This, the *inflammatory effusion*, contains a larger proportion of albumen and fibrinogen, together with phosphates and carbonates, than the normal blood serum. In consequence of this effusion the tissues become sodden and œdematous.

II. THE TISSUE CHANGES IN INFLAMMATION.

In an inflammation running through all its phases, the processes of tissue change are of three kinds, *constructive*, *destructive* and *reconstructive*.

Constructive Processes.

Exudation and Cell Growth. As a result of the migration of leucocytes from the blood, we now find the tissues swarming with them. These cells, as we already know, differ in no way from the indifferent cells from which embryonic tissues are formed. But the constructive act is not alone relegated to these emigrant cells. We find the tissue elements in the midst of which the exudation has taken place evincing a nutritive excitement. They enlarge,

become cloudy or granular, retract their processes, and finally divide. The leucocytes also multiply, and thus the inflamed tract becomes infested with a brood of young cells, consisting in part of the progeny of the cells proper to the tissue, in part of the migrated leucocytes, and in part of the progeny of these latter. These combine to form a groundwork of a new tissue. The cells of all tissues do not enter with equal facility into the reproductive act. With the increase of the corpuscular elements other changes are rendered necessary, in order to make room for them. This is effected by the degeneration and breaking down of the cells not participating in the act of reproduction, and by the softening and liquefaction of the intercellular substance. Thus, in bone, the lime salts first disappear by absorption, and the matrix fibrillates, and finally melts away. In cartilage the capsule yields to the pressure of multiplying cells, until at last the division walls between contiguous capsules are broken down, and the cell broods commingle. The principle here obtains, that everything must yield before the growing cell. Cell migration and proliferation takes place in the tissues unprovided with blood vessels, just as in the small extravascular islands between the capillaries of the vascular tissues. This is best observed in the transparent tissue of the cornea. Here, in inflammation, the vessels which encircle but do not enter its substance, become enlarged, turgid, and, in short, behave just as do the vessels elsewhere. Leucocytes are seen to leave these and enter the cornea, and the cells of the cornea to undergo cloudy swelling. Thus it will be seen that the process of inflammation is the same in the extra-vascular as in the vascular tissues. * * * * * * * * In explanation of the above phenomena, unfortunately, there is little to offer but speculation. That the dilatation of the vessels is not a mere passive condition, depending on the influx of blood, is now quite generally admitted. Carefully conducted ex-

periments have seemed to establish the fact that blood vessels, including the capillaries, possess the power of active dilatation as well as contraction. It has furthermore been found that stimulation of the vaso-motor nerves induces contraction of the vessels, whereas stimulation of the sensitive nerves of a region induces dilatation, seemingly active, by way of reflex action. The withdrawal of all nervous influence or inherent weakness in the walls of the vessel conduces to passive dilatation. Hence it has been inferred that the initial contraction of vessels was the result of irritation of the vaso-motor fibres by the irritant producing the inflammation; that the initial dilatation was the result of irritation of the sensitive fibres from the same cause, and that the final and permanent dilatation was due to the withdrawal of nervous influence, or paralysis of the vessel, from damages incident to the inflammatory state. Opposed to the above are the experiments of Cohnheim, in which inflammation in parts severed entirely from the body, with the exception of their nutrient vessels, therefore liberated from nervous influence, gave results identical with those witnessed in the undivided structures. Also, after destruction of the brain and spinal cord, the phenomena were not modified in the least. Other experiments, in which the walls of the vessels were subjected to injury, and in which other fluids and defibrinated blood were substituted for normal blood, led him to the conclusion that the vascular phenomena of inflammation, such as dilatation of the vessels, accelerated or retarded blood flow, stasis of the corpuscular elements, and their escape through the vessels, were due entirely to the condition of the *walls* of the vessel, and in no way attributable to the nervous influence, the condition of the circulating fluid, or the state of the extra-vascular parts. Notwithstanding the above, it is quite probable that the nervous apparatus plays an important *rôle* in inflammation, as it does in other processes of the economy. How else account for

the vascular phenomena elicited by injuries to extra-vascular parts, in which the vessels are not impinged on, the cornea, for instance, and many inflammations of internal organs as the result of exposure, and of certain inflammations following injuries of nerves?

The increased nutritive activity in inflamed tissue is doubtless attributable to an increased demand on the part of the injured elements, but mainly to the increased supply of nutritive fluid supplied to them in the inflammatory effusion.

The *redness* of inflammation arises from the increased quantity of blood in the tissues; the *heat*, from the rapid tissue changes; the *swelling*, in part, from the overfilled blood-vessels, but mainly from the exudation and cell proliferation; and the *pain*, from the initial injury and from the pressure and irritating properties of the inflammatory products on the sensitive nerves.

Resolution. The inflammatory process may cease at this juncture, with a gradual subsidence of all the symptoms, and return to the normal conditions, *termination by resolution*, or a new series of processes may be inaugurated, which will be considered in the following order:—

Suppuration. Suppuration is the formation of pus in the substance or on the surface of inflamed structures. Laudable pus is of the color and consistence of cream, and of a mawkish odor. It consists of a fluid, the *liquor puris*, in which are suspended corpuscular elements, the so-called *pus corpuscles*. The liquor puris is the inflammatory effusion originally derived from the blood, and consists of the serum of the same after having undergone some slight alterations. The pus corpuscles are similar in size, shape, and other details, to the leucocytes and other young cells inhabiting the inflamed structures. As there is nothing to distinguish the pus corpuscles from the latter, it is now generally conceded that they are one and the same, under somewhat different circumstances. What change,

if any, the young cells of inflamed tissues undergo, in order to be transformed into pus corpuscles, is not definitely known. Whether, as some suppose, it is a lack of vital capacity and an inability to procreate and to develop, or, as others suppose, owing entirely to the presence of an excessive amount of fluid by which the corpuscles are forced asunder, or neither, must for the present remain a question *sub judice*. It is said that the pus cell is less cohesive than the cells which constitute embryonic tissues, and that it is specially destructive to living structures. This may or may not be so, though it is noticeable *that pus corpuscles seldom aggregate even under the most favorable circumstances.* Large aggregations of cells in a given space favor the production of pus. All that is necessary to the transformation is the breaking down of the tissue between the individual cells and the presence of liquor puris. A depot of pus in the substance of tissue or organs is called an abscess. An abscess once formed, either makes its way to the surface and is discharged, undergoes fatty degeneration and is absorbed, or becomes calcareous and gradually dries up. Owing to various degenerative changes of the corpuscular elements, and to the presence of unnatural matter—blood, bacteria, the debris of the disintegrating tissues—pus may be much altered in constitution and physical properties. Thus altered, it constitutes unhealthy pus, and is very offensive to the smell and irritating to the tissues.

Destructive Processes.

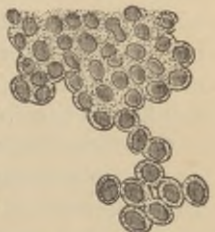
Ulceration and Gangrene. Molecular death is generally co-extensive with the area of stasis of inflamed tracts. Occurring in the substance of tissues, it is known as interstitial disintegration ; if on a free surface, it constitutes ulceration. This form of death affects the histological elements of tissues—the cells and intercellular substance—and may destroy the parts uniformly, leaving a large, even excavation, or it may

affect molecules here and there, leaving as a result a honeycombed structure. Molecular death is attended by disintegration, and the products are removed by absorption, or cast off from the surface in the discharges; in interstitial death, the products are removed by absorption alone; in ulceration by both methods, but principally by discharge. The discharges of an ulcerating surface often contain visible particles of bone and fibre which have been loosened from their attachments, but which do not properly belong to the products of molecular disintegration. These latter are microscopic in size, and have lost all semblance of structure. A more pronounced disturbance, or one affecting seriously the circulation in the larger vessels, may lead to that form of death known as *gangrene or sphacelus*, in which the tissues die and are cast off in masses, still retaining their structure. As a result of either or both forms of death, there is an excavation, or loss of substance.

Reconstructive Processes.

Granulation and Cicatrization. After the subsidence of the destructive processes above described, the process of repair begins. This is effected through the agency of those selfsame elements—the new-formed cells—which take so prominent a part throughout the inflammatory act. If, in an ulcer, for instance, the process of repair be attentively watched, it will be noticed, first, that its floor becomes covered with young cells imbedded in a scant intercellular substance. These cells form themselves in small conical masses, each of which is provided with a capillary blood vessel. These little conical bodies are *granulations* of healing tissues; the capillaries with which they are supplied

FIG. 6.



GRANULATIONS.

are of new formation, and are connected with the vessels of the subjacent parts. This first layer of granulations is covered by another, and this by another, and so on successively until the gap in the tissues is completely filled to a level with the surroundings. All this while a gradual change is transpiring in the new-formed elements. Commencing at the bottom and successively affecting each layer as it is formed, both cells and intercellular substance undergo alterations of arrangement, form and consistence, corresponding to like changes in the active tissue formation as described elsewhere. The capillary loop of each successive crop of granulations is derived from that beneath, and thus the blood supply keeps pace with the cellular proliferation. The excavation being now filled, the finishing touch is given by clothing the surface in epithelium. This is accomplished by a growth of epithelium from the periphery toward the centre, and is supposed by Rindfleisch to depend on the infection of the indifferent cells on the surface, by contact with the normal epithelium—that of the epidermis or mucous surface—whereby the former is transformed into the latter. The new tissue thus formed is called *cicatricial tissue*, the new formation a cicatrix or scar, and the process of formation *cicatrization*. It consists of some form of connective tissue. It is seldom, however, that a perfect tissue is thus evolved, or that one of the higher order of tissues, such as muscle or brain matter, is restored, these latter being substituted by an imperfect fibrous tissue.

Cicatricial tissue is noted for its crispness, dryness, its want of blood, and above all, for its tendency to contract. In consequence of this shrinkage great distortions sometimes ensue. That we may understand the reason for these properties of cicatricial tissue it will be necessary to follow the details of its development. The cells, which at the beginning constitute almost the entire mass of the growth, soon begin to elongate

and assume a spindle form. These arrange themselves side by side, and in longitudinal rows, with their pointed extremities interdigitating, thus forming a dense and compact structure. Now commences a shrinking and drying-out process, by reason of which the individual cells become greatly reduced in size, lose their vitality, and the individual elements become so indistinctly outlined as to give the appearance of an obscurely fibrillated structure. The fibrillation is contributed to by a longitudinal splitting of the cell. Here and there throughout the mass of defunct cells now acting as intercellular substance there appears a living cell, which holds sway over the region round about. By reason of this shrinkage, which commences first in the older cells at the bottom, the blood-vessels which come up into the growth from this direction are gradually strangulated, and the entire structure becomes comparatively bloodless. The contraction, which not only reduces the size of the scar, but also, at times, gives rise to unsightly distortions, is due to the loss of moisture, as, also, are the dryness and crispness.

Classes. Inflammations are divided into acute and chronic, idiopathic and traumatic, infectious and specific. An *acute* inflammation is distinguished by the violence and rapidity of its course and the evanescent nature of the tissue changes; a *chronic* inflammation by its low grade, slow progress, and the prominence and permanence of the resulting tissue changes. An *idiopathic* inflammation is one arising without obvious cause; a *traumatic* inflammation is one arising from mechanical or chemical injury. An *infectious* inflammation is due to an infectious material, such as the poison of septicæmia. A *specific* inflammation is one in which the cause, whatever its nature, impresses on it peculiar and specific characters; of such are erysipelas and tuberculosis.

Aside from the ordinary growth, or so-called inflammatory deposit, that occurs in ordinary, non-specific inflammation,

some diseases are characterized by inflammatory growths of special character. Such growths occur in tuberculosis, scrofula, syphilis, etc., and are here appended.

Tuberculosis.

Tuberculosis is a term used to indicate that state depending on, or associated with, the formation of tubercles in the tissues. Tubercles are small, disseminated growths, for the most part of a lymphatic character, but frequently associated with nodular proliferations of epithelial and connective tissue.

Classes. The older writers spoke of two forms of tubercle, the *gray, or miliary, and the yellow, or crude.* The gray tubercle is the only genuine form of growth ; the yellow consisting of caseously degenerated tuberculous matter, or inflammatory products. Nodular masses of considerable size often present in the alveoli of the lungs and other situations, from the massing of epithelial and connective tissue elements ; these rapidly pass into caseous degeneration, and present as yellow tubercles.

Causes. Among the numerous causes of tuberculosis, may be named heredity, damp, clayey soil, low lands, and variable climate. These act as predisposing causes. In many cases of post-mortem examination of the dead, of tuberculosis, depots of caseous matter have been found, which to all appearances were the centres of infection, as the tuberculous deposits occurred in radiating lines in the course of the lymphatics proceeding from them. In experiments instituted to confirm or disprove this theory, it was found that caseous depots artificially produced by exciting a low grade of inflammation in the tissues, were often the harbingers of a general tuberculosis. It has been both asserted and denied, that inflammatory products of all kinds, resulting from a low grade of inflammation, are capable of exciting the tuberculous growth when taken up and conveyed to other parts by the lymphat-

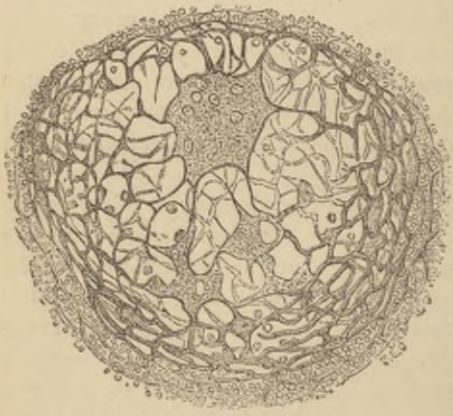
ics. Thus, the inflammation resulting from the introduction of pieces of blotting paper and other innocent matter under the skin, has been asserted to be followed by tubercular formations. The weight of evidence, however, seems to support the view that *none but tuberculous matter, or caseous matter derived from the same, are capable of giving rise to tubercles by infection.* Koch has recently discovered and demonstrated the presence of a microscopic organism in tubercles, and in the sputum of tuberculous subjects, to which he has given the name of *bacillus tuberculosis*, and which he believes to be the essential cause of tuberculosis. More extended research, by numerous investigators, seems to have established the fact that these small organisms are quite constant in, and in some way intimately associated with, the tuberculous state; but whether as a cause or consequence, or either, remains to be determined.

Development and Course. As regards the seat of tubercles, no part of the body is exempt. The favorite sites are the meninges of the brain, the lungs and the intestinal canal. In the pia mater, where it is studied most advantageously, the tubercle springs from the lymphatics which invest the smaller arteries. In the lungs it springs from the lymphatic tissue surrounding the terminal bronchioles, but we also find here the alveoli filled with epithelial elements. In other situations, it would seem that connective tissue furnished the nidus and the elements of growth. The origin of tubercle is still a mooted question. It is a singular fact that the tubercle almost invariably develops in the line of, and in immediate proximity to, the smaller blood-vessels. The result is that the vessel soon becomes occluded, the blood supply cut off, and the tubercle undergoes degeneration and death. In the intestinal canal the tubercular ulcer can be easily distinguished from others by its tendency to follow the vessels transversely around the bowel, sometimes forming

a complete girdle. The secondary changes are atrophy, fatty degeneration and disintegration.

Physical Characters. Tubercles are individually very small, varying in size from microscopic dimensions to the size of a millet seed, or larger. They exist without number, are localized or general, and are disseminated evenly or arranged in clusters. They are pellucid, or grayish translucent, and have a tolerably firm, elastic consistence. Examined microscopically, cells of three principal varieties are seen: a small, round cell, similar to the lymph corpuscle, a large round or irregular cell, frequently pigmented and containing several nuclei, and the giant cell, which is multinucleated and provided with numerous processes. One or more giant cells are to be found occupying the interior of the tubercle and the smaller cells occupy the periphery. Thin sections examined microscopically reveal a reticulated structure, the meshes of which are filled with the smaller cells. This reticulum is formed by the processes given off by the giant cells uniting with those given off by cells of intermediate size. These all unite to form a beautiful network, extending from the central mass to the periphery, where it terminates in a corona of heavier reticular fibres. This lymphatic character, though often quite conspicuous, is more frequently but dimly outlined, and sometimes not at all discernible.

FIG. 7.



STRUCTURE OF TUBERCLE.

Scrofula.

The scrofulous diathesis, which may be inherited, but also under bad hygienic circumstances acquired, not only renders the individual more susceptible to inflammation, but also modifies the inflammatory process. The increased susceptibility to inflammation is for the most part confined to certain structures, as the lymphatic glands, mucous membranes, and to a lesser degree, the skin, bones, and joints. The inflammatory process is characterized principally by *the accumulation of cell products in the tissues and their subsequent caseation.*

There is no effort at resolution, and none at organization. Resolution is not effected, because, in the first place, there is a deficiency of vascularity, and because the cell products of scrofulous inflammation are much larger than ordinary cells, many of them being multinucleated. On account of these properties they cannot readily re-enter and escape by the blood and lymph channels. Organization is not effected, because there is a deficiency of vascular supply. There are few or no new formed vessels to nourish the new-formed cells, and by the accumulation of these latter, and their pressure on the vessels, the blood supply is still further interfered with. Hence it is, that they lie quiescent in the tissues, neither able to develop or escape, until, becoming starved, they suffer fatty degeneration, and the watery portions being absorbed, a caseous mass remains.

Syphilis.

Syphilis is an inflammatory disease resulting from a specific infection and giving rise to inflammatory growths, the so-called syphilomata. Syphilomata occur under two principal forms: 1. As fibroid nodules, of rather firm consistence, —*fibroid syphilomata.* 2. As gummatous nodules, of softer consistence—*gummata.* These forms are frequently blended

in one and the same growth, occasionally one follows the other.

Development and Course.—The first departure in the formation of either of these forms is a proliferation of connective tissue, either in the skin, the subcutaneous, submucous, subserous, intermuscular, interstitial, or enveloping connective tissue of organs. The new formed tissue is identical in every respect to the germinal, or embryonic connective tissue, described elsewhere, consisting of indifferent cells closely packed in a scant, viscid intercellular substance. This undergoes more or less fibrillation, and acquires a degree of density.

As it increases in size and age, the nutrient vessels are compressed and strangulated, and the central and older parts fall into degeneration, atrophy and disintegration. These changes occur speedily. It follows that, owing to the absence of nutrient vessels, no single nodule attains to any considerable size. Several of these may, however, be grouped together, and by fusing, present a mass of some magnitude. In the subsequent course of the disease, the older, disintegrated, central part of the growth disappears by absorption, or discharges through an ulcerated opening, and the walls steadily contract toward the centre, closing the space. This contraction is not uniform from all points of the circumference, but juttings occur here and there, so as to present a scalloped border.

Physical Characters.—The syphilomata are distinguishable from other allied growths, by irregularity of distribution, paucity of numbers, and by occurring as distinctly circumscribed nodules, in the midst of perfectly healthy surroundings. Syphilitic nodules, furthermore, do not project above the surface, though frequently abutting upon it. Syphilomata sometimes present in clusters of two, three, or more, which may coalesce. The *fibroid syphiloma* is in no way distin-

guishable from the ordinary fibroma, except from its small size, its evanescent nature, or its association with gummatous growth. The *gummata* are in size from that of a hemp seed to that of a walnut, and present, on section, a great resemblance to the common horse-chestnut. Examined microscopically, three zones appear from periphery to centre. First, and most externally, appears a zone of embryonic tissue, consisting almost entirely of germinal cells. This is the last formed, and, consequently, represents the first stage of development. Next comes a zone of fibrillated connective tissue, which may resemble common fibrous tissue, cicatricial, or even adenoid tissue. This represents the stage of maturity. Next is to be seen a motley mass of atrophied, broken down, and fatty degenerated cells, occupying the centre of the nodule. This represents the last stage, wherein decay and death have ensued, from starvation. Around all is a zone, of a line or more in depth, which is pale, grayish, and translucent, from infiltration of leucocytes; this pseudo-capsule, as it may be called, is intimately blended with, and inseparable from, the growth proper, though easily to be distinguished from it. The fibrous syphilomata are, in texture and appearance, such as represented by the middle zone, above described. Syphiloma, after disintegration, leaves a cicatrix remarkable for its contractile nature and puckered appearance. A small, scarcely discernible cicatrix may thus mark the site of a former nodule, or mass of nodules. Notwithstanding the cicatrix is small, the traction on the healthy tissues sometimes greatly distorts them. The ulcers resulting from the breaking down of gummata are deep, and usually present steep walls. These must not be confounded with the superficial ulcers of the mucous membrane, or rather of the submucous lymphatic tissue, so prone to occur in constitutional syphilis.

The configuration of the growth is spheroidal where only

one nodule exists, irregular and nodular when several are joined. The resulting ulcer is circular, oval or serpentine.

Causes.—The one and only cause of syphiloma is the specific poison of syphilis, which manifests in the primary chancre, and later, gives rise to neoplastic formations of connective tissue in various parts of the body.

CHAPTER XII.

TUMORS.

Tumors are circumscribed growths of new formation. They are somewhat independent of the general organism; that is, parasitical; and in structure have their types in some one or more of the normal tissues. Under this head are included the non-inflammatory growths.

Classification of Tumors.

Tumors are best classified according to their histological characters. We have adopted the following classification, in conformity to that in general use:—

I. Type of Embryonic Connective Tissues.

Type of granulation tissue,	Sarcomata.
" mucous tissue,	Myxomata.

II. Type of Mature Connective Tissues.

Type of fibrous tissue,	Fibromata.
" adipose tissue,	Lipomata.
" cartilage,	Enchondromata.
" bone,	Osteomata.
" lymphatic tissue,	Lymphomata.

III. Type of Epithelial and Connective Tissues (Epithelio-connective).

Type of papillæ of skin, etc.,	Papillomata.
" secreting glands,	Adenomata.
" anomalous,	Carcinomata.

IV. Type of Higher Tissues.

Type of Muscle,	Myomata.
" nerve,	Neuromata.
" blood vessels,	Angiomata.

CHAPTER XIII.

NEW FORMATIONS OF CONNECTIVE TISSUE.

A knowledge of the nature and manner of growth of connective tissue is essential to a proper understanding of its morbid proliferations. Connective tissue exists in various forms, and constitutes many of the important structures of the animal organism. As a matter of convenience, all the varied forms of connective tissue are arranged under two heads: the *common connective tissue* and the *connective substances*. The former embraces the interstitial connective tissue, which fills in the spaces between other structures, and accompanies and surrounds the blood-vessels everywhere. On account of the absence of definite form, it is sometimes called *formless connective tissue*. The latter embraces those more highly organized states of connective tissue, as in bone, cartilage, tendon. The distinguishing mark of all connective tissues is the universal presence of an intercellular substance, separating and cementing the cells. In common connective tissue two kinds of cells are recognized, the *fixed* or *stable* cells, and the *mobile* or *wandering* cells. The fixed cells are stationary, and constitute integral parts of the tissue. They are of various shapes, round, oval, fusiform, and stellate. These latter are provided with long, thread-like processes, which, uniting with those of contiguous cells, form a network, in which is lodged the intercellular substance. They are, for the most part, typical nucleated cells. The mobile cells are small and round, nucleated, but without a limiting membrane. They resemble the leucocytes of the blood and lymph. Recent investigations have made it probable that the interstitial or common connective tissue is a system of intercommunicating channels, in direct communication with

the lymphatics, and that the fixed cells of the connective tissue are identical in character and function with the endothelial cells of the blood and lymph vessels. In accordance with the above, the mobile connective tissue cells may be regarded either as escaped white-blood corpuscles threading the connective-tissue passages; or, more probably, young connective tissue, or lymph corpuscles, making the rounds of the lymphatic circuit. The intercellular substance is that which fills the interstices between the cells; it is more or less firm and homogeneous, or fibrillated. In the formation of connective substances, both the cells and intercellular substance undergo various transformations in character and arrangement. As a rule, the nature of the intercellular substance determines the physical characters of the connective substance. The intercellular substance of bone is impregnated with lime salts, imparting to the structure its hardness. In cartilage it is homogeneous and hyaline, in fibrous tissue fibrillated, in mucous tissue gelatinous. Common connective tissue is the most prolific of all tissues. By some it is supposed to furnish the germinal matter for the building up and repair of all other tissues. True it is, at least, that the common connective tissue, with its analogue, the endothelia, beget the vast majority of new formations. The first step in the process of growth is the production of young cells. The cells are, in the primitive state, small, round, soft, without limiting membrane, and provided with large, spherical nuclei. These cells, known as indifferent or germinal cells, are imbedded in a scant, homogeneous, soft, intercellular substance, and constitute embryonic tissue. The cells of embryonic tissue are indistinguishable from leucocytes, except in some instances, as a result of inflammatory proliferation they are larger and have very large nuclei, as in the so-called granulation tissue. The cells, in all instances, are probably derived, in part, from the multiplication of the fixed connective tissue

cells, in part by the massing of leucocytes, or mobile cells, but principally, as it would seem, from the proliferation of the latter.

The method of reproduction is, as believed, for the fixed cells, by division and endogenous formation, for the mobile cells, by simple division, their youth and plasticity specially favoring the reproductive act. Sometimes, under the influence of nutritive excitation, a cell will take on growth; the nucleus will divide and subdivide continuously, without a coincident cleavage of the protoplasm. As the result, a very large polynucleated protoplasmic mass is formed—the so-called *myeloid* or *giant* cell. The next step consists in a diminution in number, and an increase in size and consistence of the cellular elements. At the same time many of them assume different shapes and acquire an investing membrane. Consentaneously the intercellular substance increases in quantity, becomes firmer and fibrillates. The different phases of reproduction and maturation of connective tissue, as well as those higher developmental processes by which connective substances are formed, are more or less faithfully mirrored in the various new formations of connective tissue.

CHAPTER XIV.

NEW FORMATIONS OF EMBRYONIC CONNECTIVE TISSUE.

The Sarcomata.

The sarcomata are new formations of *embryonic* connective tissue. They preserve the embryonic character throughout their entire existence. When, as exceptionally is the case, the growth advances to maturity, the structure so formed always belongs to the connective tissue family. This, together with the fact that the growth is always the offspring of connective tissue, stamps the sarcomas as new formations of the same. They are taken up first in order, because they represent the primary stage of connective tissue development.

Varieties. They may be aptly divided according to the peculiarities in the form, size and color of the cells of which they are composed. Of these there are four principal varieties; the round, the spindle-shaped, the myeloid, and the pigmented. Hence, we shall have to consider, the round-celled sarcoma, the spindle-celled sarcoma, the myeloid sarcoma, and the pigmented or melanoid sarcoma. Other peculiarities, based on the size of the cellular elements, the structure of the growth, its composition, combinations and situation, will be alluded to in a supplementary way. As several of the varieties of cells, as enumerated above, may exist in the same growth, it receives its name from the predominating variety.

Causes. Little is known in this direction. The extremes of youth and old age and constitutional syphilis are supposed to predispose to, and repeated irritation to excite, the growth.

Development and Cause. The sarcomata always originate in connective tissue, usually from the common connective tissue—the subcutaneous, submucous, subserous, the inter-

stitial tissue of organs or their investing membranes. The growth augments by proliferation and massing of the corpuscular elements, and is both central and peripheral in character, principally the latter. It infiltrates surrounding structures, both connective and other, and establishes new foci of disease, which eventually coalesce with the original. Its growth is usually rapid, though when encapsuled or bound down by dense and resisting structures, such as periosteum or the compact tissue of bone, it may be held at bay for long periods. After breaking through these barriers, it often extends very rapidly. It extends to remote regions of the body, through its wandering cells, and by the way of the lymph and blood paths. The access of the cells into the blood is specially favored by the thin and fragile condition of the smaller vessels, which supply the growth. It is by this channel that secondary infection ordinarily takes place, which is in striking contrast to that observed in cancer, where the infecting matter travels by the way of the lymphatics.

Secondary Changes. The secondary changes to which sarcomas are prone are inflammation, hemorrhage, calcareous, mucoid and fatty degeneration. Fatty degeneration is the most prevalent form, and always exists in the older central part of the growth. Though, in the main, the sarcomas preserve their embryonic characters to the last, yet it not unfrequently happens that parts of the growth go on to the mature state, either of common fibrous tissue, or advance to the higher forms of connective substances. The fibrous tissue thus constituted more nearly resembles the cicatricial tissue of wounds than normal structure, in that it is denser, dryer, more tense than the latter. The connective substances also fall short of, or deviate from, the normal, inasmuch as we seldom see a pure osseous or cartilaginous tissue proceeding from a sarcomatous growth. The *locality* of the growth seems to determine the direction in which these formative

processes will proceed, and also gives character to the cellular and inter-cellular elements. Thus, a sarcoma proceeding from the medulla of bone, is apt to contain giant cells, because this form of cell is peculiar to this region normally. That proceeding from pigmented structures, as from the choroid of the eye, is apt to contain pigmented cells, and that proceeding from bone or cartilage, is prone to the osseous or cartilaginous development.

Vascularity. Sarcomas are, as a rule, very vascular. The vessels are either normal in structure, or thicker walled, dilated, and tortuous. The capillaries, on the other hand, are frequently very thin and fragile, consisting of a single layer of embryonic cells, similar in all respects to the cells of the surrounding structure. This faulty construction of the vessels favors the entrance of the sarcomatous elements into the circulation, and also conduces to hemorrhagic extravasations. The distribution of the blood vessels is very irregular.

Physical Characters. The distinguishing mark of a sarcoma is the great preponderance of the cellular elements, and the sparsity of the intèrcellular substance. In fact, the cells seem to constitute almost the entire growth. The cells are of the various forms, sizes and colors indicated in the foregoing description. They are almost always without a limiting membrane, soft and plastic, even though a change of form presages a higher state of development. The relatively large size of the nuclei and scantiness of the protoplasm in some forms of sarcoma, give the appearance of an abundance of free nuclei studding the growth. This exceedingly characteristic appearance was regarded by Virchow as almost infallible evidence of the sarcomatous nature. The intercellular substance is scant, soft, and homogeneous. The various degenerations and hemorrhages, as well as the more highly organized parts of the mass, impart their characteristic ap-

pearances. Those sarcomas of central growth are sometimes encapsuled. Sometimes the investing membrane of the organ in which the growth is transpiring forms a false capsule. This is well illustrated in the growths occurring in lymphatic glands and beneath the periosteum. When the growth is peripheral, general diffusion and infiltration of the surrounding structures efface all lines of distinction between the normal and morbid. The typical sarcoma is soft, succulent, of a grayish-white color, and yields a juice somewhat milky, owing to the contained cells. It is malignant. The various modifications of form, color, consistence, its uniformity or variegation, the character of the expressed juice, the form of its elementary parts, and its degree of malignancy, vary according to the circumstances of growth, of degeneration, and accident. These, which are all ascribable to the plastic and impressible nature of the sarcomatous tissue, defy a generic description, and must needs be alluded to in detail.

Round-celled Sarcoma.

Small Round-celled Sarcoma. The cells are small, round, with large, spherical nuclei. The inter-cellular substance is soft, viscid and scant. Blood vessels are very abundant, the terminal branches often consisting of but a single layer of germinal cells. A general absence of structure prevails. In some the resemblance to *granulation tissue* is striking. In these papillary arrangement of the germinal tissue is sometimes observed; here, also, the large, highly refractive nuclei give the deceptive appearance of free nuclei. These growths are soft, elastic, comparatively dry. The cut surface is reddish-white, homogeneous, and on scraping yields a small amount of almost clear fluid. These are the least malignant of the round-celled sarcomas. They are found proceeding from the membranous expansions of connective tissue—sheaths of the

cranial nerves, periosteum, also from the cutaneous, mucous, and serous surfaces.

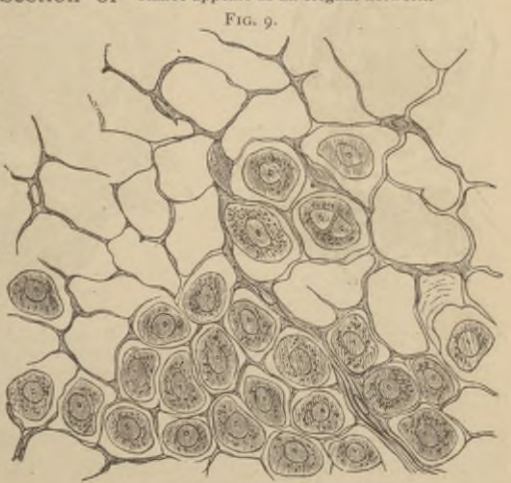
Reticulated Small Round-celled Sarcoma. In others the intercellular substance is arranged net-like, in the meshes of which repose the cells. The structure resembles that of the lymphatic follicle. Owing to the reticulated character of the intercellular substance, the cells are more isolated, less coherent, and immersed in a watery fluid. Section of the growth reveals more succulence, but aside from the reticulum the same general characters as in the above. Scraping the surface brings away an abundant milky fluid, rich in cells. Occurring in the lymphatic glands, the

FIG. 8.

ROUND-CELLED SARCOMA.

a. Vascular lumina. *b*. Parenchyma partly brushed out, so that the hardened basis-substance appears as an elegant network.

FIG. 9.

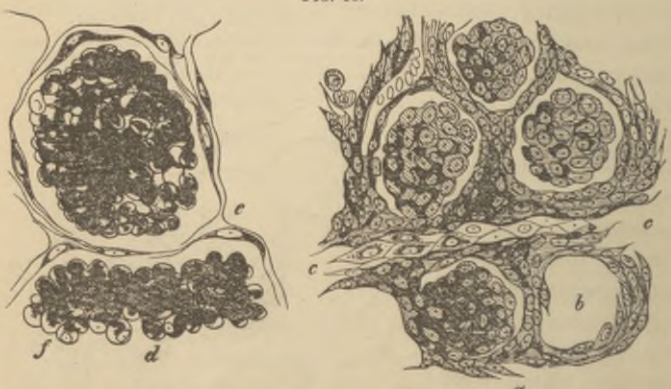


LARGE ROUND-CELLED SARCOMA.

growth is apt to be mistaken for hypertrophy of the same, on account of similarity of structure. Fatty and mucoid degeneration are common, and may attain to such an extent as to mask the true nature of the growth—*lipo-sarcoma, myxo-sarcoma.* In such cases, the sarcomatous nature of the more recently formed parts at the periphery suffices to reveal its true character. They sometimes attain enormous dimensions. The reticulated, small, round-celled sarcomas are highly malignant. Their favorite site is the interstitial and subcutaneous connective tissue of the thigh, lymphatic glands and the sub-peritoneal connective tissue. The latter are prone to the mucoid degeneration.

Large Round-celled Sarcoma.—The cells are large, round, provided with large vesicular nuclei, and bright nucleoli.

FIG. 10.



a. Alveolar round-celled sarcoma, pigmented. *b*. Alveolus from which the ball of round cells has fallen out. *c*. Vessel with pigmented endothelia. *d*. Pigmented round cells. *e*. Spindle-cells forming a stroma.

These, with the general sparseness of intercellular substance, give to them an epithelial-like appearance not always easily distinguishable from true epithelium. The cells are imbedded in a true reticulum of intercellular substance—*reticu-*

lated, large, round-celled sarcoma—or massed together in spherical balls in similarly-shaped openings of the connective tissue. This latter presents the same structural arrangement as cancer, and has won for it the name of *medullary* or *carcinomatous* sarcoma. The essential distinction between this and cancer lies in the uniformity in the size and shape of the cells. The growths are soft and brain-like in consistence, and of a pinkish or gray, or mottled appearance. They proceed from all connective tissues, but, by preference, from the eye, the medulla of bone, and the subcutaneous connective tissue. They are, especially the alveolated form, frequently pigmented, and very malignant.

Spindle-celled Sarcomata.

Small Spindle-celled Sarcoma. The cells are small, spindle-shaped, having an oval nucleus. The intercellular substance is inappreciable in quantity, so that the entire growth seems to consist of cells. The cells lie with their long axes parallel and their points interdigitating with those in front and behind. In this way bundles or fasciculi are formed, which run in all directions, so that a section of a growth in any direction will cut some of the cells transversely, some obliquely, and some longitudinally. The transversely divided cells appear as round cells, from which they must be distinguished. Being a step nearer the fibrous tissue, on account of the configuration of its cells, than the round-celled sarco-

FIG. 11.

SPINDLE-CELLED SARCOMA.

mas, a development into mature fibrous tissue is not infrequent. The small spindle-celled sarcomas are firmer and dryer than the round-celled variety, and the cut surface presents striations corresponding to the course of fasciculi. They are also less malignant. They spring from the fasciae, the sheaths of nerves and blood vessels, the subcutaneous and submucous connective tissue, as well as other connective structures.

FIG. 12.

LARGE SPINDLE-CELLED SARCOMA.

Large Spindle-celled Sarcoma. This variety differs little from the preceding in the configuration of its cells, or the arrangement of structure. The cells, however, are of colossal size, with large oval nuclei and bright nucleoli. Notwithstanding their immense size, they preserve their embryonic character, with now and then a little hardening of the long filiform extremities. The cells are sometimes arranged in radiating sheets, or fan-like. They originate preferably in the connective tissue membranes. They are among the least malignant of the sarcomas.

Myeloid Sarcoma.

The distinguishing feature of this variety is the myeloid or giant cell, a polynucleated mass of protoplasm, irregularly round in shape, and having numerous delicate processes. The cell has no investing membrane. It is always associated with other cells, usually of the fusiform kind, and takes its place in the growth after the manner in which the squares of like color are arranged on a checker-board. That is, the cells of the next succeeding row behind are intermediate between the cells of the row in front; whereas the cells of alternate rows are in line.

The myeloid sarcoma almost always springs from the medulla of bone. Whether they spring from the periosteum is a mooted question. The not infrequent instances in which they seem to spring from periosteum may, as Nélaton supposes, arise from a deep-rooted origin in the medulla of a dilated Haversian canal. Their favorite site is the medulla and heads of the long bones of the extremities, and the periosteal surface of the bones of the jaw. In the latter situation the growth is known as *epulis*. Growing from the interior of the bone the compact substance becomes expanded, thinned and bulging, and crepitates on pressure. Eventually the growth breaks through and protrudes as a fungus. Ossification and calcification of the inter-cellular substance often go hand in hand with the cellular proliferation—*osteo-sarcoma*. This tendency, together with the peculiar arrangement of the myeloid cells, which is similar to that of the corpuscles in bone, stamps this as an embryonic osseous formation; indeed, these cells are supposed to originate from bone corpuscles. Sometimes the growth is exceeding vascular, in which hemorrhages are frequent, producing ecchymoses, or blood pools. The myeloid sarcomas are usually firm and fleshy, and on section yellowish red, with or without red blotches. They are the least malignant of the sarcomas.

Melanoid Sarcoma.

This variety, so named because of the more or less dark color of the growth, may be grafted on any of the other varieties of sarcoma, and is only entitled to distinct consideration on account of its clinical importance. The color depends upon a dark pigment, in granular form, deposited in the cells. The cells are usually of a spindle form, although, as we have seen, pigmentation of the alveolar variety of the round-celled sarcoma is not uncommon. The degree of pigmentation varies greatly, as also its manner of distribution. In no case does it affect all the cells, and usually only a small proportion of them. The eye is the preferred seat of these growths, and, to a minor degree, the skin. It will be seen that they arise from normally pigmented structures, thus conforming to the general law, "like begets like," applicable as well to morbid as to normal reproductions. They are soft, vascular, and on section present a uniform, dark brown coloration or, more frequently, a less pronounced, a mottled or striated appearance. They are extremely malignant, and secondary infection occurs with great facility.

The secondary growths are, as a rule, likewise pigmented, even when arising from non-pigmented structures. By far the major part of the pigmented growths are sarcomas. This includes many of the hitherto so-called melanoid cancers.

Other Varieties. Among other varieties may be mentioned *Recurrent-Fibroid*, a spindle-celled sarcoma; *Myxo-Sarcoma*, a sarcoma undergoing mucous degeneration; *Lipo-Sarcoma*, a sarcoma undergoing fatty degeneration; *Chondro-Sarcoma*, a sarcoma showing cartilaginous development; *Osteo-Sarcoma*, a sarcoma showing osseous development: *Epulis*, a sarcoma springing from the bones of the upper or lower jaw; *Glioma*, a sarcoma of exceeding small, round cells in a delicate reticulum of intercellular substance, springing from the sheaths of the cranial nerves; *Psammoma*, a doubtful growth,

supposed to be of sarcomatous nature, springing from the membranes of the brain. It consists of the calcareously infiltrated corpora-amylaceæ, together with a few cells and blood vessels. It is of little clinical importance, except when it attains to unwonted size.

Myxomata.

The myxomata are growths of mucous tissue. Mucous tissue is an immature form of connective tissue. It displays its embryonic nature in its intercellular substance, which is soft, gelatinous, and non-fibrillated. Mucous tissue exists largely in the fœtal structures, from which is evolved many of the mature forms of connective tissue. The myxomata are, therefore, closely allied to the sarcomata, both representing new formations of embryonic connective tissue. In the sarcomata, however, the cellular elements predominate, whereas, in the myxomata, the intercellular substance is largely in excess. Mucous tissue exists physiologically in the umbilical cord at birth, and in the vitreous body of the eye throughout life. In the former, the cells are branched and form a reticulum, the meshes of which are occupied by the intercellular substance. In the latter, the cells are devoid of processes, and lie scattered throughout the intercellular substance, after the manner of cartilage cells. All mucous tissue growths pattern after one or the other of the above forms. The growths of mucous tissue must be distinguished from mucoid degenerations. This is not always easy, inasmuch as the tissues most susceptible to the mucoid change are the very ones from which the growths are most apt to spring. Notably is this the case in regard to adipose tissue. Indeed, the relation subsisting between adipose tissue and mucous tissue is very intimate, the one passing over into the other with great facility. The growth may usually be distinguished from the degeneration by its being encapsuled,

organized and projecting, whereas, the degeneration is wanting in these characters, and represents rather a destructive change in the substance of preëxisting tissues.

Classes. The myxomata are first divisible, according to the nature of the cellular elements, into: 1. The roundish or oval cells without processes, and 2. The stellate or fusiform cells, the processes of which join to form a reticulum. The latter is by far the most common form of growth. Others are based on the translucency or opacity of the growth. The former depends on the scarcity, and the latter on the density of the cellular elements. Still other varieties arise from the admixture of mucous tissue with other forms of growth. These classifications are of little practical value except in the case of myxo-sarcoma, where the malignant nature of the allied growth entails an unfavorable prognosis.

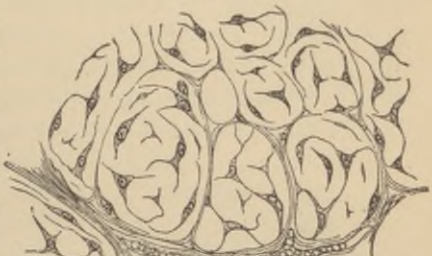
Causes. They occur in early life, from the persistence and development of embryonic tissue, and in old age, from the lack of that vitality which raises young connective tissue through its various stages to the mature state.

Development and Course. Being of the connective tissue type, the myxomata always arise from connective tissue structures, and by preference from the subcutaneous, submucous, and interstitial adipose tissue of muscles, but also from the common connective tissue in the situations above named, and of the internal organs, sheaths of nerves, and the medulla of bone. They are most frequently found in the subcutaneous tissue of the thigh, the back, and the external genitals; also springing from the inter-muscular tissue of the neck and face. These growths are usually provided with a thin capsule, the interior of which is traversed by fibrous bands which divide it into compartments, and thus form a framework in which the jelly-like substance reposes. More rarely the growth is without capsule, and extends by peripheral growth. The progress of the growth is sometimes rapid, when, if it be of the white,

opaque variety, it is liable to be mistaken for medullary cancer. Usually, however, the progress of the growth is slow, although it may attain enormous dimensions. The accidents to which these growths are prone are fatty degeneration of the cellular elements, with consequent liquefaction of the intercellular substance, and very rarely hemorrhagic effusions, from ruptured capillary vessels.

Physical Characters. The cells are spherical, ovoid, fusiform, or stellate. They are nucleated and ill defined, owing to the strongly refractive nature of the inter-cellular substance. The branched cells communicate with each other to form a network, but the spheroidal cells lie scattered and isolated. When very abundant and closely packed, they impart to the growth a whitish opacity, of brain-like appearance. Usually, however, they are sparsely distributed when the growth is translucent. The inter-cellular substance is soft, gelatinous, colorless, translucent, and usually very abundant. It yields mucin. The blood-vessels are few in number, and mostly confined to the fibrous septa. The growth, taken as a whole, is soft, gelatinous and trembling, somewhat translucent, and of a pinkish-white, or grayish-white color. It is more or less globular, lobulated, and when found on the surface, pedunculated, or tending to become so. The cut surface is uniform, with now and then striations of glistening fibres, and exudes, on pressure, a jelly-like substance, in which may be distinguished, microscopically, the cellular elements. The growth is not multiple, except when

FIG. 13.



HYALINE MYXOMA.

springing from the sheaths of nerves. The myxomata are benign, non-recurrent, non-infectious, and give rise to little inconvenience, except from their size or situation. Occurring in the nasal passages,—*nasal polypi*—they interfere with voice and respiration. When situated along the course of a nerve, they are sometimes exceedingly painful. In the latter situation they are known as *painful tubercles*, and erroneously as *neuromata*. If associated with sarcoma they, of course, become malignant.

Examples. Nasal polypi; uterine moles, or placental hydatids.

CHAPTER XV.

NEW FORMATIONS OF MATURE CONNECTIVE TISSUE.

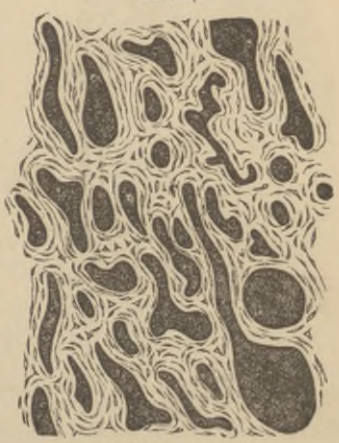
Fibromata.

The fibromata are growths of mature connective tissue. They differ from the foregoing in that both cells and intercellular substance are in a state of complete development, and resemble normal connective tissue as it occurs in its various situations and under its various forms.

Causes. Besides a constitutional predisposition, which seems to underlie the multiple growths in general, the fibromata result from prolonged irritation, succeed to inflammation, and are sometimes traceable to over-nutrition, depending on occlusion of the lymph channels and consequent inundation of the tissues with nutritive fluids.

Classes. As the fibromata are merely exaggerated growths of connective tissue in its various forms, it follows that any classification not including all will be defective. The varieties usually recognized are the *solid* or dense form, as it exists in tendon and aponeurosis; the soft and succulent form, as it exists in the subcutaneous areolar tissue; and to these is added a *cavernous* form, in which the growth is permeated by large, cavernous sinuses, with un-

FIG. 14.



CAVERNOUS FIBROMA.

yielding walls, and which are apt to give rise to troublesome hemorrhage when injured.

Development and Course. The fibromata spring from connective tissue in all situations. They at first consist of embryonic connective tissue, with the usual abundance of cells and scantiness of intercellular substance. In the process of development, this order is reversed, the cells diminishing in number while the intercellular substance increases enormously, fibrillates and hardens. The density of the growth is proportionate to the completeness of this change; hence, we look for the embryonic character only in the rapidly formed tumors. The fibromata are always encapsuled, and the growth is gradual and central. They are subject to *hemorrhage*, to *inflammation*, to *mucoid*, *fatty* and *calcareous* degeneration.

FIG. 15.

TRANSVERSE SECTION OF A FIBROMA OF UTERUS.

a. Isolated cellular elements. *b*. An unraveled fasciculus of the fibroma.

Physical Characters.—The cells, for the most part, are exceedingly small, spindle-shaped, and few in number. They are most abundant in the vicinity of blood-vessels, and exist here and there, very sparsely distributed, and hidden away amid the fibres. At times they present other forms, are more abundant, and easily recognizable. The intercellular substance is very abundant and fibrillated, the

fibres running in every conceivable direction, without law or order. Occasionally, the fibres run in parallel bundles, radiate fan-like, or arrange themselves concentrically around the blood-vessels. The latter arrangement is not uncommon. The growth is spheroidal, encapsuled, lobulated, and varies in consistence from that of the densest cicatricial tissue which creaks under the knife, and presents a dry, glistening surface of section, to that of areolar tissue, which is succulent, and exudes from its meshes an abundant serous or mucoid fluid. The cut surface is gray, with a cast of white, yellow, or red, and is now and then intersected with glistening bands of fibres. They vary in size from the most minute to the most massive of growths; are usually single, except as springing from the skin and sheaths of nerves; painless, except in the latter situation; harmless, except as to their size or situation; benign and non-recurrent. The softer variety is usually found springing from the skin and mucous surfaces, and is apt to become pedunculated; the denser variety from the deeper-seated structures.

Lipomata.

The lipomata are growths of adipose tissue. Adipose tissue, it will be remembered, is common connective tissue, the cells of which are infiltrated with fat. When the infiltration is general and diffused, it constitutes obesity.

Development and Course.—The lipomata originate in the connective or adipose tissue in all situations where fat exists normally. They are produced either by the fatty infiltration of existing connective tissue cells, or, and by far more frequently, by the proliferation and subsequent infiltration of new connective tissue cells. They are of central growth, lobulated and encapsuled, increasing very slowly at first, but gaining momentum as the growth increases in size. They are subject to inflammation, to calcareous and mucoid degeneration. The

interstitial fibrous tissue sometimes acquires density and volume, or other forms of connective tissue growth are associated with it, constituting mixed growths, known as myxomatous, fibromatous, or enchondromatous lipoma.

Physical Characters.—The cells of the lipoma are larger, plumper, and the contained fat more fluid than in normal adipose tissue. They are round, or, from mutual pressure, polygonal in form, and are gathered in clusters, constituting lobules. The nucleus and protoplasm are crowded to the periphery of the cell, and constitute a mere enveloping film, usually indistinguishable until after treatment with acetic acid. Each lobule has a thin investment of connective tissue, as has also the aggregation of lobules of which the growth consists. The vascular supply usually springs from one trunk, centrally located, which penetrates the capsule and gives off numberless branches, which ramify in the connective tissue septa, between the lobules and vesicles. The lipomata are of all sizes; in form, irregularly globular, except when bound down by surrounding structures; and in consistency and color resemble ordinary adipose tissue. Owing to the central growth, their independence and loose attachment to the normal tissues, the lipomata are apt to glide out from the deeper structures, and present under the skin, when they may become pedunculated. They are simple or multiple, painless and benign. When associated with other forms of growth, their physical characters are altered correspondingly.

Enchondromata.

Enchondroma is a growth of cartilaginous tissue. Cartilage is a non-vascular form of connective tissue, which receives its nourishment by imbibing fluids thrown out by the vessels which approach to, but do not enter, its substance. It exists normally in three principal forms: 1. As cells imbedded in a hyaline basis substance. 2. As cells imbedded

in a fibrillated basis substance. 3. As cells imbedded in a mucoid basis substance. Of these three forms, the first is, by all odds, the most common, and the last, least so. *The cells* of cartilage are in the main round or oval, occasionally spindle-formed, especially in the second variety, or stellate and reticulated, as in the cornea. The first variety is called *hyaline* cartilage, the second *fibro-cartilage* and the third *gelatinoid*, or *mucoid* cartilage.

Causes. Enchondromata occur most frequently in early life. They are supposed to originate, as a rule, from a nidus of immature cartilage which has failed to ripen with the surrounding tissues, and which, for some reason, has been incited to proliferation.

Classes. The morbid growths of cartilage are of the various types mentioned above, and in order of frequency similar to the normal growths. Hence, the hyaline form vastly more frequent than either of the others. To these may be added an osteoid form, in which the growth, in whole or in part, tends to ossification. The various combinations of cartilaginous with other forms of growth give rise to names indicative of these combinations. Of such are fibrous, myxomatous, osteoid, and sarcomatous, enchondroma.

Development and Course. The enchondromata originate in common connective tissue, in the medulla or periosteum of bone, and in cartilage. Fully three-fourths of the enchondromas spring from bone, notably from the shaft of long bones;—phalanges, and the long bones of the upper and lower extremities. The subcutaneous connective tissue, and the connective tissue of the testes, ovaries, the parotid and mammary glands, furnish the next largest quota; while, curiously enough, cartilage proper yields but few enchondromas, and those are small and inconsequential. The growth is central and slow, usually single, and may attain

great size. The secondary changes are ulceration, fibrillation, calcification, or mucoid degeneration of the inter-cellular substance, and calcification of the cellular elements.

Physical Characters. Cartilaginous growths are distinctly lobulated; the lobules being small, of even size, and invested, individually and collectively, by fibrous tissue, in which ramify the nutrient vessels. In the central part of the larger growths these vessels are jugulated by pressure, and the ill-nourished parts fall into degeneration. In the osteoid variety this does not occur, because of the protection to the vessels by the ossified trabeculæ. Pure enchondromata are almost always innocent, the only exception being in those softer varieties springing from the medulla of bone. The sarcomatous variety is essentially malignant.

Osteomata.

Osteomata are growths of osseous tissue. Osseous tissue is a form of connective substance in which the cells—*bone corpuscles*—are imbedded in a calcified intercellular substance. Bone originally develops from fibrous membrane or cartilage, and subsequently, in a great measure, from periosteum, all of which are varieties of connective tissue. Normally, the internal surface of the periosteum furnishes layer after layer of plasmatic material, which subsequently hardens and matures into genuine compact substance.

Causes. The causes of osteoma are to be sought in irritation of bone, its medulla or periosteum. Common connective tissue proliferations sometimes develop into bone, especially if occurring in the vicinity of irritated or inflamed osseous structures.

Classes. The osseous new formations are divisible into two classes: The *exostoses*, in which the growth proceeds from bone or its membranes, and the *osteophytes*, in which it originates in connective tissue, more or less remote from bone.

When an osteoma resembles the spongy tissue of bone, it is called *cancellous* osteoma; when the compact tissue, *compact* osteoma. Some, however, are of such exceeding density as to be neither included in one or the other. These, on account of their ivory consistence, are known as *eburnated* osteomata. Cancellous osteoma is always provided with a thin shell of compact substance, and often contains depots of fat or embryonic tissue. Eburnated osteoma contains no blood vessels or cancellous tissue, and presents a smooth, shining surface of section. Section is only possible by means of a chisel or saw.

Development and Course. Osteomata spring from bone, periosteum, medulla and common connective tissue. Their preferred seats are the internal and external tables of the skull; the orbit and the periosteum of the upper and lower jaw for the harder varieties, and the articular ends or the medulla of long bones, for the cancellous variety. The osteophytes occur in the common connective tissue, cartilage or tendon; the interstitial connective tissue of muscles, glands or organs, as a result of chronic irritation, and especially in the neighborhood of diseased bones or joints. They differ from calcareous deposits by exhibiting Haversian canals, bone corpuscles, blood vessels, and, in short, by their osseous structure. Compact osteoma growing from the surface of bone is separated from it by a demarkating line, but nevertheless, is covered by the common periosteum. The growth is slow, central, of comparatively small size, often multiple and perfectly innocent. Ossified sarcomas and cancers must not be mistaken for osteomas. The true character of these growths will be revealed in that portion of the tumor which has not undergone the secondary change. These are malignant.

New Formations of Lymphatic Tissue.

Lymphatic tissue is that form of tissue which constitutes the essential part of lymphatic glands and the malpighian bodies of the spleen. Not long since it was supposed to be confined to the structures above named, but it is now known to exist much more extensively. It occurs as an essential element in many of the ductless glands; the thymus, the tonsils, the follicles of the pharynx, and the agminated and solitary follicles of the intestines; in many of the serous membranes, the pia mater, pleura, peritoneum; it underlies many mucous membranes; accompanies the terminal bronchial tubes; envelopes the smaller blood-vessels; and is demonstratable in the medulla of bone. It consists of a stroma or reticulum of branched cells, in the meshes of which are other cells:—*lymph corpuscles*—which are identical with white blood corpuscles. It will be seen that the peculiarity of this tissue is, that both the reticulum and that which is contained in the meshes of the reticulum consist of *cells*, and we have no dealing with an *intercellular* substance. True, there exists in both situations a scant intercellular substance, but it plays no active part in the pathological changes of the tissue. The cells forming the reticulum are branched, the process joining with those of other cells, to form a network. The body of the cell is to be sought as a very slight nucleated enlargement at the angle of a mesh. The processes are frequently quite as heavy as the body, when the reticulum appears to be composed of intersecting strands or threads, arranged as in a fish-net. Ordinarily the reticulum is very delicate, with exceedingly minute meshes, in which rest one, two or three of the lymph corpuscles:—

Lymphomata.

Lymphomata are growths of lymphatic or *adenoid* tissue.

Classes. They may be conveniently considered: 1. As soft lymphomata, in which the lymph corpuscles preponderate. 2. As indurated lymphomata, in which the stroma preponderates.

Causes. The causes of lymphomata are so numerous and varied as to defy enumeration. The reasons for this are twofold: First, the lymphatic tissue, owing to the abundance of lymph corpuscles, or leucocytes, in its composition, is embryonic in character. Being embryonic, it is very impressible, and easily excited to nutritive activity by any excitant. Second, the lymphatic glands, and lymphatic structures in general, act as filters to the waste fluids of the body, thereby being exposed to many noxious and deleterious agencies. Now, if these agencies be indifferent, the resulting lymphatic growth will be a simple hyperplasia. If, on the other hand, the agent be specific, such as the poison of smallpox, syphilis, scrofula, the resulting growth will present specific characters. It must not be forgotten that many morbid growths occurring in the lymphatic tissue are not properly lymphomata. Thus, the infectious elements of cancer, finding lodgment in a lymphatic gland, produce a growth having the elements and structure of cancer. This would constitute cancer of a lymphatic gland, but not a lymphoma, because the new formed tissue is not of a lymphatic nature. A great majority of the morbid proliferations may be, and are, produced in the lymphatic structures; but those having special characters are not included under the lymphomata. True growths of lymphatic tissue occur in many diseases, among which may be named typhoid fever, leucocythemia, smallpox, syphilis, scarlet fever, measles, certain heart affections, and Bright's disease.

Soft Lymphomata commence in a proliferation of the lymph

corpuscles, and probably, also, in a migration of white-blood corpuscles. The cells are, many of them, larger than natural, polynucleated, augmented in numbers, and are clustered many together in a mesh. All this denotes a nutritive excitation. In consequence of the pressure exerted by the amassed cells, the reticular fibres frequently suffer attenuation, and sometimes destruction. The growth, as a whole, is soft and pultaceous, of the color and consistence of brain tissue. The cut surface is of a uniform dull, white color, and yields an abundant milky juice, abounding in leucocytes. Thin sections, under the microscope, show massive aggregations of lymph corpuscles, which, in their profusion, entirely conceal the stroma. These agitated in water, dislodge the corpuscles, and reveal a delicate reticulum of filamentous strands. This form is of rapid growth, frequently attains great size, and is prone to burst the confines of the structure in which it is located, and infiltrate surrounding structures. They do not, however, infect remote districts.

Indurated Lymphomata. These are characterized by the opposite condition of things. Here the branched cells of the reticulum undergo development, becoming large and massive, and encroaching on the interstitial spaces occupied by the lymph corpuscles. These latter, as a consequence, diminish in size and numbers. The indurated lymphoma is of small size, slow development, hard and nodular to the feel, never infiltrates surrounding structures, presents a fibrous or cartilaginous surface of section, yields no juice, and under the microscope reveals a heavy-barred reticulum with few lymph corpuscles. It sometimes succeeds to the softer variety after the subsidence of acute symptoms.

Lymphomata occur most frequently in the lymphatic glands of the neck, axilla, groin, thoracic and abdominal cavities. They also occur in the spleen, liver, kidneys, muscles, bones, serous membranes, along the intestinal tract, and in the nasal

cavities; in which latter situation they form polypi. They are often single, sometimes multiple, fused and lobulated. Occasionally a systemic condition prevails, in which the lymphatic tissues of the entire body participate in a morbid proliferation. A rapidly growing and mammoth lymphoma, is prone to start in the mediastinal glands and fill the thoracic cavity. This is sometimes erroneously called encephaloid, or thoracic cancer.

Secondary Changes. The secondary changes of lymphomata vary much, according to the cause and nature of the growth. Whereas the scrofulous form of growth rapidly passes over into fatty degeneration, caseation and general disintegration; the simple form, arising from indifferent causes, and that which occurs in syphilis, leucocythemia, and in some other diseases, present a marked contrast. These latter exhibit a wonderful pertinacity, very slowly and imperceptibly falling into retrogressive change, so slowly, indeed, that the waste products are removed by absorption as rapidly as formed, and the growth gradually melts away without obvious change in character. As a rule, it is in the soft lymphoma that we look for the more rapid degenerations. The lymphomata are innocent, although sometimes fatal from their situation and extent.

Adénie: Hodgkin's Disease.

Adénie, otherwise known as *Hodgkin's Disease*, is characterized by a very general overgrowth of the lymph glands and lymphatic structures throughout the body, and by progressive anæmia. The new growths differ in no way from the lymphomata above considered; but the course and tendencies of the disease are somewhat peculiar. It differs from them in the progressive anæmia, which is due to the loss of red blood corpuscles, and in the very general involvement of the lymphatic structures. It differs from leucæmia in that

there is no increase in the number of white blood corpuscles, though the loss of the red corpuscles disturbs the relative proportions that should exist between the two. The growth, usually, first manifests itself in the lymph glands, affecting a single group, from whence it extends to others and to the lymphatic structures of other parts, until, in the end, most of the structures of this kind throughout the body may be involved. The order in which different groups of glands are affected is about as follows: The cervical, axillary, inguinal, retro-peritoneal, bronchial, mediastinal and mesenteric. As the growth advances, the capsule gives way and contiguous glands become fused into a lobulated mass. By continued growth it may extend into and infiltrate the adjacent structures. Not only are the lymph glands involved in this morbid proliferation, but the lymphatic structures throughout the body also participate in the same. This is notably the case as regards the spleen. Here the growth starts in the malpighian bodies, and gives rise to scattered nodules. These vary in size from a pin head to a walnut, are of a grayish or yellowish white color, somewhat firm in consistence, and are not encapsuled. The spleen is somewhat increased in size, its capsule thickened and often adherent to the adjacent organs. Sometimes, instead of being nodular, the spleen is uniformly enlarged. The liver, kidneys, alimentary canal, lungs, medulla of bone and subcutaneous connective tissue may all become involved after the manner of the spleen. The growth of adénie may present either as the soft or indurated variety of the lymphomata, and is due to the same conditions—the relative proportions of the cells and stroma. Retrograde changes rarely occur. As to the pathogeny of the disease, little is known. It is not infectious, as is evidenced by its appearance in distant groups of glands at the same time. Its confinement to the lymphatic structures alone, argues an inherent weakness or vice in these structures, which renders them susceptible to morbid growth.

CHAPTER XVI.

NEW FORMATIONS OF THE HIGHER TISSUES.

Myomata.

Myomata are growths of muscular tissue. They are seldom purely muscular, being associated with a development of connective tissue. The older the growth, the more prominent does the connective tissue element become.

Classes. Myomata consist of striated and non-striated muscular fibres. Of the *striated* variety, few cases are on record; hence this form of growth must be regarded as a pathological curiosity. Myomata, therefore, almost without exception, consist of *non-striated* muscular fibres, interspersed with a variable amount of connective tissue.

Development and Course. They always originate in muscular tissue, such as the uterus, œsophagus, stomach, or bowels. By far the greater number spring from the walls of the uterus, and as they enlarge crowd the normal tissues aside, and protrude either into the peritoneal or uterine cavity. In the latter situation, they are often pedunculated, constituting one form of *uterine polypus.* The growth is central and slow; sometimes single, but frequently multiple, and generally enveloped in a firm, fibrous capsule. The interstitial connective tissue is so abundant in these uterine growths, as to win for them the misnomer of *uterine fibroids.* In this connective tissue ramify the blood-vessels, which are usually not abundant, and as they enter at the base, they are apt to become injuriously compressed in the pedunculated growths; leading to their degeneration or death. This is a mode of spontaneous cure which occasionally happens. The myoma is particularly prone to calcareous degeneration, and in the womb, this change is sometimes so radical, as to change the

growth into a lump of stony hardness; the so called *womb stone*. This is occasionally expelled in this form by uterine contraction. The intra-uterine myomata sometimes give rise to exhaustive hemorrhages. A mucoid degeneration sometimes occurs, which frequently leads to cyst-like formations in the substance of a growth.

Physical Characters. The growth is more or less firm, elastic, lobular, and spheroidal, or pyriform. Its firmness depends, to a great degree, on the amount and age of the connective tissue. In color it varies from a muscular redness to a pinkish or grayish white. The cut surface is striated, dry and dull. Examined microscopically, the characteristic spindle-shaped cells, with rod-like nuclei, of unstriated muscular fibres, are seen interspersed or gathered in fasciculi, in the midst of the connective tissue. The grouping and arrangement of the muscular fibres varies greatly, as do, also, the quantity and density of the connective tissue, and the number and size of the blood-vessels. The myomata are innocent. They develop and decline with the evolution and involution of the uterus, during and after pregnancy. In the atrophy of the organ, after the menopause, they frequently disappear altogether.

Neuromata.

The neuromata are growths of nervous tissue.

Classes. The pathological, like the physiological growth, consists of *gray matter;* nerve cells, non-medullated fibres, or *white matter;* ordinary medullated nerve fibres. The former is extremely rare, consequently, almost all neuromata consist of white nerve fibres.

Development and Course. Neuromata always spring from nervous tissue—the brain, spinal cord, or, more frequently, the cranial or spinal nerves. They may occur in the course of nerves, but are generally found at the extremities of

divided nerves, as in the stump of an amputated limb, or the cicatrix of a wound, where they are always intimately blended with the cicatricial tissue.

Physical Characters. They occur as small, nodular masses, of roundish or elongated form, of the color and consistence of nerve tissue. They are slow of growth, never become large, are frequently multiple, and, though always exceedingly painful, are perfectly innocent. Other growths, such as the fibromata, myxomata, sarcomata, gummata, occurring in the course of a nerve, or in the substance of nervous tissue, are frequently, though erroneously, called neuromata.

Angiomata.

Angiomata are growths consisting of blood vessels.

Classes. They are divisible into—

1. *Simple angiomata*, in which the growth consists of arteries, veins, or capillaries, held together by a small amount of connective tissue, and 2. The *cavernous angiomata*, in which the blood-passages are wide, tortuous, and communicate freely with each other, as in normal erectile tissues.

Development and Course. The angiomata spring from blood-vessels. They occur, for the most part, on the skin, but also on the mucous membrane, and less frequently in the substance of muscles, glands, and other internal organs. They are slow of growth, seldom large, and are prone to ulceration and bleeding.

Physical Characters. They consist of arteries, veins, or capillaries, mostly of new growth, and, in the cavernous form, of sinuses. In color they are red, purple, or blue, according to the kind of blood they contain. They are usually superficial, inconstant as to regularity of outline, more or less spongy, sometimes pulsatile or throbbing, always compressible, losing their color under pressure, seldom painful, and always innocent. Under this head are included *vascular nævi*, erectile tumors, and anastomosing aneurisms.

CHAPTER XVII.

NEW FORMATIONS OF EPITHELIAL TISSUE.

Pure epithelial new formations are not common; growths of this tissue being usually associated with the underlying connective tissue, upon which it is so dependent. Independent epithelial growths do, however, occur, forming on the surface of the skin laminated plates of horny tissue, and on the mucous and serous surfaces analogous formations of softer consistence. They are found also in glandular organs. Corns, callosities, cutaneous horns, are familiar examples of these as they occur on the skin.

Causes. They result from mechanical and chemical irritation, increased functional activity, and from various other stimuli to growth, common to all tissues. Corns are produced by the intermittent pressure of a boot; callosities, by the jar of a working tool. Pent up secretions in a follicle or duct, irritating secretions flowing over an epithelial-clad surface, morbid and irritating matter in the blood, and excessive functional activity owing to a loss of a portion of the gland, or of a fellow organ, all stand in a causative relation to these growths. They occur in the neighborhood of cicatrices of the liver; and the blood of diabetics and drunkards favors their production in the kidneys.

Development and Course. The growth is by hypertrophy and proliferation of the proper epithelial elements, and probably in some instances, by connective tissue proliferation, and transformation into epithelium. This is attested by enlarged multinuclear and new formed cells in the substance of the growth, and between it and the connective tissue substratum. The cells partake of the nature of the normal cells of the situation; being tessellated, columnar, or glandular, as the

case may be. They are of a horny consistence on the skin, and softer in the interior. The arrangement of the cells is in laminated plates, piled tier on tier, as in corns; in the form of tubular prolongations, as constituting the offshoots from follicles, or in massive aggregations, as in the liver. The laminated growths are diffused or circumscribed, and either conform to the contour of the surface to which they are applied, or, by unequal growth, obliterate all landmarks. The circumscribed growths project from the surface as flattened, conical, or pointed elevations. The growths are, as a rule, harder and thicker on the skin, less hard and thick on the mucous surfaces, and still less so on serous surfaces.

CHAPTER XVIII.

EPITHELIO-CONNECTIVE NEW FORMATIONS.

Papillomata.

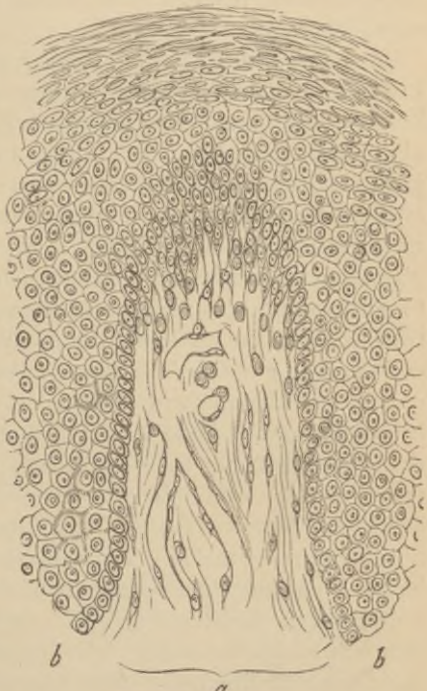
The papillomata are growths of papillæ—*epithelio-connective* formations, occurring on the cutaneous, mucous, and serous surfaces.

Development and Course. They usually spring from the existing papillæ; especially on the skin and mucous membrane, but may originate anew, from the sub-epithelial connective tissue. They grow outward from the surface, as conical, clubbed, or dendritic excrescences, and sometimes form polypoid masses by aggregation. Especially is this the case in the nares, larynx, and along the intestinal tract. They are slow of development, and rarely attain large size, except by combination. Though sometimes obstinately rebellious to treatment, they frequently, on the other hand, disappear spontaneously, in a sudden and mysterious manner. They are prone to hemorrhage and ulceration.

Physical Characters. A simple papilloma is, for the most part, small and conical, consisting of a connective tissue core, enveloped by epithelium. The connective tissue is vascular; the vessels, as in the normal papillæ, forming loops by mounting to the apex and returning upon themselves, or form a plexus, by being more elaborately disposed. The epithelial covering varies in density and abundance, being frequently piled, layer upon layer, on the skin; less abundant and softer on the mucous surfaces, and still less so on the serous. The *dendritic* form of growth is due to secondary branches springing laterally from the primary, which, in their turn, may send off side shoots. These have a tufted, cocks-

comb, or filamentous appearance. When, however, the epithelium is very abundant, all the inequalities between the branches of a papilloma, or between adjacent ones, may be filled to the surface, and a more or less large, even elevation result. In some situations, as in the bladder, and in the intestinal canal, the papillæ are apt to be very vascular, with large, tender-walled vessels. These are liable to rupture on slight provocation, and give rise to even dangerous hemorrhage. Under the head of papillomata are included *warts*, *condylomata*, and certain *tufted*, *vascular vegetations*, that are frequently confounded with epithelioma. The papillomata are innocent, though the transition is easy to epithelioma. The latter, as will be seen, consists of a growing downward of the epithelium into the connective tissue, which may readily occur, if the outward growth from the bottom of a cleft be impeded by the closure of the branches above.

FIG. 16.



PAPILLOMA OF THE SKIN.

Adenomata.

The adenomata, or glandular tumors, are growths of glandular structure. They belong to the epithelio-connective new formations, inasmuch as they consist of new formed glandular epithelium, planted on a connective tissue base, also of new formation.

Development and Course. The adenomata always originate in glands and follicles: the mammary glands, the mucous follicles of the nares, pharynx, stomach, intestines, uterus, vagina; also, though less frequently, in the liver and other glandular organs. They commence either as proliferations of the epithelium lining the acini or tubules, or as cylindrical or sacculated offshoots from the same, resembling the normal gland structure. In either event, the epithelial growth is apt to outstrip the connective tissue groundwork and pile up in the interior of the spaces until they are converted into solid cylinders or globes. The new-formed gland structure may remain in continuity with the original; but, more frequently, becomes encapsuled and fenced off from it, constituting a distinct tumor. When the new growth is equably distributed throughout the entire gland, it constitutes *glandular hypertrophy*. It is, however, much oftener circumscribed, being confined to certain lobules. These, by their increase in size and injurious pressure, cause occlusion of ducts, cystic formations, atrophy and degeneration. The epithelium thus formed seems little fitted for the physiological changes incident to glandular epithelium, but seems to approach the character of cutaneous epithelium. As such, it is slow to undergo the retrograde change, is harder and denser than glandular epithelium, though never distinctly corneous. The secondary changes are fatty degeneration, which tends to caseation, and mucoid softening. The latter is more frequent in the adenomata of mucous follicles.

Physical Characters. The adenomata are firm, elastic, and

nodular; in outline they are globular, ovoid, or irregular, and distinctly lobulated. They vary in color, according to situation, usually resembling that of the tissues in which they originate. The growth is slow and rarely becomes large. Occurring in the large glands, they present as distinct tumors, scarcely distinguishable from the gland proper. Occurring in mucous membranes, they are soft and gelatinous, and tend to force their way to the surface; where they become pendulous and constitute one form of mucous polypus. Upon section, they are lobulated, and sometimes, even to the naked eye, betray their glandular nature, in the arrangement of their follicles. Microscopically, this glandular nature becomes very evident. Cystic cavities are not infrequent, which are due to pent-up secretions from the occlusion of the excretory ducts, or to mucoid degeneration of circumscribed patches of the tumor. Gaps and fissures frequently present on section, which are the spaces left vacant by the ingrowing of tumors from the walls of the dilated cavity. The adenomata proper are not common, and are always innocent. Other growths—sarcomata, fibromata, myxomata—affect glandular organs much more frequently, and as they are usually attended by more or less glandular hypertrophy, are often confounded with the adenomata. These mixed growths, are known as adeno-sarcomata, adeno-fibromata, and adeno-myxomata. It is sometimes very difficult to distinguish an adenoma from a carcinoma of a glandular organ. As in both cases we have the massing of epithelial cells in spaces bounded by connective tissue, the resemblance is very close. In carcinoma, however, the epithelial elements may usually be distinguished by their irregular size and shape, and by the number and size of their nuclei.

Carcinomata.

The carcinomata are epithelio-connective growths, consisting of an alveolated stroma, supporting aggregations of epithelium of anomalous character. The connective tissue constitutes the framework of the growth, and is arranged so as to leave round or oval spaces, the *alveoli* or *loculi*, in which spaces are crowded the epithelial elements. This connective-tissue stroma gives support to the blood-vessels which encircle but do not enter the loculi; hence, the cellular aggregations in the latter are not vascularized. The stroma varies greatly in quantity, being most abundant in the hard, and least so in the soft varieties. It also varies in density, and in its intimate structure, being sometimes distinctly fibrous, and at others abounding in spindle-formed cells; and, in fact, is subject to all the manifold changes of connective tissue elsewhere. The loculi are round or oval, less frequently elliptical in outline, and communicate freely with each other, so as to form a network of cavernous passages in the substance of the growth. They are filled with the closely-packed epithelial elements. These latter are of all sizes and shapes, and contain one or more nuclei, with nucleoli, both of which are large and distinct. These cells have no definite arrangement within the loculi, which, together

FIG. 17.

BRUSHED-OUT STROMA OF SOFT CANCER.
a. Section of cylinder of cancer-cells. *b*. Trabeculæ of the stroma.

with the mutual pressure exerted upon each other, accounts for the diversity of form. These qualities, together with the alveolated structure of the stroma, are usually sufficient to distinguish cancers from other forms of growth. It must be admitted, however, that outside this *ensemble* of appearances, there is no peculiarity of structure, or anatomical elements special to cancerous growths. The alveolated structure is found in adenoma. The cells of other growths may be large or irregular in outline, or polynucleated, so that one cannot speak of a specific cancer-cell as differing from all other cells. *Notwithstanding the alveolated structure alone, or the anomalous cell forms alone, are not distinctive of cancer, yet the association of these in one and the same growth is usually sufficient to stamp it as cancerous.* The cells infesting the loculi are here classed with the epithelial cells. They resemble true epithelium in that they rest on a connective tissue base—the walls of the loculi—from which originate all new cells, the older ones being shoved toward the centre. They are, furthermore, in immediate contact one with another, there being no intercellular substance, and they are not penetrated by blood-vessels. On the other hand, they are without investing membrane, and lack the cohesive properties of true epithelium. On this account it would be better to designate them as *epithelioid* cells.

Causes. The causes of carcinoma are imperfectly understood. Like tuberculosis, it is supposed by many to depend on specific infection; the infecting matter residing in the cells, or the fluids of cancerous growths. Others again believe in an inherited or acquired predisposition on the part of the general system, or certain of the tissue, which manifests after irritation of any kind. Others, still, think that the simple down-growing of epithelium into the subjacent connective tissue is all there is of cancer. The hitherto unsuc-

cessful efforts to transplant cancer by inoculation, or to establish it by planting epithelium in the substance of connective tissue, enshrouds this question in much doubt.

Development and Course. No tissue of the body is exempt from cancer. Cancers are, however, much more frequent in some situations than in others. Then, again, it is somewhat notable that the original or primary growths exhibit a predilection for certain situations, and the secondary growths for others. Primary cancers are most frequent in the mammary glands, uterus and stomach; secondary cancers, in the lymphatic glands, liver and lungs; in the order named. The origin of cancer is not definitely settled. The preponderance of evidence classes it as a downward growth of epithelium into the subjacent connective tissue. There are those who believe that the growth always takes place in the lymph spaces and along the lymph canals, distending the same by their cellular aggregations. This being the case the alveoli must represent the pre-existing lymphatic vessels, only greatly distended, and must be continuous with the same. This accords with the reticulated and cavernous arrangement of the alveoli, and also with the known fact that secondary infection takes place almost exclusively through and by the way of the lymphatics. Furthermore, this continuity is not infrequently demonstrable. That the foregoing is the manner of growth in many instances, positive demonstration clearly attests; but that all cancers originate in and extend along the lymph channels, yet needs confirmation. The stroma is formed either by new connective tissue proliferation, which keeps pace with the epithelioid growth surrounding and supporting it, or consists of the tissues proper, into which the epithelioid elements have burrowed. In the latter instance it is reinforced by interstitial growth. The growth of cancer is principally peripheral. The rapidity of de-

velopment depends on the variety, the softer varieties developing most rapidly. Secondary growths are established sooner or later, which may be limited in number and confined to the immediate vicinity of the original growth, or more numerous, and widely disseminated. The infective material—probably the cancer cells—travels almost exclusively by the way of the lymphatics. The nearest lymph glands in the line of these vessels are first involved, then the next group, and so on successively, until general infection ensues. In this respect cancer differs from sarcoma, where the blood vessels carry the infective matter. The cells occupying the loculi fall into rapid degeneration, fatty, mucoid, colloid, or pigmentary, which degenerations impart peculiar characters to the growth. Calcareous degeneration of the stroma is also, now and then, witnessed.

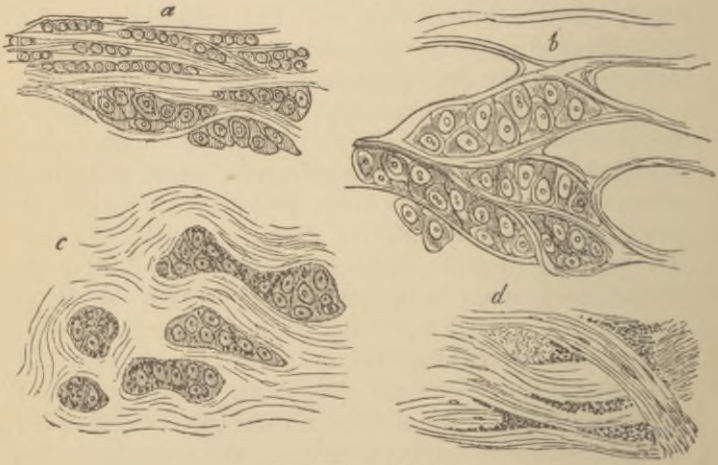
Physical Characters. The carcinomata occur as infiltrations and as distinct tumors. The growths being peripheral, they are seldom encapsuled or sharply defined. They are more or less irregular in outline, and send offshoots far beyond the confines of the nodular mass which constitutes the body of the growth. These offshoots, as before intimated, are in the line of the lymphatics. In density, color, size and general outline, cancers vary according to variety. They yield on pressure, or by scraping, a milky juice, the so-called *cancer juice*, which consists of serum, impregnated with the epithelioid cells. These cells, examined microscopically, are found to be of that variegated character described elsewhere. Thin sections reveal the alveolated nature of the stroma, and the closely packed epithelioid elements occupying the alveoli. All cancers are malignant, though not equally so.

Varieties. The varieties of cancer are *scirrhous*, *encephaloid*, *colloid* and *epithelioma*. The three first are closely related in structure and properties, the one sometimes breeding the

other; but the last has distinctive characters, anatomical and clinical, which hardly entitle it to recognition among the true cancers.

Scirrhus, Fibrous, or Hard Cancer. This variety is characterized by the abundance and density of the stroma, the small size of the loculi, the sparsity of the epithelioid elements, and its slow growth. In its incipiency, and in the most external, therefore latest developed, parts of the growth, the loculi are well marked, and filled with the characteristic

FIG. 18.



SCIRRHUS CANCER.

a. Development of nests of cancer cells. *b*. Fully formed carcinoma tissue. *c*. Commencing cicatrization; at the same time a representation of the relations of stroma and cells in scirrhus. *d*. Cancer cicatrix.

cells. These, however, soon undergo atrophy and degeneration, the stroma at the same time increasing in density, until, finally, there remains nothing but miniature crevices, or clefts in the connective tissue, filled in with the debris and shriveled remains of cells. This is the appearance of sections taken from the central part of the growth. Scirrhus

exists as a well-defined tumor, hard, lobular, and uneven. *This hardness and unevenness of outline are quite characteristic.* All tumors of this kind are not equally hard, neither are all parts of the same tumor. It is in the older, central part, which has lost its cellular elements, and which consists of a dense, fibrous, or cicatricial tissue, where this quality is most marked, the periphery being less dense and more succulent. Cut into, these growths show a fibrous, shining, grayish-white surface of section, and yield sparingly the *cancer juice*, which is derived principally from its peripheral portions. Occurring in the vicinity of the skin, it first contracts adhesions with the same, and then, by subsequent shrinking or contraction, produces dimples and depressions on the surface. This is characteristically shown in the mammary gland, where the retracted nipple over a tumorous enlargement is regarded as almost pathognomonic of scirrhus. Though the growth is slow, and the degeneration of the epithelioid elements so prompt that often a mere tunic of living cancer intervenes between the degenerated parts within, and the normal tissues around, yet it gradually extends, and finally establishes secondary foci of disease in near or remote parts. The secondary growths are usually of the soft variety, and grow rapidly. The favorite sites of scirrhus are the mammary glands, the skin, and along the alimentary canal, the œsophagus, pylorus and rectum.

Encephaloid, Medullary, or Soft Cancer.

This variety, while similar in structure to that last described, differs from it in the relative proportion of the histological elements. In that we have an abundant stroma with small loculi; here we have a scant stroma, large loculi, and a great abundance of the epithelioid elements. These latter are of the various sizes and shapes before mentioned, with probably a disposition to overgrowth. They are so abundant

and closely packed as, in many instances, to override and conceal the connective tissue stroma, which is only revealed after their partial removal by washing or penciling. As in scirrhus, it was the dominance of the stroma that imparted its peculiar density, so here it is the dominance of the cellular elements that imparts softness and succulence to the growth. The stroma of encephaloid is very delicate and very vascular. The vessels, though usually of ordinary calibre and structure, are sometimes very thin walled, dilated and brittle, and, not being firmly supported by the cells filling the loculi, are liable to rupture and give rise to hemorrhagic extravasations. The loculi are large and round, or oval, in outline. Owing to the magnitude of these cellular aggregations, their rapid growth and frail constitution, with only one source of nourishment, *i.e.*, the blood vessels encircling their outskirts, degeneration is very rapid. This is, for the most part, fatty, and so general is it that most of the cells examined, at any stage of the growth, reveal fat globules in their interior. Later, the central part of the growth may show only disorganized cells, fatty detritus and free nuclei in one confused, pultaceous or diffluent mass. Pigmentation of the cells not unfrequently transpires, either from physiological imbibition, or in consequence of bloody extravasations in their midst. It is, however, not nearly so frequent here as in sarcoma; the majority of pigmented growths being of the latter nature. Encephaloid occurs as an infiltration, or as a tumor. As a general rule, the primary growths appear as infiltrations and the secondary as tumors. As the majority of encephaloids are secondary, it follows that the tumorous form of growth is most prevalent. These tumors, however, are ill defined, and shade off into the surrounding tissues. Encephaloid is of rapid growth, and speedily establishes secondary points of infection. They are of the color and consistence of brain tissue, though from degenerative change, pigmentation or

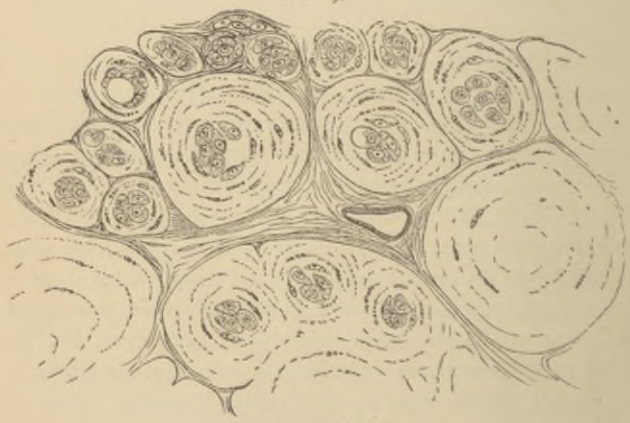
hemorrhage, they are often much softer, and present a mottled surface of section ; the discoloration being dark or red, according to its origin. They are rich in cancer juice, which becomes more abundant the longer the growth stands after removal from the body. While the *typical* scirrhus and encephaloid are so widely distinct in physical properties, modifications of these growths often approximate each other so closely as to baffle differentiation. Encephaloid cancer is very malignant.

Colloid, Gelatinous or Alveolar Cancer.

This, which has generally been considered as one of the varieties of cancer, is not entitled to that distinction ; inasmuch as it only represents a degenerative change in other forms. This arises, in part, from the very marked changes in the physical character of tissues wrought by colloid degeneration, and in part from the celerity with which it sometimes declares itself. The colloid and mucoid change, both of which here, as elsewhere, frequently go hand in hand, are characterized by an enormous swelling, a gelatinous or mucous consistence, and a colorless or slightly yellowish translucency. This change affecting even a moderate portion of the tissue elements, if evenly distributed, is sufficient to impart its distinctive characters to the entire growth. That it is not a distinct variety, is evidenced by the physical and chemical identity of the so-called colloid cancer, and colloid degeneration as it occurs elsewhere. Furthermore, the unchanged elements of the growth, and those most recently formed, are found, on examination, to be identical in character and arrangement with those of scirrhus and encephaloid. And yet again, cancers are to be found presenting all grades of this form of degeneration, from the most trivial to the most pronounced. The degenerative change may be confined to the epithelioid elements, the

stroma, or affect both together. In accordance with the rule that colloid degeneration affects the cells, and mucoid the intercellular substance, we find the epithelioid elements going over into the former, and the stroma into the latter. The growth, so changed, appears as a gelatinous, trembling mass, clear and colorless, or slightly yellowish, and translucent. Owing to the swelling of the contents, the loculi are large, round and appreciable to the naked eye. The appearance is very much like that of a honeycomb, hence the name alveolar cancer. While the loculi are large, the walls of the

FIG. 19.



COLLOID CANCER.

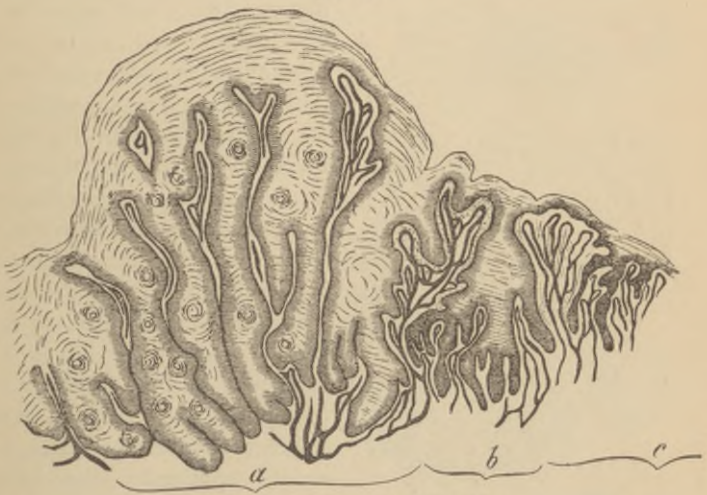
same are very thin, unless they be affected with mucoid degeneration, when they are thicker and pultaceous. On section a sizey or mucilaginous substance exudes, which is for the most part amorphous, but which may also contain cells, some of which are unchanged, and others exhibiting all grades of fatty or colloid degeneration. The colloid cancer, though it may increase rapidly in volume, owing to the swelling of its elements, does not in reality grow so fast, and is much less infectious than encephaloid; probably because

of this same degeneration. It is found principally in the stomach, large bowel, peritoneum, uterus and mammæ. Included among the colloid growths, are some possessing a genuine mucous tissue stroma.

Epithelioma. Epithelial Cancer.

Epithelioma occupies a position midway between the cancerous and innocent epithelio-connective growths. The term cancroid, by which the growth is also known, expresses its resemblance to cancer, but it also implies a deviation from

FIG. 20.



EPITHELIAL CANCER OF THE SKIN.

a. Tumor-mass in full development; cylinder of epithelial cells, with pearly globules longitudinally divided. *b*. An enlarged sebaceous gland. *c*. Commencing viliform elongation of the epidermis inward.

the true cancerous type. Like cancer, it consists of an alveolated stroma and epithelial elements, occupying the same. It deviates from true cancer in the following details. The stroma, as a rule, is not a new formation, but made up principally of preëxisting tissues, into which the epithelium has

grown. The alveoli vary greatly in size and shape, and in the manner of their distribution. The epithelial elements resemble very closely the normal epithelium in size, form, and appearance, and often present a definite arrangement within the loculi. The growth always springs from an epithelial-clad surface, such as the skin or mucous membrane. In its subsequent career it may involve any and all of the subjacent structures, and the nearest lymphatics, but very seldom establishes foci of disease in remote parts. It is slow of growth, very tardily yields to degeneration, and may be effectually eradicated by prompt and efficient excision. Although the stroma consists, for the most part, of the remains of the normal tissues, into which the epithelium has grown, it is, nevertheless, infiltrated, sometimes sparsely, sometimes densely, with young connective tissue cells. These latter always advance in front of the ingrowing epithelium, and may, by their numbers and further development, supercede the old stroma. The epithelial cells are mostly of the squamous variety, such as are seen on the surface of the skin, and lining the cavity of the mouth. They fill the irregular chambers of the loculi, and often appear to be distributed without aim or purpose in the clefts of the connective tissue.

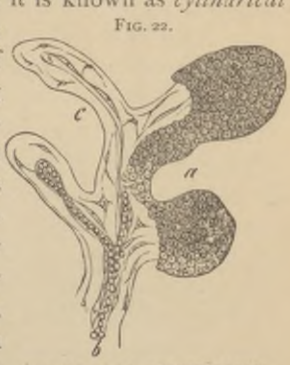
FIG. 21.

EPITHELIAL NESTS.

a. The cylinder itself, with the characteristic stratification of its cells, a younger and an older concentric globule. *b*. The stroma, very rich in cells at *c*, and contributing directly to the enlargement by apposition of the cylinder.

These, when untrammeled, tend to form globular masses, in which the cells are arranged in concentric laminæ, layer over layer. The globule, which is known as the *concentric globule* or *epithelial nest*, and which is very characteristic of epithelioma, has for its nucleus a single large cell, a group of cells, or, at times, a structureless mass. Around this nucleus are arranged the other elements, in widening circles; those nearer the centre being roundish, and those at the periphery flattened and scale-like. While the individual cells inhabiting the loculi, may present deviations of various kinds, from mutual pressure, the diversity in shape and size does not approach to that of true cancer, and, indeed, it is not usually difficult to trace the analogy between these cells and those of the normal tissues. Sometimes the cells of a "nest" become dry and hard, like those on the surface of the skin. These masses, which are dense, brittle, and dark tinted,—yellow, or brownish-yellow,—are sometimes so abundant as to impart peculiar characters to the growth. When the growth is made up of columnar or cylindrical epithelium, it is known as *cylindrical epithelioma*. These always spring from situations in which this form of epithelium normally exists; along the alimentary canal, in the air passages, on the neck of the uterus, in the bladder, etc. These growths have generally a follicular arrangement, and are with much difficulty differentiated from adenoma. They are soft and gelatinous in consistence.

FIG. 22.



CYLINDRICAL EPITHELIOMA.

Epithelioma commences as a fissure, or as a small, subcutaneous nodule, which subsequently ulcerates. The surface of the ulcer is foul and smooth, with indurated, sometimes nodu-

lar edges ; or is covered with a more or less luxuriant papillary growth, which may reveal itself as a fungus above the level of surrounding tissues. The growth is firm and friable, its cut surface unctuous, granular, and of a dull, grayish-white tint. On pressure, a small amount of clear or turbid fluid escapes, and the surface is found to be studded, sometimes abundantly, sometimes scantily, with little maggot-like bodies. The latter, which are the analogues to the comedones found on the face, are unctuous and crumbling, and consist of the epithelial contents of the larger loculi. They are exceedingly characteristic of epithelioma, and when very abundant impart a caseous, granular consistence to the entire growth. Although all epithelial clad surfaces are subject to epithelioma, its preferred seat is at the junction of the mucous and cutaneous surfaces, at the various outlets of the body, such as the mouth, nose, ears, anus, and genito-urinary outlets.

CHAPTER XIX.

CYSTS.

Cysts are cavities of regular, for the most part rounded, outlines, containing a fluid or pultaceous matter. The walls of this cavity are usually of connective tissue, sometimes distinct and membranous, at others, less sharply defined, and at others still, consisting of the tissue structure proper of the organ in which the cyst is located. Both the cyst wall and contents vary greatly, according to the origin and nature of the cyst.

Cysts are *simple* or *compound;* simple, when they consist of one loculus or chamber, *unilocular cysts*; compound, when they consist of more than one, *multilocular cysts*. The loculi of a compound cyst are sometimes ranged side by side, at others, contained one within another. They may or may not communicate with each other. The cystic nature of a new formation is designated by the prefix *cysto*, as cystosarcoma. Cysts are very properly classified as follows:

1. *Cysts of Retention.* These result from the accumulation of pent-up secretions, from the occlusion of the excretory duct. All secreting glands with excretory ducts are subject to this accident, of which sebaceous cysts and ranula are common examples. Cysts of like nature are formed in the dendritic papillomatous growths, where, from lateral pressure, the branches are pressed together, and adhere at certain points of contact, leaving irregular closed passages, which eventually, from the accumulation of fluid, become round.

2. *Exudation Cysts.* These result from the accumulation of fluids within the natural closed cavities of the body—serous cavities, the sheaths of tendons, bursæ mucosæ; also the cavities of the brain and spinal cord.

3. *Extravasation Cysts.* These result from the extravasation of blood into closed cavities, or into the substance of organs. In the latter event, in order to constitute a cyst, it must be regular in outline and sharply defined.

4. *Softening Cysts.* These result from the softening of tissues by degeneration. The most common forms of softening are fatty and mucoid; the former producing caseous or atheromatous, the latter watery and mucilaginous, depots. The walls here consist of the proper structure of the tissue undergoing the change. Later, when the process of degeneration has ceased, a connective tissue capsule may be thrown around the softened structures, to fence them off from the living. This capsule is sometimes lined with epithelium, thus constituting a bursa. Most of the cysts occurring in new formations, are of this variety. Foreign bodies, which become encysted in order to protect the flesh from their irritating presence, are hardly entitled to consideration here. They might be included with the extravasation cysts.

CHAPTER XX.

PATHOLOGY OF THE BLOOD.

Thrombosis.

Thrombosis is the formation of a clot within the vessel during life. The clot is called a *thrombus*. A clot may form either in the blood vessels or the lymphatics. Occurring in the blood vessels, it consists of coagulated blood; in the lymphatics, of coagulated lymph. A coagulation of blood often takes place in the heart and great vessels immediately preceding, or after, death. These are known as *post-mortem* clots, to distinguish them from thrombi proper, as it is very important that these two forms of clot be not confounded. The distinctive characters of each are, briefly, as follows:—

(*a*) A thrombus always applies itself closely to the walls of the vessel, and is not easily separated therefrom; whereas the post-mortem clot lies loose in the vessel. A post-mortem clot may, however, become entangled in the fleshy columns and the tendons of the heart chambers, and offer some resistance to extraction; nevertheless, it never contracts adhesions.

(*b*) Some thrombi, on being cut into, appear stratiform, exhibiting alternate shades of light and dark; this is never the case in a post-mortem clot.

(*c*) Thrombi sometimes organize, showing a connective tissue structure.

(*d*) Both thrombi and post-mortem clots, in the course of time, lose their coloring matter to some extent; consequently, decolorization is not distinctive. If, however, the clot be much decolorized, dry and brittle, it is an indication of age, and the clot is presumably a thrombus.

(*e*) Post-mortem clots, though never presenting a regularly

stratified arrangement, may yet separate into colored and colorless portions. This is owing to the separation of the red-blood corpuscles from the fibrin, and is of no significance. Thrombi occur either in the heart, arteries, capillaries, or veins, much more frequently in the latter. They are of two kinds, stratified and unstratified.

Unstratified Thrombus. The unstratified thrombus shows a uniform color throughout, which, according to age, is dark red, yellowish, or even colorless, and depends on the equal distribution of the red corpuscles through the mass. This is the most common form of thrombus.

Stratified Thrombus. A stratified thrombus exhibits, on section, alternate layers of light and dark shade, which are often disposed concentrically, ring within ring. The darker layers consist of fibrin and red-blood corpuscles, which is the proper coagulum; and the lighter layers consist of leucocytes, which have successively, as each layer of the coagulum formed, covered it over, from their innate tendency to adhere to a roughened surface. The unstratified thrombi are of quick formation, and result from the sudden and complete arrest of the circulation in a vessel, as after the application of a ligature. The stratified thrombi are of gradual formation, as in the filling of an aneurismal sac.

An *obstructing* thrombus is one which entirely fills the lumen of a vessel; an *incomplete* thrombus is one which only partially fills it. A complete thrombus forms a perfect mould of the vessel which it occupies. It varies in length, usually extending in the direction of the heart as far as the first collateral branch, and is conical at the extremity. An incomplete thrombus often forms a ring within the vessel, with an opening through the centre, through which the blood flows. At other times it is attached to one side of the vessel wall, and is variable in configuration. By gradual accretion, an incomplete frequently becomes a complete thrombus. The

progressive extension of a thrombus along a vessel constitutes a *continuous* thrombus. These are sometimes of great length.

Causes. The causes of thrombosis are threefold: retardation of the blood flow, changes in the vessel walls, and changes in the circulating fluid.

1. *Retardation of the Blood-flow.* This is incomparably the most potent factor of thrombosis, and may arise

(*a*) *From external pressure on the vessel;* as from ligatures, morbid growths, effusions, and displacement of parts.

(*b*) *From an obstruction in the vessel;* as an embolus, a morbid growth projecting into the lumen, a roughened internal surface.

(*c*) *From dilatation;* as in dilated heart, aneurism, varicose enlargement of the veins; and lastly,

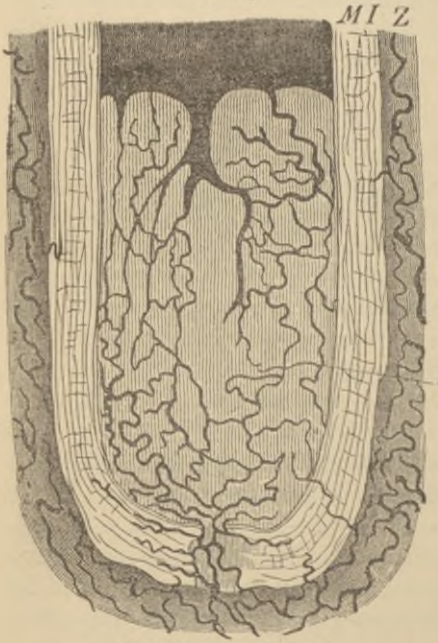
(*d*) *From weak heart action;* as in the case of cardiac degeneration, valvular obstruction, or insufficiency, etc. The heart becomes weak and the *vis a tergo* diminished in many of the exhaustive diseases, notably in tuberculosis, and typhoid fever, in which, also, it is not uncommon for thrombotic formations to occur. Rupture, or division of a blood vessel, by allowing the escape and interfering with the onward flow of the blood, may conduce to thrombosis.

2. *Changes in the Vessel Walls.* It was formerly supposed that all thrombi were due to an inflammatory change in the vessel walls. Thrombosis was hence regarded as pathognomonic of vascular inflammation. We now know that inflammation of a vessel may exist without the coagulation of the blood within it, and, *per contra*, that coagulation may occur without coincident inflammation. Inflammation almost never attacks the inner coat of a vessel primarily, but rather commences in the outer or middle coat, or the external surface of the intima, thus leaving the smooth, shining surface of the internal coat unchanged to the last. Where, however, this

becomes involved and roughened, coagulation takes place. A thrombus, however, once formed may, and frequently does, develop an inflammation in the vessel walls, and here it is first the *intima* that suffers from contact with the irritant.

3. *Changes in the Circulating Fluid.* Many inflammatory conditions, notably pneumonia and the puerperal state, are attended by an increase of the fibrinogenous constituents of the blood, which conduce to, and if conjoined with retarded blood flow often lead to, extensive and frequently dangerous coagulations of the same. Of these, heart clot on the one hand, and phlegmasia dolens on the other, are familiar examples. A thrombus once formed, either undergoes organization or softening.

FIG. 23.



ORGANIZED THROMBUS.
Th. Thrombus. *M I* Middle tunic of vessel. *Z.* Cellular tissue tunic.

Organization. In the process of organization the thrombus becomes converted into connective tissue. This is effected through young cells, which disperse themselves throughout the mass, by which a connective tissue web is formed, and becoming vascularized, finally absorb and carry away the intervening substance, substituting therefor an

intercellular substance proper. The blood vessels of the organizing thrombus tap and communicate with the vasa vasorum of the vessel in which the thrombus lies, and also communicate directly with the main current above and below. Just where these cellular elements originate, is not certainly known. Some have attributed the work of organization to the white blood corpuscles incorporated in the thrombus, others to the proliferating endothelium of the vessel, and others still to the connective tissue in and around the vessel walls. It is highly probable that all three of the above named may contribute to this end. Experimental investigation, indeed, brings to light a proliferation of the endothelium of the intima, and of the connective tissue cells in and around the vessels. At an early period the vessel walls and the adjacent territory is found to be swarming with leucocytes. If, now, these be colored with cinnabar, some of them will subsequently be found in the interior of the thrombus, which is evidently their destination. It will be seen that, as the cells engaged in the organizing process are derived, in a large measure, at least, from parts outside the thrombus, and as the other matters are removed through the agency of these, to be supplanted by intercellular substance proper, very little of the original thrombus is represented in the organized plug remaining. This plug is at first an exact counterpart of the original thrombus. It is, however, more intimately connected with the vessel walls, and may, in fact, be considered as an outgrowth therefrom, having a common vascular supply. It soon begins to contract, drawing toward the centre, in which the new-formed vessels are jugulated, and as a consequence the mass becomes exsanguined, and eventually nothing remains but a small, impervious cord. Occasionally the vessels of the thrombus undergo dilatation, with a wasting of the substance between them, and meeting, their walls melt away at the point of contact, and large cavernous passages

develop in the thrombus, which either communicate with the vasa vasorum of the vessel walls or allow a free communication between the blood above and below, thus virtually reëstablishing the circulation. Failing to organize, the thrombus either undergoes absorption or softening. Although it is highly probable that thrombi may, and sometimes do, become absorbed, yet so little is known in this direction that the mere allusion to the possibility of such an event is all that remains for us.

Softening. Softening and disintegration usually commence early in clots that fail to organize. Beginning at the centre, it extends toward the periphery, and thus in time involves the entire clot. One portion of a thrombus may be softening while another is organizing, or softening may be going on in one direction, while the thrombus is extending in another. The softened part is pultaceous, of a dark, fleshy, grumous appearance, or being more fluid, resembles the dregs of wine, and shows under the microscope molecules of albumen and fat, besides atrophied and broken-down blood corpuscles. Coincident with these changes others are transpiring in the vessel walls, as a result of the irritating presence of the clot. These are inflammatory in character, and contrary to the general rule, first make their appearance on the smooth, internal surface of the intima, which becomes lustreless, opaque and roughened. Each coat from within outward successively inflames, and as a result the walls of the vessel become very much thickened, so that a vein ultimately resembles an artery. The thickening is due to the infiltration by leucocytes, and to inflammatory exudation. The effect of thrombosis on the circulation will be considered under the head of embolism.

Embolism.

Embolism is the plugging of a vessel by something being carried into it along with the circulating fluid. The obstructing substance is called an *embolus*. The distinction between a thrombus and an embolus is, that the former is *formed* at the point of obstruction, and the latter is *conveyed* thither. A substance floating with the blood current only becomes arrested in its passage from larger into smaller vessels.

This usually occurs at the point of bifurcation of vessels, or where, in consequence of a rapid subdivision, the calibre is suddenly reduced. This may occur in three directions: 1. In any of the branches of the arterial tree of the general system. 2. In any of the branches of the pulmonary artery. 3. In any of the branches of the portal vein. A substance starting from the cardiac side of a capillary plexus will meet with no opposition until, after having passed through the heart, it again enters the branching vessels, which are becoming smaller and smaller. Thus, starting in the pulmonary veins, it passes easily to the left heart and goes out with the arterial blood, to become arrested in the smaller arteries or capillaries of the general system; or, starting in the veins of the general system, it passes to and through the right heart, to become arrested in the branches of the pulmonary arteries or capillaries. If, however, it starts in any of the venous radicles contributing to the formation of the portal vein, it passes to and through the latter, to become lodged in its ramifications in the liver. An embolus may consist of any solid, fluid, or gas which is capable of arresting the circulation in a vessel. These sometimes consist of particles of foreign matter which have entered the vessel from without, but more frequently of substances formed within the vessel. Among the latter may be named fibrinous concretions, atheromatous and calcareous particles from the lining membrane of vessels, fat, pigment, air bubbles, and also detached

particles of morbid growth which have penetrated the walls of the vessel. By far the most common cause of embolism is the broken-down fragments of a thrombus. Although embolism may occur in any of the arteries, veins, or capillaries of the system, all are not affected with equal frequency. The direction of a foreign substance in the circulation is largely governed by the force of the circulation and by gravity. Hence it is that those vessels which are given off more directly in line with the larger vessels are the ones most frequently affected. These are mostly on the left side of the body for the branches of the aorta, such as the left carotid, the left renal, the left iliac, and their branches. In the lesser circulation the right pulmonary artery and its branches suffer embolism more frequently than the left; this is because of the left being crossed by the aorta, which impedes the force of the current through it. A heavy body in the circulating fluid will drag along on the lower side of the vessel, dropping successively into those branches given off from that side.

This explains why emboli are so frequently found in the lower, or most dependent parts of organs. In the lungs, this is still further favored by the large size and direct course of the vessels leading to their posterior and inferior parts. Contrary to the general rule, emboli have been known to move backward against the tide of circulation, and becoming arrested in the venous radicles, produce embolism. In this manner bodies have been known to drop down the vena cava into the hepatic veins, and finding lodgment in some of its radicles, produce embolism of the liver. This is more apt to occur in conditions in which the normal thoracic aspiration—which is so prominent a factor in venous circulation,—is deficient, or wanting. The consequences of embolism relate; 1. To the circulation; 2. To the tissues or organs supplied by the obstructed vessel.

Effects on the Circulation. Much depends on the character of the embolus, its size and situation. A hard, angular body becoming arrested in a vessel does not entirely fill its lumen, and consequently does not at once entirely obstruct the passage of blood. Soft and pultaceous substances, on the other hand, mould themselves to the interior of the vessel, and immediately produce a complete obstruction. The first variety soon, however, becomes converted into an obstructing embolus by the deposition of fibrin, when the effect on the circulation, so far as that particular vessel is concerned, is identical with that produced by the more plastic embolus. The first effect of embolism is a stagnation of blood before and behind, as far as the next collateral branch. The *vis a tergo* being removed, the blood beyond the plug has nothing to drive it forward, and, as a result, it settles back against the plug. In addition to this, the blood from the collateral branches beyond the embolus finds its way into the stagnated region and refuses to go forward, thus increasing the turgidity of the vessels. The hyperæmia being confined to those vessels branching off from the obstructed vessel will, of course, be conical or wedge-shaped, with the apex at the point of obstruction. The blood thus imprisoned in the branches of the obstructed vessel being stagnant, is incapable of nourishing the tissues or the vessels themselves, and sooner or later these latter, especially the

FIG. 24.

EMBOLIC HYPERÆMIA OF THE LUNGS.
A, Small artery occluded at *E* by an embolus. V, Small vein filled, even into its trunk, by a blood coagulum. The shaded part of the capillary net is the static hyperæmic territory of distribution of the artery, which thereafter becomes the seat of a hemorrhagic exudation. The arrows indicate the collateral routes from which the abnormal congestion is produced.

capillaries in the centre of the hyperæmic region, undergo degenerative changes. Being thus weakened, they yield to the intra-vascular pressure, and an extravasation of blood ensues. This extravasation is known as the—

Hemorrhagic Infarct. The extent and degree of hemorrhagic infarction is proportionate to the size of the obstructed vessel, and the absence of collateral circulation. A blood extravasation, surrounded by a wedged-shaped zone of hyperæmia, is exceedingly characteristic of embolism.

Secondary Changes. Emboli undergo the same changes as thrombi. The softening and breaking up of an embolus of larger size may lead to secondary embolism in other and sometimes remote parts. If these secondary emboli be numerous, it constitutes what is known as *multiple-embolism.* Multiple-embolism is generally the result of infective or putrid matter. This always provokes destructive inflammation in the vessels in which it becomes lodged, disintegrates, and is carried into the smaller vessels or capillaries.

Effects on Tissues and Organs. The nutrition and function of an organ suffers in proportion to the interference with its blood supply. Consequently this will be proportionate to the size of the vessel obstructed, the completeness of the obstruction, and the absence of collateral circulation. An obstructing embolus of a vessel of considerable size ordinarily produces instantaneous arrest of function in the parts supplied by it. Thus embolism of a cerebral artery produces instantaneous loss of consciousness and paralysis; of one of the pulmonary arteries, sudden dyspnœa; of the coronary artery, sudden paralysis of the heart. Where, however, the vessel is of less importance, or obstruction is incomplete, the effect is less marked, though equally sudden. If life be not extinguished instantly, the case terminates in gradual recovery, with the restoration of function, or death and disintegration of the affected region. Recovery ensues

from the establishment of a satisfying collateral circulation, or from the disintegration and dispersion of the embolus. This failing, the parts robbed of their nutriment degenerate and die. The parts most apt to suffer on account of the absence of collateral circulation, are the brain, kidneys, liver, and spleen, in the order named. The hemorrhagic infarct undergoes the same changes as hemorrhagic extravasations from other causes.

Plethora.

Plethora is an increase in the total amount of blood, or in the number of the red blood corpuscles. People are said to have too much blood when, together with a full habit and a ruddy complexion, there exists a strong heart impulse, a bounding pulse, and a sensation of warmth and fullness about the chest and head. This condition of things is generally the result of a life of indolence and luxury, associated with a constitutional tendency. It also results from the arrest of habitual hemorrhages. Active exercise, restricted diet and periodical depletion correct it. Notwithstanding the etiology and treatment of the *ensemble* of symptoms ascribed to plethora would indicate the same, yet, as a matter of fact, an excess of blood or of red blood corpuscles has never been demonstrated. Hence it is a legitimate question whether there be such a thing as plethora. In induced plethora, caused by transfusion of blood in inferior animals, it has been found that the quantity of blood may be doubled without manifest effect on the animal, so far as the excess of blood is concerned, but that any considerable increase above this produces rapid exhaustion, vomiting and renal hemorrhage. It is furthermore found that, owing to inordinate distention, the tonicity of the vessels is lost, so that even small abstractions of blood cannot be borne, and that the blood quite rapidly returns to its normal quantity by a rapid transudation and destruction of the red blood corpuscles. The avenue of escape is

principally by the way of the kidneys; an excess of urea indicating the corpuscular decomposition. It will be seen that the effects of induced plethora are not those usually ascribed to plethora; that it cannot be maintained for any length of time, and that the former ill affords the loss of blood, whereas the latter is benefited by it.

Still the conditions are not identical. In true plethora a vascular development may go hand-in-hand with an increase of blood, and the symptomatology be thus materially modified. In conclusion, it may be said that while no actual proof of plethora exists, it is not impossible that, owing to excessive activity of the blood-forming organs, such a condition may obtain. Irregular fluxions of blood from vaso-motor disturbances are often mistaken for plethora.

Anæmia.

Anæmia is a decrease in the coloring matter of the blood, with or without a corresponding decrease in the number of the red blood corpuscles. Usually, both coexist. The number of red blood corpuscles is frequently reduced one-half in anæmia, and in extreme cases much more. The utmost limit of reduction compatible with life has been placed at nine tenths. The amount of hæmoglobin may be reduced to one-sixth the normal quantity. Anæmia occurs as an acute and chronic affection.

Acute Anæmia. This form occurs suddenly, as from hemorrhage. The symptoms of acute anæmia are general weakness, pallor and coldness of the surface, vertigo and faintness, dimness of vision, rapid, compressible pulse, and in the severer forms, syncope, and epileptiform convulsions. The effects of hemorrhage depend principally on the amount of blood lost, but also upon the rapidity of its escape, the posture and individual peculiarity. A loss equal to one-half the circulating fluid is usually fatal; lesser amounts may be

rallied from more or less quickly. Blood escaping in a large stream more profoundly affects the subject than the same amount more gradually withdrawn; so, also, blood withdrawn while the subject is in the erect posture, affects him more than if recumbent. As a rule, women stand the loss of blood better than men, but the extremes of life are especially susceptible to such losses. A few weeks usually suffice to restore the quantity and quality of the circulating fluid lost in acute anæmia. The *volume* of the blood is almost immediately restored by absorption of water, but the albumen, salts, and corpuscular elements, more gradually.

The white corpuscles, because of their lightness and viscidity, are not wasted in hemorrhage so rapidly as the red, and as the increased activity of the lymphatics after hemorrhage still augments the number, they are relatively in excess for the time.

Restoration of the Red Blood Corpuscles. Nothing very definite is known as to the origin of the red blood corpuscle. The views of to-day are based on the following data: 1. White blood corpuscles, somewhat tinted, have been found in the lymphatics. 2. Nucleated red corpuscles frequently abound in the medulla of bones, in the spleen, and, more scantily, in the blood of anæmics. 3. Small, red corpuscles —*mycrocytes*—resembling, but much smaller than, the red blood corpuscles, are sometimes very abundant in the blood of anæmics.

From the foregoing the inference has been drawn, that the red blood corpuscle is derived from the white; that the colored corpuscle in the marrow of bone represents the transition state, which is completed by the extrusion of the nucleus, and that the mycrocytes formed in the blood are the progeny of the same, which eventually develop into full-formed red blood corpuscles.

Chronic Anæmia. This form declares more gradually as

the result of more persistent causes. Under this head are included the anæmias of lingering diseases, repeated hemorrhages, exhaustive discharges, as albumen in Bright's disease, sugar in diabetes, purulent and diarrhœal fluxes; also those resulting from insufficient nourishment. Here, also, are included the anæmias associated with Addison's disease, leucocythæmia and that occult form of the disease evidently depending on the derangement of the blood-forming organs, and known as essential anæmia. The symptoms of chronic anæmia are similar to those of the acute form, having superadded many phenomena referable to the nervous system, such as neuralgias, perverted nervous sensations, palpitation, etc. Impaired digestion and heart murmurs are accompaniments. The latter is due to impoverished blood, and disappears when that is corrected.

Structural Changes. The structural changes induced by chronic anæmia consist of fatty degeneration of the heart, great vessels, liver, spleen, kidneys, and at times of the voluntary muscles. Atrophy of various organs may ensue, seldom, however, implicating the brain and nervous system. Lastly, a very remarkable change sometimes takes place in the medulla of the bones, in which the natural tint of this substance gives way to a deep red coloration. This redness depends upon the presence of vast numbers of the above mentioned *nucleated red corpuscles*. This condition is identical with that found in the embryonic state; but whether it represents a retrogressive or progressive act remains to be determined.

Hydræmia.

Hydræmia denotes that condition of the blood in which the quantity of water is relatively in excess. It may depend on an absolute excess of water, a deficiency of the solids, or both combined. Hydræmia is always associated with a deficiency of albumen in the blood, *and depends on the same.*

It is proper, then, to regard the watery condition of the blood as the most prominent symptom indicating the want of albumen. Although hydræmia is a very constant accompaniment of anæmia, and especially that form depending on sudden and copious hemorrhage, wherein water is absorbed to restore the volume, yet the most pronounced examples are found in Bright's disease, in which there is a deficiency of water eliminated by the kidneys, together with an excessive waste of the blood albumen. As œdema and dropsical effusions are often associated with hydræmia, it has been supposed that these depended upon the deficiency of albumen and excess of water in the blood. Cohnheim's recent experiments, however, in which the hydræmic state was induced artificially, by injecting saline solutions in the blood, disprove this view. It was found by him that so long as the vascular walls were in a healthy condition, transudations into the tissues did not occur, but if these were injured, then it occurred immediately. The inference is that hydræmia in itself does not cause transudations into the cellular tissues, or the cavities of the body, but may secondarily lead to them, by inducing malnutrition of the vascular walls. In the experiments alluded to above, the blood pressure was but slightly increased, even after the largest injections, and the surplus fluid very rapidly escaped by the glandular organs, along the intestinal canal, and by the kidneys.

Glycohæmia, Diabetes.

Glycohæmia signifies an excess of sugar in the blood. A somewhat definite, though small, amount of sugar belongs to the blood in the healthful state. This amounts to from one to one and a half parts per thousand for arterial blood. In passing through the capillaries of the system, much of this is lost, so that the veins contain less sugar than the arteries.

Origin of Sugar in the Blood. The greater portion of the

sugar in the blood is derived from the liver. Its process of formation is called the *glycogenic function* of the liver. Bernard, the discoverer of the glycogenic function of the liver, established the following facts in connection therewith: 1. That the sugar formed in the liver is derived from a substance stored up in its tissues, known as *glycogen*. 2. That this glycogen, in turn, is derived from the sugar and sugar forming materials taken with the food and carried to the liver by the portal blood. 3. That the glycogen becomes gradually reconverted into sugar, to be borne off in the blood of the hepatic vein, and thence into the general circulation. It is owing to this primary conversion of sugars into glycogen and their subsequent reconversion into sugar, and gradual liberation into the blood stream, that the standard of sugar in the blood is so evenly maintained. Glycogen is, in the main, derived from the hydrocarbons—sugar, starch, etc.—taken with the food, but to a less extent also, from albuminous substances. It is maintained by some that although the liver is the source of the normal supply of sugar, the tissues themselves yield sugar in the process of decomposition. Sugar thus formed is rapidly disposed of in passing through the capillaries of the lungs, and those of the general system. It is probably oxidized or burnt up, and also assimilated and taken up by the tissues in the nutritive process.

Diabetes Mellitus. Slight and temporary excesses in the amount of sugar are quickly disposed of without appreciable effect on the system or the secretions. If, however, the amount be very considerably increased the sugar appears as an excretion in the urine, constituting *glycosuria*. Any quantity above five parts per thousand suffices to produce glycosuria in the rabbit, while in diabetic patients the amount may reach several times that quantity. Glycosuria may be of brief duration, owing to a temporary increase in the amount of sugar in the blood, or permanent, owing to a constant

surplus of the same. In the latter case it constitutes the disease, *diabetes mellitus*.

Causes. An excess of sugar in the blood may depend on an excessive production, or a deficient consumption, or both.

1. Excessive production may result from an *excessive indulgence in sugar*, or sugar-forming substances, on an empty stomach. Here the sugar is absorbed so rapidly, and in such quantities, that all of it cannot be converted into glycogen in its passage through the liver, and consequently it surcharges the blood. Injections of saccharine solutions into the veins produce the same result. These are transitory in duration. *Accelerated circulation* of the blood through the liver will cause an excess of sugar by the rapid conversion of the glycogen there stored up into sugar. This conversion is effected through a substance in the liquor sanguinis similar to ptyaline, and will be rapid in proportion to the celerity with which fresh blood takes the place of that already charged with sugar. An acceleration of the blood through the liver may be effected in many ways: by puncturing the floor of the fourth ventricle, by compression of the brain, by injury to certain of the sympathetic ganglia, by section of certain of the sympathetic nerves, all of which operate by inducing vaso-motor paralysis. Kneading the abdomen, contusions over the liver, and muscular paralysis induced by the exhibition of curare and other paralytics, also accelerate the hepatic circulation. *Rapid decomposition of the tissues* may be another factor in glycohæmia, if, as is held by some, such change is attended by the formation of sugar. It is claimed in this connection that tissue metamorphosis is very rapid in diabetes, so that all the sugar thus formed is not oxidized, and that the oxygen of the blood is deficient, by reason of a deficiency or defection of the red corpuscles; these latter sharing in the general malnutrition of the body. Here, then, is a twofold cause of accumulation: an over-production of sugar

and a deficiency of the oxidizing agent. This view rests, for the present, principally on hypothetical grounds.

2. *Deficient consumption of sugar* may result from an absence of oxygen in the blood, as in conditions of anæmia; or from a retardation of those changes by which sugar is converted into tissue substances. All we know with regard to either of these changes is, that the sugar disappears from the blood normally in its passage through the capillaries, where those interchanges take place between the blood and the tissues which are included among the nutritive processes. As will be seen, the pathogeny of glycohæmia is still involved in much obscurity, and does not admit of present solution.

Uræmia.

Uræmia signifies an excess of urea in the blood. Urea is an excrementitious substance, the result of decomposition of the nitrogeneous elements of the body. Being such, it is formed at the tissues, and carried by the blood to the kidneys for elimination. It is at once the most abundant and most important of the solid constituents of the urine. In the healthful state, it exists in the blood in very small quantities, but if the function of the kidneys be impaired, it may accumulate enormously. The circumstances under which this accumulation is most apt to occur are, diffuse structural changes affecting both kidneys, as in Bright's disease, and after extirpation of the kidneys or occlusion of the ureters. Uræmia is usually associated with symptoms of intoxication, which have been ascribed to the toxic properties of urea. These relate more especially to the nervous system, and consist of neuralgia, amaurosis, delirium, convulsions and coma. Vomiting and diarrhœa are not infrequent, being attempts at vicarious elimination. There is also generally a pallor and puffiness of the face, the result of anæmia and œdema. These symptoms, taken in connection with the impaired functions of

the kidneys, as shown by albuminous urine, casts in the same, and a diminished quantity of the excreted urea, generally suffice to establish the diagnosis.

Uræmic Poisoning. Whether the so-called uræmic poisoning is due to the specific poisonous properties of urea, or to something else, has given rise to much discussion, backed by much ingenious investigation.

While the majority of observers believe that uræmic poisoning is due directly to an accumulation of urea in the blood, and that it is specifically poisonous, there are others who believe and maintain differently. It has been asserted that urea is not always present in excess in cases of so-called uræmic poisoning; that uræmic poisoning does not always follow an excess of urea in the blood; that injections of urea into the blood and feeding of urea to animals, even in large quantities, does not produce uræmic poisoning, so long as the kidneys are active, and that, finally, even after extirpation of the kidneys, the injection of urea into the blood has not apparently hastened the inevitable uræmic intoxication. The phenomena of the so-called uræmic poisoning have been variously ascribed to the presence of carbonate of ammonia in the blood, to œdema of the brain, and to the interference with the nutritive processes because of the accumulation of waste products in the blood and tissues.

Carbonate of Ammonia in the Blood. Carbonate of ammonia, which may result from decomposition of urea, is frequently found in the alimentary canal, and in the vomited matters of uræmics, but so far as investigation goes, *is never found in the blood.* Small quantities may be absorbed from the intestinal canal, and, exceptionally, it may even be detected in the breath. This, however, is inconsequential, as it is inconstant. The symptoms resulting from injecting carbonate of ammonia into the blood are convulsions and coma, with slowing of the pulse and respiration, which, so far as they go,

are similar to those of uræmic poisoning. Many other of the symptoms of uræmia are, however, wanting, so that this theory fails to satisfactorily explain the phenomena of uræmic poisoning. Carbonate of ammonia is, furthermore, often not to be detected in the blood of uræmics.

Œdema of the Brain. This, though a frequent accompaniment of the uræmic state, owing to the prevailing hydræmia and high blood pressure, is yet, nevertheless, absent in a goodly number of cases of well marked uræmic poisoning. It is also found every now and then in cases in which, during life, there were none of the uræmic symptoms. It is, therefore, untenable.

Accumulation of Waste Products in the Blood and Tissues. Much might be adduced for and against this, at present, fashionable theory of uræmia; but as it is very indefinite in its application and range, as it presupposes an accumulation of many and various excrementitious principles, some of which—the extractive matters—we are unacquainted with, and as the phenomena resulting therefrom may be attributable as well to a specific action of any one or more of them, as to a mere mechanical interference with the vital functions, it cannot be easily gainsayed. In conclusion, the matter may be summarized as follows: (*a*) It is quite evident that the uræmic state depends upon a failure in the proper function of the kidneys. (*b*) As the result of that failure various matters accumulate in the blood and tissues, the most noteworthy of which is urea. (*c*) The uræmic poisoning, all things being equal, is proportionate to the amount of the retained urea. (*d*) The introduction of urea into the blood under circumstances precluding its elimination, is followed by uræmic poisoning. (*e*) The introduction of none of the other excrementitious matters, so far as known, is followed by like phenomena. Hence, it is almost certain that uræmic poisoning is very directly the result of an excess of urea in the blood.

Septicæmia.

Septicæmia is a disease resulting from infection by putrid material. It is characterized by fever, great depression of the vital powers, and frequently, by the formation of abscesses. The more prominent symptoms of the disease are about as follows: a rigor, ending in a profuse sweat without an intervening hot stage, and recurring at irregular intervals, with the general evidences of great systemic depression. This latter is indicated by the rapid pulse and breathing, the suffused, sunken features, diarrhœa and vomiting, muscular weakness, delirium, hypnotism, or coma. Coupled with the above, the formation of multiple abscesses in various regions of the body is very characteristic. The thermal tracings in septicæmia are peculiar, the mercury mounting in the chill stage, sinking below the normal in the sweating stage, but varying as regards the amplitude of the excursions in different paroxysms.

The Causes of Septicæmia. The constant association of this disease with the putrefactive process in open wounds, and the ease with which it can be induced, artificially, by introducing septic fluids into the blood or tissues of lower animals, leave little doubt as to the cause. The source of infection is usually an open wound, in which the inflammatory products are undergoing putrefaction. Putrefaction is a form of decomposition peculiar to albuminous matter, effected through the agency of little organisms, known as bacteria. Of these there are several varieties, and they act by feeding on the albuminous matter, and secreting, or evolving therefrom the putrid material. In other words, it is the albuminous matters worked over, and chemically changed through the agency of bacteria, and in this respect resembles very closely the fermentation produced in saccharine matter by the presence of the yeast plant. The activity of the putrefying process is proportionate to the numbers and activity of the bacteria.

These latter thrive under the circumstances of warmth, moisture and atmospheric air, in their native soil—dead albuminous matter. Hence it is, that putrefaction is much more common in open wounds, where these conditions subsist; and it is in this class of injuries where septic poisoning is most frequent. Septicæmia may, however, occur as the result of internal inflammations, as of the viscera and bones. Though there can scarcely be a doubt as to the causal relation of putrid matter to septicæmia, yet it remains for us to seek in this matter for the essential cause. We have, usually, in a putrefying sore, three elements: pus, bacteria and the liquid secreted by the latter, each of which has been credited with engendering the disease. As pus corpuscles are indistinguishable from, if not identical with, the leucocytes of the blood, and as the introduction of healthy pus corpuscles into the circulating fluid is followed by no particular deleterious effects, it is safe to conclude that they are not the offending agents. Then, again, putrid matters, from which pus corpuscles had been excluded by filtration, have repeatedly been used to induce septicæmia in animals, and it does not seem that its virulence is in any degree abated by such treatment. As between the bacteria and the amorphous elements of the putrid fluid, nothing definite can at present be said. The presence of bacteria at the point of infection in the lymph, in the inflamed structures, and sometimes in the blood, argues their intimate association, if not their identity, with the essential cause.

Absorption of Septic Matter. Taking it for granted that the *materies morbi* resides in putrid matter, it follows that, before this can produce its baneful results, it must gain access to the system. This it does by entering the blood vessels and lymphatics. It has long been known that injuries of certain parts of the body were much more apt to be followed by septicæmia than others. These are, respectively,

the bones of the head, the long bones of the extremities, and the viscera of the pelvic region. The rigid and unyielding nature of the blood vessels in the two former, and the abundance of open-mouthed sinuses in the latter, afford opportunities particularly favorable to the entrance of the putrid fluids. A relaxed and cachectic state of the system, and want of tonicity of the vascular system, also favor absorption; whereas, a system in good tone, with vessels that promptly retract after injury, together with a healthy granulating surface, interpose the strongest barriers to its entrance. Hence it is that, though putrefaction occurs so frequently in the inflammatory products of wounds, septicæmia is not more common.

Structural Changes in Septicæmia. In cases running a rapid course to a fatal termination, the post-mortem evidences of the disease are almost negative. Here the poison seems to have done its work by overwhelming the vital functions, as in some cases of scarlet fever. Usually, however, there is enlargement of the liver and spleen, which are gorged with blood, friable, and sometimes pultaceous. If vomiting and diarrhœa have been present, the mucous lining of the intestinal tract is in the same condition. Other viscera may present similar appearances. The blood itself is very dark, fluid, or imperfectly coagulated, and the solid tissues quickly fall into decomposition. In other cases numerous localized abscesses are found, studding some one or more of the viscera. These abscesses, known as *multiple* or *metastatic* abscesses, are found in the more chronic forms of the disease, and are supposed by many to indicate a distinct affection—*Pyæmia* or *purulent infection.* The reasons for not regarding it as such have been adduced above. These abscesses are found most frequently in the lungs, but also in the liver, kidney, spleen, heart, the subcutaneous cellular tissue, and other situations, about in the order named. Besides the above, larger depots of puru-

lent matter are not unfrequently found in the joints, the pleura, pericardium, and other serous cavities, as the result of a more diffused inflammation.

Origin and Nature of the Metastatic Abscess. These abscesses commence as a nodular infiltration, of conical form, and are at first red, granular, and friable. They vary in size, from that of a pea to that of a walnut, and are usually situated near the periphery of the organ in which they are located, with their apices directed inward, and are surrounded by a zone of hyperæmic tissue. Owing to their frequent proximity to the investing capsule, this latter often becomes inflamed, giving rise to a more diffused pleuritis, pericarditis, or synovitis, according to the part affected. Soon the central part of the nodule breaks down into a puruloid fluid, and the disintegration rapidly extends to the zone of hyperæmia. The primary cause of metastatic abscess is embolism of the capillaries and smaller vessels of the affected region. The emboli are derived from broken-down coagula formed at the original point of infection, or from secondary coagula, the result of embolism and consequent inflammation in more remote parts. The intensity of the inflammatory process in the vicinity of these emboli is because of their saturation with the septic fluid. The disproportionate frequency with which the lungs are affected with multiple abscess in septicæmia, and the relative order with which other viscera are affected, together with the conical shape of the same, and their ordinary situation near the surface of the affected organ, are all accounted for by their embolic origin.

CHAPTER XXI.

DISEASES OF CARTILAGE.

Inflammation of Cartilage.

Cartilage being a non-vascular structure, the initial circulatory disturbances do not take place within its own substance, but in the contiguous vascularized parts, such as bone, synovial membrane, etc. These are in every respect similar to what occurs in the inflammation of vascularized structures, and consist of hyperæmia, followed by exudation and cell migration, the latter of which takes place into the cartilage. The cartilage itself evinces remarkable changes, the most noteworthy of which are the softening and disintegration of the intercellular substance, the dissolution of the cell capsules, and a more or less dense infiltration with embryonic cells. Occurring on the free surface, the disintegrative process, as above described, constitutes the *acute ulcer* of cartilage. It is characterized by a ragged and irregular bottom, owing to the unequal depth to which the process extends in different directions. The discharge consists of young cells and a granular débris. Into this softened mass new-formed blood vessels—the offshoots from the border vessels—extend, in the form of loops, and it is through the agency of these that the reparative process is instituted. Repair is effected, as in other instances, by granulation, and eventually the gap becomes filled with a fibrillated structure, after the nature of cicatricial tissue.

Inflammation of the Cornea. The cornea being of a cartilaginous nature, the inflammatory process is similar to that as described above. A zone of hyperæmia surrounds the cornea, and certain changes take place within the corneal substance, which consists of cloudy swelling of the corneal cells,

by which they become visible, softening of the intercellular substance, cellular infiltration, and finally disintegration. Repair is effected as in the case of cartilage, but the resulting structure, instead of being clear and transparent, as the original tissue was, is opaque and white. This gives rise to opacity of the cornea.

As to the origin of the young cells so abundantly present in inflamed cartilaginous structures, it is now pretty generally conceded that they are for the most part, if not entirely, emigrants. The old notion that they originated in the proliferation of the local cartilage cells is not borne out by observation.

Subacute Inflammation of Cartilage. A subacute form of inflammation is sometimes met with, in which the cartilage has a worm-eaten appearance. Here, owing to the moderate intensity of the inflammatory process, the intercellular softening is less extensive, the cellular infiltration less dense, and reconstruction more prompt, the formative processes treading close upon the heels of the destructive. Nevertheless, gaps occur here and there, from loss of substance, which, together with the fibrillated structures of new formation intercalated between irregular tracts of unchanged cartilage, gives to the structure a motley aspect.

Erosion of Cartilage. This consists in the formation of small, yellow, flaky spots on the surface of articular cartilages, which by gradual enlargement and subsequent breaking down, leave superficial erosions. It occurs, for the most part, after middle life. It is most frequently met with in the vicinity of the knee joint, in the articular cartilage and over the patella. It is attended by more or less enlargement and fatty degeneration of the cartilage cells, and by fibrillation of the intercellular substance. Its pathology is somewhat obscure, though it is evidently a retrogressive change, due to irritation from continued pressure.

CHAPTER XXII.

DISEASES OF CONNECTIVE TISSUE.

Inflammation of Connective Tissue.

A peculiar interest attaches to inflammation of connective tissue, both because of its extreme frequency, and because it furnishes the type of the reparative process as it occurs in other tissues. It is through the medium of a connective tissue new formation—cicatricial tissue—that, with few exceptions, the breaches of continuity occurring in the various tissues, are repaired. Leaving out of consideration the circulatory disturbances, the first signs of an inflammatory change are found in the presence within the connective tissue of a greater or less number of small, round cells. Coincidently, the intercellular substance often loses its fibrillated character, and becomes gelatinous and homogeneous. The subsequent changes are in the same line, differing only in degree, according to the intensity of the inflammatory process. In mild cases, this amounts to a moderate percolation of the cellular elements into a softened matrix, in which the semblance of the normal tissue is still preserved. In the severer form, a complete disintegration ensues, and nothing remains but a dense aggregation of cells, with a scant, hardly appreciable quantity of viscid intercellular substance. In the latter case, the fixed connective tissue corpuscles have mostly disappeared; probably by fatty degeneration, and the intercellular substance has become liquefied. As to the origin of the cells which crowd the inflamed area, there is now little doubt but that they are almost, if not entirely, all migrated corpuscles, or derived from them by multiplication. The old idea, that they were in great measure derived by multiplication from the fixed connective tissue corpuscles, is now exploded. No

one has seen these latter in the act of dividing, though, according to Stricker, they have been seen to acquire the amœboid movement in the late stages of the inflammatory process. It is, therefore, possible that at such a time they may contribute to the cell production. The terminations of connective tissue inflammation are in resolution, organization and suppuration.

Resolution. In the milder forms this is the rule. The invading cells either undergo fatty degeneration and are absorbed, or finding their way into the blood and lymph channels, return to the circulation. The intercellular substance also hardens and returns to the fibrillated state, and the circulation being reëstablished, the tissue is restored to its original condition.

Organization. This is the mode of termination in cases of a somewhat severer form in which there has resulted a degree of structural change incompatible with resolution, or a breach of continuity. It consists in the development of an organized tissue from the inflammatory products. In order that this may take place there must be an abatement of inflammatory action. It is accomplished by certain progressive changes in the young cells, and presents two stages: development into granulation tissue and subsequently into cicatricial tissue.

1. *Granulation Tissue.* This is a reticulated structure, made up of large branched cells, the branches meeting to form the reticulum, and containing in its meshes small, round cells. Ordinarily, one or more larger multinucleated masses of protoplasm—giant cells—are found contributing to its formation. The larger cells, which are about twice the size of the ordinary cells, are derived from the latter by extraordinary growth. They contain a single, or sometimes two, large oval nuclei, and are at first round; but subsequently many of them become branched, and constitute a network. The giant cells make their appearance at a later date, by an overgrowth and nuclear division of the primitive elements, with-

out a corresponding division of the protoplasm. They are likewise branched, and unite their processes with the others. While these changes are taking place in the cellular elements, capillary blood vessels make their appearance, traversing the embryo tissue. This vascularization occurs about the fourth or fifth day, and is absolutely essential to the perfected organization; as when this fails, the quasi-organized mass glides rapidly into retrograde metamorphosis. The exact manner in which the new blood vessels are formed is, as yet, not definitely determined. It is probable, however, that they originate in, or by, a canalization of the branched cells and their processes. This, as it now stands, constitutes what is known as *vascularized granulation tissue*.

Cicatricial Tissue. The vascularized granulation tissue now undergoes further change, by which it becomes converted into an adenoid or fibroid structure. If an adenoid structure is to be developed, the reticulated character is still preserved, the meshes of which are still occupied by the aforenamed small, round cells. There is, nevertheless, an increased density, some degree of fibrillation, and a diminished vascularity of the reticulum, and also a dimunition in the number of the small cells.

If, on the other hand, a fibroid structure is to be developed, the change is more radical. Many of the small cells disappear, the larger cells elongate and tend to assume the spindle shape and split up into fibrils. By reason of the increased density and compactness, the new formed capillaries are obliterated, and the recent richly cellular mass becomes converted into a dry, crisp, fibrillated structure—*cicatricial tissue*. The two forms of repair tissue—the adenoid and fibroid—are of about equal frequency, and are often associated. The former has the general characters of adenoid tissue, consisting of a network including lymphoid corpuscles; the latter of fibroid tissue, and consists of a compact, wavy, fibrillated structure,

sparsely interspersed with elongated spindle-shaped elements. The latter is the more highly organized and more permanent.

Suppuration. In the event of a failure to resolve, or to organize, either from the intensity or persistency of inflammatory action, a cellular impaction ensues, which breaks down into pus. This, if in the substance of tissues, forms an abscess, if on the surface, an ulcer, or suppurating wound. The characters of pus and the mode of repair after suppuration have been considered elsewhere.

CHAPTER XXIII.

DISEASES OF BONES.

Rickets.

Rickets is a disease of the bones peculiar to the growing period, and is characterized by an unnatural softening of the osseous structure, which usually leads to deformity. Of its intimate nature little is known, notwithstanding its obvious dependence on malnutrition. Like other maladies of this class it prevails among the ill-fed and ill-nourished, and in the offspring of the cachectic and broken down. It consists essentially in a disturbance of nutrition, whereby the regular course of osseous development is perverted. This perversion, as has been aptly stated, consists in extensive *preparation* for the ossifying process, coupled with a failure to *accomplish* the same. It will be better understood by reverting to the physiological process of ossification, and comparing this with that; for here, as elsewhere, the pathological copies after the physiological; is, in fact, an ill-timed, ill-placed, excessive or deficient *attempt* at the physiological. Take, for example, the ossifying process as it occurs in the intervening cartilage, between the shaft and extremity of a long bone. Ossification does not take place simultaneously throughout the thickness of the cartilage; but progressively and regularly, advancing layer by layer, from the ossified to the unossified. As the ossification advances, a thin stratum of cartilage immediately in front undergoes a preparatory change, by which it becomes softened. On the other hand, the medullary spaces of the advancing bone structure are filled, not with marrow, as at a later period, but with vascularized granulation tissue. Now, when the zone of cartilage immediately in front of the ossified part softens, the

granulation tissue pushes up into it, and spreads about like an arborescent growth. It thus establishes a system of medullary spaces, like unto those of bone, and around which the ossific changes quickly take place. Thus gradually, and by successive steps, the cartilage becomes transformed into bone.

FIG. 25.

RACHITIC HUMERUS.

a. Hyaline cartilage of epiphysis. *b*. Its proliferating layer pervaded by medullary spaces. At *c*. A large piece of cartilage actually ossified. *d*. Limits of the bone. *e*. The medullary cavity. *f*. The compact substance. *g*. Proliferating layer of the periosteum.

In Rickets, this preparatory stage is marked by excesses. Instead of a thin stratum of cartilage immediately in front of the ossified portion becoming soft, a broad zone of softening extends far into the cartilage. Likewise, the granulation tissue from the medullary canals eagerly pushes forward to the very confines of this softened zone, as if to complete the ossifying process by one masterly effort. But here the process meets with a check. Ossification does not keep pace with the preparatory processes. It does not take place with that rapidity and completeness that characterizes the normal development. Neither does it advance regularly from the bone into the prepared zone, but pushes in, here and there, to great depth, at other places scarcely advancing, and, withal, giving rise to a very irregular, jagged front. The line of ossification in rickets reminds one of the splintered trunk of a tree from which the top had been

wrenched in a wind storm. Furthermore, the ossification is not only incomplete, but also imperfect in those parts to which it has extended; so that they lack firmness and density. This does not seem to be due to any lack of ossifying material, or to a want of energy in the initial stage, but because of an ineffectual effort to occupy too much territory at once. A similar exuberance and imperfection marks the periosteal contribution to bone formation. The periosteum contributes to the formation of bone in the normal, by throwing out between it and the surface of the bone a delicate layer of plastic material, which quickly assumes the character of granulation tissue, and, as this undergoes the osseous transition, another and another are added successively. In rickets, however, this material is thrown out in large quantities at once, and, not being evenly distributed, forms cushion-like bulgings on the side of the bone. This, as in the case of the cartilage above cited, is imperfectly ossified; nevertheless, a cancellation of the deeper compact substance proceeds, as in the natural growth, so that in these cases the bone does not acquire its wonted hardness and stability. Similar changes take place in the flat and irregular bones as well. There results, in consequence, a growth, at first more massive, but also a very imperfect one, and the structure is soft, spongy and yielding, leading to various deformities. Some of these deformities are due to bending of the pliant structures, others to a bulging or displacement of them, as when a soft material is pressed upon from two sides. Others, again, are due to the uneven deposits under the periosteum. As examples of the first, bow-legs, deformed pelvis, and chicken breast, may be cited. These are the results of pressure, either from the superincumbent weight of the body, or from the contained viscera. As examples of the second, may be cited the *roundish rolls* which encircle the bone in the vicinity of the joints, especially the knee joints, and which impart a double-jointed

appearance. These are due to the bulging of the broad zone of softened material under a vertical pressure. The growing act having exhausted itself in an ill-timed and inordinate effort, now suddenly abates, and a stunted development is the result. Gradually, and by degrees, a hardening and condensation takes place, and stamps the seal of permanency on the dwarfed and deformed structures. Thus ends in signal failure a developmental process so rashly begun and so ingloriously abandoned! No allusion has been made to the atrophy of bone structure so common in rickets. This notably affects the occipital bone, and comes of the imperfect ossification—the failure to produce a condensed tissue on its outer surface. In the ordinary course of development, the inner table undergoes progressive absorption, as new layers of condensed tissue are formed on the outer surface. This, in order to make room for the growing brain. Here, however, the soft, luxuriant mass on the exterior, which takes the place of the outer table, atrophies, under the pressure of the head on the pillow, and so it comes that, between the two—the physiological wasting from the interior, and the pathological from the exterior—a great thinning, or even complete loss, of bone structure ensues. In this way, roundish holes are formed in the occipital bone, being covered only by the membranes.

Mollities Ossium.

Mollities ossium or osteo-malacia, is, as the name implies, a disease of the bones characterized by softening. It is a very rare disease, and occurs only in adults. Like rickets it is a nutritive disorder of an obscure nature, and probably non-inflammatory in character. The softening is occasioned, in part, by a decalcification of the bone tissue, in part by a rarification of the same, whereby it becomes spongy throughout, and in part by a mucoid change in the matrix. Bones so affected

are very cancellous, have large medullary canals, and an exceedingly thin encasement, of more or less altered condensed tissue. They are very soft and flexible, are capable of being bent to almost any extent, and offer but little resistance to the knife. The medullary tissue is very vascular and much altered in other respects, but does not entirely resemble vascularized granulation tissue, in that it contains much fat. The primal cause of these changes is unknown. The decalcification has been supposed to depend on the solvent action of some acid. Lactic acid has been found, both in the bone and in the urine. The urine usually contains large quantities of lime salts which have been removed from the bone. The solvent action of certain acids on the lime salts has been more explicitly set forth under the head of causes of calcareous infiltration.

Inflammation of Bones.

In inflammation of bone, the inflammatory process follows the course of the vessels—through the medullary spaces, and along the Haversian canals. These parts become the seat of a cellular infiltration, and as a consequence, the contiguous parts become atrophied. The atrophy, which consists of the wasting of the contents of the fat vesicles of the medullary tissues, together with a decalcification and more or less destruction of the osseous laminæ, is attended by a degree of nutritive activity of the bone cells, whereby many of them enlarge, become multinucleated, and constitute myeloid cells. It will be observed, that the change produced in osseous structure by inflammation, consists essentially in a reversal of the developmental process. In the growing bone, a soft cancellous formation, abounding in myeloid cells, precedes the condensation, whereas, here, the order is reversed, and the bone becomes spongy, soft, and contains myeloid cells. This is known as the *rarefication* of bone. The infiltrating

FIG. 26.

RAREFYING OSTEITIS.

cells are, for the most part, emigrants. Through the gradual wasting and destruction of the lamella, the medullary spaces are enlarged, the Haversian canals widened, and not infrequently, the partition walls between adjacent spaces broken down, and in this way a system of tortuous, widened, ramifying passages are produced. This is occasioned by the soft, fleshy material known as *medullary granulation tissue*, which also fills the spaces. It is constructed from the new cell forms, which align themselves along the course of the vessels, and therefore permeates the bone tissue in all directions. This medullary granulation tissue is an important factor in many of the constructive and destructive processes of bone, and should not be lost sight of in the succeeding pages. It absorbs and removes the products of waste as it proceeds, so that, ordinarily, there remains no debris on the ground. The above, which is the common course of an ordinarily active inflammation of bone structure, is known as *rarefying osteitis*.

The terminations are in *resolution, suppuration, organization* or *death* of bone structures. A mild case may terminate in resolution, in the way that a connective tissue resolution is effected. If the cellular infiltration be very dense, the conditions are not favorable to the development and maintenance of the medullary granulation tissue, and hence, purulent depots are liable to form in the substance of the bone, or under the periosteum. These, by coalition of neighboring depots, may acquire considerable size. The purulent matter, if deep seated and not relieved artificially, entails a long series of disturbances, and in the sub-periosteal variety not infrequently leads to necrosis. Suppurative ostitis is otherwise known as osteo-myelitis and acute ostitis. Organization takes place in cases of less severity than the suppurative form, or after the subsidence and ejection of the products of a suppurative or necrotic ostitis. The space and excavations caused by the inflammatory process become filled with the vascularized granulation tissue, which passes through the various phases of development into bone. In this way, by a concentric and progressively narrowing deposit of bone substance within the medullary spaces and Haversian canals, these become almost solid. The bone is now heavier, denser and harder than natural. It represents the condensed form of bone substance, and is called *sclerosis* of bone. Death of the bone substance, as it occurs in inflammation and otherwise, will receive attention under the heads of Necrosis and Caries.

Periostitis.

It is through and by the periosteum that the more superficial parts of the bone are nourished. Hence, it will readily appear how inflammations of the periosteum may profoundly affect the bone structure. An acute inflammation of the periosteum frequently terminates in suppuration, the pus accumulating between the membrane and the bone. This, in

turn, by compressing and tearing asunder the vessels passing between the bone and membrane, interferes with the blood supply, and quite frequently leads to necrosis. The necrosis will be circumscribed or diffuse, according to the extent of the purulent accumulation. If the nutrient vessels that pass to the interior of the bone be involved, the entire bone may die. With a less intense inflammation the inflammatory products may become organized and converted into bone tissue. In this way the bone may acquire additional thickness, and in the same manner breaches of continuity of the surface of the bone may be repaired.

Necrosis of Bone.

Necrosis is a death of bone *en masse*—that is to say, the dead portion still preserves its structure, so that it may be recognized as bone tissue. Bones, like other structures, die when the blood supply is cut off. The necrosis may involve an entire bone, or what is much more common, limited portions of the same. The blood supply may be interrupted in many ways—by injury to the nutrient arteries ; by injuries to, or detachment of, the periosteum, and as the result of inflammatory changes. Fragments of broken bone which have lost their vascular connections also become necrosed. The necrosed part, if not already separated from the living structure, becomes so by the formation between them of a granulation tissue, which, by subsequently melting down, leaves it free. This is usually a very tedious process, and if the dead part be deeply situated, its final separation and ejection is greatly retarded. In such cases a purulent collection, containing the debris of broken down tissues, forms around the dead portion, and gradually finds its way to the surface, through which it discharges. Not infrequently an organizing periostitis is excited at the same time, and layer upon layer of condensed tissue is superadded to the old bone which enclosed

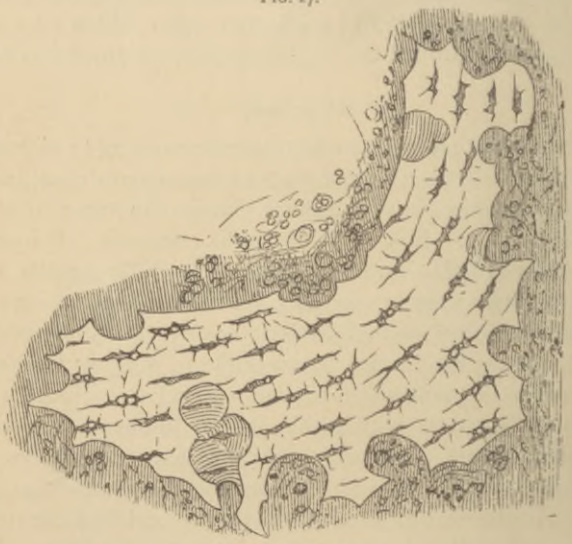
the dead portion. The dead portion is called the *sequestrum*, that which surrounds it the *involucrum*, and the openings in the latter *cloacæ*. These openings are maintained in the new formation, through which the discharge continues, and which in time may carry away with it the sequestrum, piecemeal. After the riddance of the sequestrum a gradual alteration takes place in the cavity and surroundings, by which gaps are filled, redundancies removed, rarefied and condensed portions respectively brought to the proper standard, and the bone is restored to something like its former self. Much of this is accomplished through the instrumentality of the granulation tissue.

Caries.

Caries is a disease of the bones corresponding to ulceration of soft parts. It is, in other words, a molecular disintegration of bone structure, in which there remains no trace of structural formation. It is, therefore, unlike necrosis. It is one of the results of inflammation, and does not differ greatly from the process as seen in rarefying ostitis. Indeed, a rarefying ostitis is frequently associated with caries. It will be remembered that the rarification or cancellation of bone is effected by the development of a medullary granulative tissue, which grows and expands within the natural meshes and vascular channels. This, as it were, eats its way into the osseous structure, removing by absorption the waste products as it goes. In this way a system of devious, broadened channels is formed, extending from the centre to the periphery. Here the cellular infiltration designed for the formation of this granulation tissue becomes impacted in the small meshes of the condensed tissue, strangulates the vessels, and both vessels and cells fall into decay. More slowly, but not less certainly, the osseous lamella themselves crumble away; the detritus accumulating on the surface and in the meshes of the same, because it cannot be removed by absorption. There

results a superficial, irregular excavation, with a spongy, friable base. This base is covered and infiltrated with an ichorous, purulent matter, containing the debris of dissolving tissues. The fluid parts of the discharge percolate, or well up from the subjacent medullary tissue. Sometimes this tissue breaks through into the carious cavity, and protrudes, fungus-like, from its floor and sides. Sometimes a layer of condensed tissue forms beneath the floor of the excavation, as if to pro-

FIG. 27.



FUNGOUS CARIES.

tect the living from the dead parts. Superficial caries may result from a superficial ostitis or periostitis, without a coincident deep-seated inflammation. Necrosed fragments of bone are frequently found in the carious excavation, owing to a circumventing or undermining caries. The carious products, if pent up, sometimes, especially in scrofulous subjects, undergo caseous change.

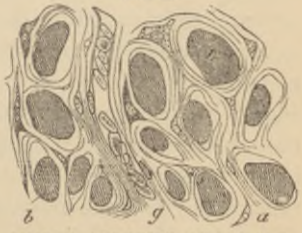
CHAPTER XXIV.

DISEASES OF MUSCLES.

The diseases of the voluntary muscles are, for the most part, so aptly illustrated in the diseases of the heart muscle, that only a brief allusion will here be made to them.

Atrophy of Muscles. In simple atrophy the muscular fibre shrinks within the sarcolemma, which is held apart from it by its attachment to the interstitial connective tissue. The interstitial tissue quite often grows and increases in thickness as the contractile substance diminishes (Fig. 28). At other times, the cells of the interstitial substance become infiltrated with fat, in order to fill the vacuum occasioned by the shrinking of the muscular fibres. This is shown in (Fig. 29.) In the atrophies of muscle it will be observed that there is no accumulation of fat within the sarcolemma, but in the interstitial connective tissue and outside the fibre sheath.

FIG. 28.



SIMPLE ATROPHY OF MUSCLE.

a. Interstitial connective tissue, with large cells, *b*. Muscular fibres in various stages of decreasing volume. *g*. Filling capillary.

Hypertrophy of Muscles. True hypertrophy of muscle is characterized by an increase of the contractile substance. A false hypertrophy—*pseudo-muscular hypertrophy*—may arise from a deposit of fat between the muscular fibres, as in the case of fatty infiltration of the interstitial substance above mentioned. Here, however, the fatty infiltration is not preceded by atrophy of the muscular fibres. These latter are simply

FIG. 29.

PSEUDO-HYPERTROPHY OF MUSCLE.

forced apart by the fatty deposition, and may not waste at all (Fig. 29), nevertheless, the functional capacity of the muscle is impaired, because of the forced separation of individual fibres. The increased bulk and density of the muscle gives to it the external appearance of true hypertrophy.

The Typhoid Change. The voluntary muscles are prone to a peculiar change in typhoid fever, of a nature not yet understood. The change is usually most marked in the muscles of the abdomen, the inner aspect of the thigh, and in the diaphragm, and affects isolated fibres or fasciculi, but almost never the muscle *in toto*. The fibres so affected are swollen, pale and friable, and consist of a waxy, lustrous, homogeneous material, which is transversely seamed or broken into fragments. The fragility and incontractile nature of the material, which, by the way, has not the least semblance to muscle fibre, often leads to the rupture of the fasciculi, and consequent hemorrhage. It is very absorbable, and is quickly replaced by genuine muscular fibre, when the conditions are favorable. It sometimes occurs in other forms of fever, in the vicinity of muscular abscess, and in muscles that have been bruised. The change somewhat resembles colloid degeneration. Cohnheim regards it as a modified post-mortem coagulation, something after the nature of what occurs in rigor mortis.

CHAPTER XXV.

DISEASES OF SEROUS MEMBRANES.

Inflammation of Serous Membranes.

Inflammation of serous membranes is characterized by an effusion into the serous cavities, and by the formation of a false membrane on the inflamed surface. The character of the effusion varies according to the intensity of the inflammation, being, in the milder forms, somewhat turbid and watery, and in the severer forms, purulent. The inflammatory process commences in a hyperæmia of the membrane, which is followed by exudation and cell migration from the blood vessels, and a cellular proliferation from the endothelial surface. Under the influence of an increased nutritive activity, the endothelial cells swell up, become granular, and ultimately exhibit a nuclear division, and an endogenous formation of young cells. These latter are subsequently liberated, and, together with the liquor sanguinis, migrated corpuscles, and a varying number of detached endothelial elements and flakes of coagulated fibrin, constitute the fluid which occupies the serous cavity. This fluid, unlike the transudation of dropsy, is turbid, from the number of cells which it contains. Owing to the changes transpiring in the endothelium, the surface of the membrane, which, in its natural state, is polished and glistening, now becomes roughened and opaque, and exhibits an exceeding vascularity. It is also smeared over, or covered, to a greater or less depth, with a coating of false membrane. This latter consists of interlacing strands of coagulated fibrin, holding in their meshes such of the cell forms and endothelial elements above alluded to as have been prevented from dropping into the

cavity, by becoming entangled in this network. The fibrin, which constitutes the network, escapes from the blood with the liquor sanguinis, and coagulates on reaching the surface of the membrane, probably from being brought in contact with dead endothelial elements. The cells which fill the reticulum of the false membrane, and also those suspended in the effusion, are, for the most part, emigrant corpuscles; and they continue to multiply after reaching these positions. The false membrane, which at first is soft and viscid, agglutinates opposing surfaces when they come in contact, which, by a subsequent hardening and organization, produces permanent adhesions. In the process of organization, the cells of the false membrane elongate and assume the spindle form; blood vessels of new formation make their appearance in their midst; the fibrinous material is removed by absorption; and is substituted by a true intercellular substance; and by a subsequent fibrillation a connective tissue is evolved. It will thus be seen that coagulated fibrin, as first exuded, only plays a temporary *rôle;* serving to fix the cells until such time as they may be able to inaugurate the organizing process. Subsequently, many of the blood vessels disappear, and by the contraction of the new formed tissue, a close and firm union of the apposed surface is effected. This constitutes the *adhesive inflammation* of serous membrane. If, however, the effusion into the cavity be abundant, so as to separate the opposing surfaces, adhesive inflammation cannot take place until this be removed. When the inflammatory action is very intense,

FIG. 30.

FALSE MEMBRANE VESSELS.

and the cell production correspondingly rapid and abundant, the effusion becomes so impregnated with them as to form pus. This, the *purulent inflammation* of serous membranes, is of grave import, in that the purulent collection in the cavity cannot readily be removed, and abiding there, provokes further changes. Three conditions conspire to render its removal by natural means difficult and tardy: 1. Pus

FIG. 31.

PURULENT INFLAMMATION OF SEROUS MEMBRANE.

a. Membrane infiltrated with colorless blood corpuscles. *b*. Surface secreting pus corpuscles. *c*. Muscular structure.

cannot be removed by absorption until it has undergone degeneration and disintegrated. 2. Its long continuance in the serous cavity has resulted in the destruction of the endothelial layer, and the production of a richly vascular granulation tissue, which continues to pour its purulent secretion into the cavity. 3. The presence of so large a quantity of fluid in the cavity exercises such a pressure on the absorbents

as to greatly embarrass them in their efforts at removal of the same. If, however, this be removed, either by natural or artificial means, and the inflammatory action has subsided, the raw, granulating surfaces come in contact, and by fusing, constitute another form of adhesion, in which the false membrane plays no part. This form of adhesion may occur in the more persistent non-purulent effusion as well. Membranous bands and bridles may result from the touching and subsequent separation of surfaces, in consequence of which the soft and viscid exudate is drawn out so as to form a bridge between them.

CHAPTER XXVI.

DISEASES OF MUCOUS MEMBRANES.

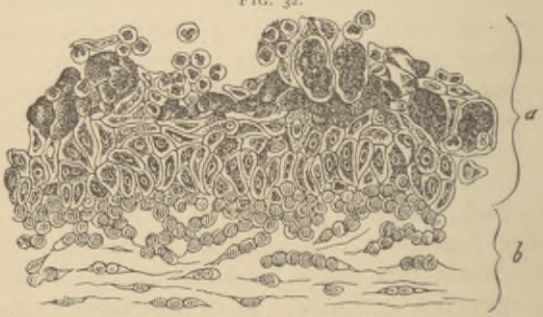
Inflammation of Mucous Membrane.

The inflammations of mucous membranes occur under two types, the *Catarrhal* and *Croupous*.

1. *Catarrhal Inflammation.* Catarrhal inflammation, or as it is sometimes called, *Catarrh*, is the most common type. It is characterized mainly by a discharge from the surface, which varies in character according to the intensity and stage of the inflammatory process. In some instances it is watery, at others consists of mucus, and at others still of a muco-purulent or purulent matter. In the initial stage the membrane is usually dry, tumid and hyperæmic, which, however, is quickly succeeded by an abundant transudation from the blood vessels, and a larger increase in the number of the mucous corpuscles. These latter are small, round cells, resembling leucocytes, but, as a rule, above the average size of the latter. They are derived in part from the migrating cells, and in part by proliferation from the epithelial elements. The mucus, which is formed by the union of the transudate and the mucous corpuscles, is usually very rich in these cell forms, and often contains besides a number of detached epithelial cells. On the interior of some of these latter may occasionally be seen groups of young cells, which are evidently destined for mucous corpuscles. Whether they are of endogenous formation, or leucocytes which have penetrated to the interior of the old cell, has not been determined. In the more severe forms of inflammation the cell elements are greatly augmented in numbers, and the discharge assumes a muco-purulent or purulent aspect. Many of the cells have

now assumed the characters of pus cells, being somewhat smaller than the average mucus-corpuscle, less regular in contour, and not infrequently containing the fragments of a broken nucleus. There is, however, no essential difference between a mucus corpuscle and a pus corpuscle, as they each may answer the characters of the other. When the discharge is distinctly purulent it no longer yields mucin. Later in the course of the disease the sub-epithelial tissue becomes infiltrated, interfering still more with the nutrition of the epithelium, which is apt to become detached in flakes, leaving here and there a denuded surface of irregular extent and outline.

FIG. 32.



PURULENT CATARRH OF CONJUNCTIVA.
a. Epithelium. *b*. Connective tissue stratum.

The inflammatory process is not confined to the free surface of the mucous membrane, but involves the involutions of the same, the mucous follicles, the proper gland follicles of the part, and also the lymphatic structure underlying or imbedded in the membrane. In the stomach, for instance, both the mucous and gastric follicles are involved, and by an active proliferation of their lining epithelium, contribute to the discharges. Occasionally they become impacted with epithelial elements, and being no longer able to functionate, undergo a gradual wasting. The lymph follicles likewise

inflame, become enlarged, sometimes soften, and bursting, leave the so-called *follicular ulcer*. The appearance of the inflamed mucous membrane is swollen and red, but after death the redness fades, on account of the recession of blood from the vessels. Acute catarrh usually terminates in resolution, but occasionally only partially subsides, and becoming persistent, constitutes chronic catarrh.

Chronic Catarrh. In the chronic form of the disease, there is some abatement of the hyperæmia and of the rapidity of cell proliferation; nevertheless, these continue. The principal pathological changes here occur in the deeper structures of the mucous membrane—the sub-epithelial connective tissue—which becomes swollen, from infiltration with small, round cells. Occasionally, an imperfectly fibrillated tissue results from the organization of these new elements, and the mucous membrane becomes not only thickened, but also indurated. In this, as in the acute form of catarrh, the glandular structures in and about the mucous membrane participate in the inflammatory process, and are subject to like changes as there mentioned. The pressure exercised by the sub-epithelial growth, furthermore, greatly interferes with the nutrition of these little bodies, and often leads to their destruction. It also, at times, prevents the discharge of their secretion, by occluding their mouths, and may thus cause accumulation within them, and the formation of retention cysts. Examples of this kind are frequent in the catarrhs of the stomach and bowels. By involvement of the lymph follicles they become enlarged and indurated, and conspicuous as nodular or granular masses beneath the epithelium. These are well shown in that common disease, follicular pharyngitis. They occasionally ulcerate, leaving pits or cavities, which are often pigmented, especially so as they occur in the intestinal canal.

2. *Croupous Inflammation.* This type is characterized by the formation of a false membrane, as in croup and diph-

theria. On account of this membrane it is also called *fibrinous* or *diphtheritic* inflammation. The false membrane is usually of a grayish-white or yellowish color, and varies in consistence from a pultaceous softness to a parchment-like toughness. It also varies in size, thickness, configuration, and the depth to which it extends into the subjacent structures. It sometimes consists of small, scattered patches, at others of a uniform layer of greater or less magnitude. It is more or less easily detached, according as it lies on the surface or dips deeply into the tissues. Upon being detached, it always exposes an abraded surface, the epithelium coming away with it. If it extends deeply into the tissues its separation is more difficult, and is attended by some uprooting of the tissues with which it is incorporated. Until recently, the more superficial variety has been regarded as distinctive of croup, and the deeper variety of diphtheria. There is now, however, much question as to this relationship, and it is quite generally conceded that the depth of the false membrane depends not so much on the nature of the disease with which it is associated as upon the intensity of the inflammatory process. It may also depend on the structure of the particular mucous membrane inflamed. In some situations the mucous membrane is provided with a distinct basement membrane, and in others this is wanting. The basement membrane tends to limit the depth to which the false membrane may extend, and thus gives rise to the superficial variety. The mucous membrane of the pharynx and air passages is provided with a basement membrane, and in these situations the false membrane is apt to be superficial, whereas, in the eyelids and intestinal canal, where the basement membrane is wanting, the false membrane penetrates deeply.

Structure of the False Membrane. The essential constituents of the false membrane are coagulated fibrine and leucocytes. The fibrin is derived from the blood, and

escapes with the liquor sanguinis along with the leucocytes and other products of inflammation. In coagulating it forms a reticulum, the meshes of which are occupied by the leucocytes. Microscopic examination not only reveals these elements, but also other matters, such as epithelial cells, granular matter, and, not infrequently, minute organisms. These are all found entangled in the meshes of the fibrinous network. The cells, germs and debris are most abundant on the surface, where they form a fused mass or encrustation, while the fibrinous material abounds most in the deeper parts. The formation of the false membrane seems to depend entirely on the coagulation of the fibrine, which entangles and holds the other elements, as there is no essential difference between the exudate of croupous and other forms of inflammation. The old theory that it depended on an excess of fibrine, has been abundantly disproved. Recent investigations make it highly probable that *the coagulation of the fibrine is caused by the exudate coming in contact with dead epithelium*, just as dead endothelium will produce coagulation of the blood within the blood-vessels. The death of the epithelium may depend on the violence of the inflammation, or be occasioned by the same injury that gave rise to the inflammation. Until the inflammation abates, the artificial removal of the false membrane is followed by its immediate reproduction, but with the abatement of the inflammation it is cast off and the surface again becomes clothed with epithelium.

Causes. Croupous inflammation may result from any irritation, provided it be of sufficient intensity to produce destruction of the epithelium, or to evoke an inflammation resulting in the same. In experiments on the lower animals, it has been found to follow the application of acids and other corroding agents to the air passages, and in children, quite commonly follows the drinking of very hot water, concentrated lye, etc; mistakes to which they are prone. The

most common cause, however, is of an infectious nature, which not only gives rise to the disease, but also imparts to the false membrane infectious properties. Croup and diphtheria originate in this way, and their false membranes are infectious. The presence of minute organisms—the so-called micrococci—in the false membrane of these diseases, has led to the belief that they are the infecting agents. It does not necessarily follow that they are such, for their presence may be merely accidental, or it may be, that the conditions are such as to afford a congenial nidus for their lodgment and development.

CHAPTER XXVII.

DISEASES OF LYMPHATIC STRUCTURES.

Inflammation of Lymphatic Structures—Adenitis.

Inflammation of the lymphatic glands, and of the adenoid structures in general, are due, as a rule, to the irritation of matters conveyed to them by lymphatics. Examples are found in the inflammation of the axillary glands following injuries of the hand, of the inguinal glands in gonorrhœa, and of the intestinal glands in typhoid fever. The inflammation may be *acute* or *chronic*, *simple* or *specific*.

Acute Adenitis. Acute inflammation of the lymph glands is attended by hyperæmia, and a very abundant increase in the lymphoid elements, these—the lymph corpuscles—which occupy the meshes of the reticulum, become augmented in number, and many of them increase in size. These latter are multinucleated, and frequently attain such dimensions as to entitle them to the appellation of giant cells. Giant cells are quite common, and almost characteristic of the formative processes of adenoid tissue, as evidenced in these cases, and in the formation of tubercles, etc. These new formed elements are derived in part from the proliferation of the lymph cells, and in part from migrated corpuscles. The trabeculæ also participate in the inflammatory action. As the result of these changes, the gland becomes enlarged, soft and pulpy, and quite uniform throughout, so that it is no longer possible to distinguish the cortical from the medullary portions. The terminations are in resolution or suppuration. If in resolution, the inflammatory process subsides, the new formed elements disintegrate, and are absorbed, and the gland returns to its normal condition. If suppuration ensue, the cellular infiltra-

tion becomes purulent, the trabeculæ are broken down, and purulent depots form here and there, which, by fusing, may involve the entire gland. The surrounding connective tissue participates in the inflammatory action, and may even suppurate in advance of the lymphatic structure.

Chronic Adenitis. The chronic form of adenitis is marked by less intensity and a longer continuance, whereby the cellular elements of new formation are utilized in building up the stroma of the gland. Hence the fibrous reticulum becomes developed at the expense of the lymphoid elements. When cut into, the gland presents a hard, fibrous structure; the reticulating fibres are much thicker, the meshes much smaller, and the lymph cells much less numerous, than natural.

Adenitis of Scrofula. In the scrofulous inflammation of lymph glands, the infiltration presents the ordinary character of scrofulous inflammation in general; the cells are enlarged, many of them multinucleated, there is little or no tendency to resolution, and the blood supply is much interfered with by the density and pressure of the infiltrate. As a consequence, the latter tends to become caseous. The caseous products may liquefy, or become infiltrated with calcareous matter. The gland is enlarged, soft and elastic in the earlier stage, fluctuating in the stage of liquefaction, and more or less hard and shrunken in the stage of calcareous change. *Tuberculous* inflammation of the lymph glands presents about the same characters as the above.

Adenitis of Typhoid Fever. The absorption of the specific poison of typhoid fever gives rise to a specific inflammation of the lymphatic structures of the intestinal canal, and of the mesenteric glands, the spleen, and more rarely of the lymph glands of other and more remote parts of the body. In the intestinal canal, it is the patches of Peyer that suffer most and most frequently, though the solitary follicles may also be

involved. The process is often limited to the patches in the vicinity of the ileo-cæcal valve, where it is always most intense. The early changes are analogous to those of acute adenitis, in consequence of which the gland becomes swollen, soft, and projects, cushion-like, above the general surface. The mucous membrane in the vicinity of the glands is intensely red, and in a condition of catarrhal inflammation, so that the cushion-like elevation of these latter, and their brain-like color and consistence, make them very conspicuous. The cellular infiltration is not confined to the patches, but invades the surrounding structures; mucous, submucous and muscular.

Terminations. The terminations of this form of adenitis are in resolution or a necrosis of the gland substance. If in resolution, the inflammatory products disintegrate and are absorbed, leaving the gland as before.

The more characteristic termination for typhoid adenitis is in the death and sloughing of the gland structure. This may take place little by little, from several distinct points, or the entire gland may die and be cast off *en masse*. The resulting excavation after the casting off of the slough is known as the *typhoid ulcer*, and presents some marks of peculiarity. In its situation and configuration it corresponds to the original gland, being oval in form, with its long diameter running lengthwise the bowel, and situated opposite the mesenteric attachment. This will serve to distinguish it from the tuberculous ulcer, which extends circularly around the bowel. With the separation of the slough there is a general abatement of the inflammatory process in the environs of the ulcer, which presents as a clean, sharply-cut cavity, with overhanging edges, where the mucous membrane partially covered the gland. In rare instances the sloughing extends beyond the gland into the other tissues, and may even involve the subjacent layers, leading, in the end, to perforation of the

bowel. More commonly, however, perforation is due to a secondary ulceration, established in the bottom of the original ulcer, after the separation of the slough. Profuse hemorrhages are liable to attend the secondary ulcerative process. Perforation of the bowel is the most dreaded accident of typhoid fever, as it almost invariably ends fatally, through the ensuing peritonitis. In the more favorable cases and commonly, the ulcer becomes filled with a granulation tissue, which subsequently fibrillates and becomes covered with epithelium. The scar, which is slightly depressed below the surface and paler than the surroundings, contains no trace of gland substance, is not covered with villi, and only serves to fill a gap in the tissues. It does not contract, as does the ordinary cicatricial tissue, and, consequently, does not tend to constrict the bowel.

CHAPTER XXVIII.

DISEASES OF THE BRAIN AND SPINAL CORD.

Softening of the Brain.

Softening of the brain is essentially a fatty degeneration of the cerebral tissue, the result of faulty nutrition. It presents in three varieties, the *red*, *white* and *yellow*, and is of every degree of intensity, from a consistency almost natural to that of perfect diffluence. The area of softening is seldom sharply defined, but shades off imperceptibly into healthy parts.

A stream of water projected against the brain will serve to distinguish the healthy from the diseased parts; the former being unaffected, and the latter breaking down under it. Examined under the microscope, degenerative changes proportionate to the degree of softening are revealed. The white matter of the brain first coagulates, then breaks up into irregular masses of double contour—the myeloid forms—and eventually melts away. The cells of the gray matter likewise take on fatty metamorphosis, as do also the connective tissue cells, and the leucocytes of the involved tract. Later on, all the structures disintegrate and fall into a heterogeneous, pultaceous, or diffluent mass, in which broken-down fibres, granular matter and molecular fat, are all that is recognizable. Conspicuous in the midst of these are usually to be found large numbers of *granular corpuscles*. These, the ghosts of former cells, are aggregations of granular matter, for the most part fatty, the particles of which still cohere, and in many instances preserve the semblance of cell forms. Like corpuscles are not infrequently found in the blood vessel of the part, and are believed by Cohnheim to consist of leucocytes gorged, or impregnated with granular matter derived

from the surroundings. Whatever their nature, they are highly characteristic of brain softening, and unerring indications of degeneration.

Causes. These are chiefly such as arise from circulatory disturbance, as from atheromatous vessels, embolism, thrombosis and the stasis of inflammation.

White Softening. This variety, so called because of the natural, or dirty, opaque white appearance, is generally of slow formation, and therefore chronic in its nature. It is due mainly to the slowly progressive changes in the smaller cerebral vessels incident to old age, whereby the circulation becomes gradually impeded, and finally almost abolished. Regions of the brain thus become starved out. The result is, degeneration, death and disintegration; and as the parts affected are almost bloodless, there is a corresponding absence of color. The progress of such cases is slow and insidious. Exceptionally, white softening occurs as an acute affection, as when, by occlusion of one of the larger cerebral vessels by embolism, the blood becomes suddenly shut off from a certain territory; here, owing to the absence of collateral circulation a total ischæmia prevails, and a colorless necrosis results.

Red Softening. This is distinguished by the deep red color of the necrosed part. Red softening occurs oftenest from the occlusion of some of the smaller cerebral vessels. These become gorged, from absence of *vis a tergo*, and gradual infiltration from collateral branches, leading in the end to rupture and extravasation of blood. The rupture of diseased vessels in the midst of white softening depots may likewise impart the characters of red-softening to the parts in which the effusion takes place. In this way, areas of red and white softening are sometimes seen lying side by side. Cerebral inflammation, resulting in the death of the part, often gives rise to red softening, from the presence of pent-up blood. In all these cases the red color is caused by the imbuing of

the tissues and their debris in the coloring matter of the blood. Red softening is, for the most part, an acute affection.

Yellow Softening. This is a condition intermediate between that of red and white softening. It contains less of the blood pigment than the former, and more than the latter. The color is of a dead, yellowish white, with considerable

FIG. 33.

YELLOW SOFTENING OF THE WHITE SUBSTANCE OF THE BRAIN.

A. Border of the depot of softening, *B*, and of the brain-substance, *C*, not yet softened. *D.* A fatty degenerated vessel.

variableness as to the depth of the tint. Indeed, there is no definite boundary line between the red, white and yellow, as they gradually and insensibly merge into each other. It is sometimes due to punctiform hemorrhages from capillary blood-vessels, sometimes to the fading of a red softening by gradual absorption of the coloring matter, and sometimes—probably most frequently—to an increased depth of tint, occasioned by a close aggregation of very minute granular particles. The yellow, gelatinous, and œdematous environs

of a cerebral tumor are sometimes spoken of as, and frequently mistaken for, yellow softening. Yellow softening is generally of slow formation.

Thrombosis and Embolism of the Brain.

The chief peculiarities of thrombosis and embolism of the brain are the characters impressed upon the degenerative changes resulting therefrom. These have been more fully described under the head of "Softening of the Brain," of which they are the most fruitful cause. The form of softening, whether red or white, will depend upon the presence or absence of blood in the part at the time of the necrosis, or upon the subsequent fading of the same. Blood is apt to be present in cases of sudden occlusion of some of the smaller cerebral vessels, when, from the absence of *vis a tergo*, it remains. It also gradually accumulates by seepage, or back-water action, from side branches. The over-distention of the vessels, together with the weakened condition of their walls from disturbed nutrition, is apt to result in their rupture and extravasation of blood. These afford instances of red softening. When, however, the circulation is more slowly diverted from a region, as in the case of a gradually forming thrombosis, or an incomplete embolus, the parts are bloodless, and white softening ensues. White softening also occurs from the sudden occlusion of a large cerebral vessel. This will be understood when it is remembered that the brain is divided into several distinct vascular territories, each of which is supplied by an arterial trunk, and which have, practically, no vascular inter-communication, one with another. If one of these trunk vessels be occluded, the entire territory to which it is distributed is robbed of its blood supply, and there is no collateral seepage, because of the absence of anastomosing vessels. An obstruction of any one of the vessels contributing to the formation of the circle of Willis, is

not usually followed by destructive changes in the brain, for the reason that all parts are supplied through this abundant anastomosis.

Causes. The proximate causes of cerebral thrombosis are found, for the most part, in the roughened interior and unyielding walls of the cerebral vessels, occasioned by atheromatous and calcareous degeneration and the syphilitic taint. While it is possible for an embolus to be wafted into any of the cerebral vessels, yet, in the majority of cases, it takes the most direct and least tortuous route, and lodges in some one of the branches of the middle meningeal artery of the left side.

Inflammation of the Brain and Spinal Cord.

Inflammation of the brain and spinal cord is seldom or never diffuse and general, but, on the other hand, distinctly localized. Hence, we usually find an inflammation affecting the central nervous system limited to certain districts, tracts or patches. Of these there may be one or many. The inflammatory process begins in a hyperæmia, more or less intense, and distinctly localized. This is followed by exudation and infiltration of the affected region with young cells. Blood is frequently extravasated into the same, by the rupture of the over distended vessels. The color of the affected portion is usually a deep red, but at times it is mottled ; but, in course of time, it shades off into a brownish or brownish-yellow ; as the hæmoglobin takes on the ordinary changes, the consistence is altered, the tissues becoming soft and friable. The microscope reveals, besides the ordinary products of inflammation, extensive changes in the nerve fibres, the nerve cells and the cells of the neuroglia. These changes partake of the nature of fatty degeneration, and result in the formation of granular corpuscles. The color, consistence and general integrity of the inflamed part will vary according to the

intensity and stage of the inflammatory process. In the worst forms, complete disorganization and diffluent disintegration ensue. This constitutes one of the forms of softening of the brain, and is generally, on account of the color, classified with the red variety. But red softening, as we know, originates much more frequently because of occlusion of the cerebral vessels by embolism, etc., than because of inflammation. Hence, those who look upon every case of red softening as evidence of preëxisting inflammation think they encounter many more cases of cerebral inflammation than really exist.

Causes. The principal causes of inflammation of the nervous centres are such as come from external violence, wounds, contusions, etc. To these may be added depressed plates and spicules of bone, blood clots, the result of hemorrhage, and, more rarely, the poison of septicæmia.

Abscess of the Brain. When the inflammatory process is characterized by a very dense infiltration of the tissues, an abscess is likely to form. The contents of the abscess are of a reddish, yellowish or greenish color, and present the dual character of pus intermingled with the products of red softening. In this, as in all other phases of inflammation of the nervous tissue, the corpuscular elements are emigrants, as neither the neurogliæ or nerve cells are known to proliferate. By continuous infiltration of its walls, the abscess may extend until it opens into one of the natural cavities of the brain. At times, however, a limiting membrane is thrown out by the neuroglia, and the abscess becomes encapsuled. It is not uncommon to find the abscess traversed by a delicate network, the remains of the neurogliar framework. The encapsuled matter, from absorption of its fluid parts, usually undergoes caseation or calcification. Under very favorable circumstances it may be entirely removed by absorption after a preliminary liquefaction. In the latter case, a small linear or

stellate scar is all that remains to mark the site. Abscesses seldom occur in the spinal cord.

Sclerosis of the Brain and Spinal Cord. As the term indicates, this is a disease of the nervous centres, characterized by an increased hardness or density of the affected parts. This increased hardness depends on an overgrowth of the neurogliæ or connective tissue elements, with a corresponding atrophy and degeneration of the proper nervous elements, such as the nerve fibres and nerve cells. In this respect it resembles the cirrhosis of the liver and other organs. Owing to a peculiar grayish and translucent appearance of the affected parts, it sometimes goes by the name of *gray degeneration.* The gray aspect is due to the absence of the medullary or white substance, which is the first to disappear. The microscope shows a marked increase in the interstitial elements, and absence or sparsity of nerve cells ; fewer nerve fibres, and those for the most part denuded of their medullary investment. The individual nerve fibres are widely separated by the intervening interstitial material. This latter usually presents a granular, nucleated, or more or less fibrillated, appearance. The walls of the blood-vessels are also thickened, from increase of the connective tissue layers. The adventitious matter, which is at first soft and succulent, gradually acquires the firmness of mature connective tissue. This, by its presence and contraction, gradually destroys the more highly endowed and less hardy nerve elements. At times the interstitial matter fails to undergo these changes, and preserves its embryonic characters throughout. In such cases, instead of an increased hardness, the affected structures may exhibit an unnatural softness. The test for sclerosis of nervous tissues is the action of carmine coloring, which imparts a deep red to the affected parts. The value of this test lies in the fact that carmine will not affect the medullary matter of nervous tissue, while it readily and deeply stains connect-

ive tissue. The test is valuable, in that it enables us to determine a sclerosis of the brain or cord with reasonable certainty, in the absence, or independently of, microscopic investigation. Sclerosis for the most part occurs in small patches, which may or may not be disseminated. Occasionally it extends along certain tracts. Examples of the latter are found in the sclerosis of the posterior columns of the cord, as it occurs in locomotor ataxy, and of the anterior horns of gray matter, as it occurs in progressive muscular paralysis. Sclerosis of the nervous centres never occurs in the form of a continuous, uninterrupted extension, but always in patches, which, however, may, interruptedly, extend along tracts or cover broad areas. In the brain it is confined to the white matter; in the cord it involves both gray and white matter. It, also, is occasionally found in the nerves and nerve trunks.

Causes. Sclerosis is a disease of young adult life, being rarely encountered before the age of ten, or after forty-five. Heredity seems to be the most potent factor in its production. Exposure, privation, mental distress and the state of convalescence are the conditions under which it is most apt to declare. As to its nature, it is generally conceded to be of inflammatory origin, the connective tissue growth being the result of chronic inflammatory action.

Tuberculosis of the Brain and Meninges.

Tuberculosis occurs both in the substance of and in the meninges of the brain.

Tuberculosis of the Brain. Tuberculosis of the brain occurs, for the most part, in large, isolated, and globular masses. These masses are of a pale yellow color, of a firm consistence, and, as usually found post-mortem, of a size ranging from that of a cherry to that of a hen's egg, or even larger. Their *habitat* is in the cerebral substance, at the base of the brain. They are few in number, seldom exceeding

one or two. Their surface is studded with numberless small gray tubercles, some of which are occasionally found interspersing their interior. They are also to be found in considerable abundance in the otherwise healthy environments of the tumors. In structure, the more superficial parts present the adenoid character, the coronal network and the giant cells, characteristic of tubercular organization. The remainder of the mass is caseous. In some cases the periphery of the tumor is seen to be made up of an aggregation of nodules, each of which surrounds an arterial sprig. It is probable that this is the method by which all such masses are formed, *i. e.* by an aggregation and fusion of a number of miliary nodules, which envelop the arterioles, as in other situations.

Tuberculosis of the Meninges. Tuberculosis of the pia mater is much more common than that of the brain substance. It is almost invariably present in cases of general tuberculosis. As it is usually attended by inflammation of the meninges, it is generally spoken of as *tubercular meningitis*, and as it occurs almost exclusively in the membranes of the base of the brain, as *basilar meningitis*. The tubercles originate in a proliferation of the cells of the lymphatic sheaths, which enclose the smaller arteries of the pia mater. These little growths spring up from numerous points, and by continued accretion form the characteristic, pale, gray, translucent, miliary tubercle. The tubercle, by extending inward, compresses and occludes the vessel, and by extending outward, produces a globular or elongated bulging of the peri-vascular lymphatic sheath,

FIG. 34.

TUBERCULOUS NODULES.

These nodules are to be found at the base of the brain—in the pia mater, which dips down between the convolutions, and especially in the Sylvian fissure. Occasionally they are found sparsely scattered over the vertex and in other situations. Because of their pale color and translucency they are apt to be overlooked. The disturbance of circulation occasioned by the occlusion of the embraced vessels results in an intense hyperæmia in the collateral vessels, which gives rise to transudations and occasional hemorrhages. These latter, together with the irritation of the tubercles themselves, provoke a meningeal inflammation, or basic meningitis. The hyperæmia extends to the choroid plexus and the lining of the ventricles. These latter become distended by a serous transudation, which, by its pressure, flattens the convolutions. It is because of these serous accumulations within the ventricles, that the disease is often spoken of as *acute hydrocephalus*. As the result of these processes, the pia mater at the base of the brain is sodden, opaque, and infiltrated with exudates or purulent matter. The arachnoid is dry and adhesive, the brain substance softened and partially disorganized beneath the pia mater at the base, in the walls of the ventricles, and also in the fornix and soft commissure. Tuberculosis of the brain and meninges is a disease of childhood.

CHAPTER XXIX.

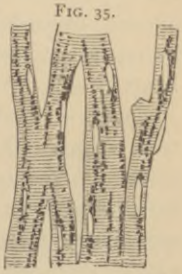
DISEASES OF THE HEART.

Atrophy of the Heart.

The heart, owing to its incessant activity, requires an uninterrupted and unstinted supply of nutritive material for its sustenance. Hence, any lack of nutrition, whether general in its scope, or affecting only the heart muscle itself, is evinced by speedy retrograde changes in the latter. Atrophy of the heart is manifested by an increased thinness, flabbiness and absence of turgor of its walls. The individual fibres are attenuated and weak. The size of the heart is not always diminished, but the weight always. Atrophy of the heart from general marasmus affects the heart *in toto*. Local atrophies affecting certain layers, or certain areas, arise from local causes, such as impediments to the circulation in certain vessels, etc.

Brown Atrophy. This form of atrophy is distinguished by a rusty brown pigmentation of the heart structure. The pigment itself is yellow, and occupies the contractile substance or forms granular rows *between* the primitive fibrillæ. The origin of the pigment is not definitely known. Brown atrophy affects the entire heart, which is also reduced in size. It is oftenest found in the marasmus of old age, in that of inanition, and in the cancerous and tuberlous cachexias. The heart is enfeebled and often irritable.

FIG. 35.



BROWN ATROPHY.

Fatty Degenerations of the Heart.

Fatty metamorphosis affects the heart muscle in whole or in part. When diffuse and general the fibres become pale and fragile, from gradual conversion into fat. As the disease progresses the transverse markings of the fibres are obliterated, molecules or globules appear here and there in their substance, and eventually entire fibres and bundles of fibres undergo the fatty change. According to the degree of degeneration, are the color, consistence and function affected. First there is an increasing paleness, shading into yellow, then, as the fat becomes more abundant, its peculiar whiteness and opacity become more and more manifest, until the last traces of a flesh color are obliterated.

The consistence gradually diminishes, as shown by an increased tenderness and brittleness of the heart structure, until, in the latter stages, it becomes almost rotten, and breaks down under the finger with a granular, unctuous feel. Fatty fibres become more and more feeble as the degeneration advances, ultimately losing their contractility altogether, and by their presence in the midst of contracting fibres, mechanically derange the action of the latter. The heart's action becomes proportionately weakened, at times almost suspended, giving rise to alarming syncopes, and is liable to cease altogether. Diffuse fatty degeneration of the heart results from those general disturbances of nutrition, of an acute character, in which a depraved blood is associated with a high and continued body heat, as in the acute febrile diseases; typhus, typhoid, the exanthemata, etc. The worst degree of fatty degeneration is seldom found in this, the general form; because, owing to the extent and evenness of the degeneration, if recovery does not ensue, death by paralysis of the enfeebled organ anticipates the more advanced changes.

Partial Degeneration. These occur, either as a diffuse

affection of the superficial layers underlying the pericardium; as a punctated or shot-like affection of the innermost layers underlying the endocardium; or, in a nodular form, affecting, for the most part, the centre of the left ventricle, towards the apex. The first is the result of pericarditis, the second of dilatation of the heart chambers with concomitant atrophy of the blood vessels, and the third of atheromatous changes and thrombotic occlusion of the branches of the coronary artery. In all these instances a disturbed nutrition of a local character lies at the bottom of the local changes. The third, or last form named is, by all odds, the most dangerous. It occurs in the old, the broken-down and the cachectic. The tender, friable and passive degenerated portion is, little by little, torn asunder by the vigorous contractions of the balance of the heart muscle, until eventually the last filaments yield, and the patient dies of a ruptured heart. It will be seen that the mode of death in diffuse fatty degeneration is by paralysis of the heart; in the nodular form, by rupture.

Fatty Infiltration. This is very different from fatty metamorphosis. Infiltration consists in the deposit of fatty matter *between* the fibres of the heart; metamorphosis of a transformation of the fibres *themselves* into fat. The one operates to impair function, in a purely mechanical manner; the other, by loss of vitality in the functioning part. A fatty infiltrated heart is more conspicuously fatty than a fatty metamorphosed heart. Not only is the fat infiltrated between the histological elements, sometimes to such an extent as to entirely hide them from view, but it also envelops the exterior of the organ, so as sometimes to leave only a small portion of each ventricle visible. Hence, it is generally known as the *fatty heart.* Fatty infiltration of the heart is found in people prone to fatty deposits elsewhere, and is, consequently, an expression of the obese tendency. While not so baneful as the fatty metamorphosis, it is, nevertheless, not devoid of

evil, and may even lead to fatal results. It may always be differentiated from fatty metamorphosis by observing that the histological elements, though hidden, are still present, and of their proper consistence, color and strength. The normal deposit of fat in the natural grooves of the heart, is the starting point for fatty infiltration.

Inflammation of the Heart--Myocarditis.

Myocarditis, or inflammation of the heart substance, may present in several different forms: (1) As a more or less extensive, but superficial, inflammation of the muscular structure, immediately beneath the peri- or endocardium; (2) as a diffuse and general inflammation of the heart structure, and (3) as an indurative, and also a purulent, inflammation. The first is the result of extension from the inflamed peri- or endocardium. When from the pericardium, it may affect any portion of the heart's surface, but when consecutive to endocarditis, it is confined to the walls of the heart cavities on the left side, for the reason that endocarditis almost never occurs on the right side. The more general form is sometimes found as a concomitant of acute rheumatism. It is comparatively rare, but probably more common than is generally supposed. The signs of cardiac inflammation consist, first, in an infiltration of the inter-muscular tissue with young cells, followed, sooner or later, by a softening and friability of the muscular tissue. Examined microscopically, the muscular fibres are seen to have lost their striations, to have become granular, and to evince signs, more or less pronounced, of fatty degeneration. All this denotes a disturbance of nutrition, and is commensurate with the intensity of the inflammatory process.

Fibroid Induration. When the inflammation is of a mild, persistent type, a fibroid tissue is developed from the infiltrating cells, which, as they are located in the intermuscular

septa, results in an overgrowth and increased density of the same. The muscular fibres disappear, from atrophy and fatty degeneration, in proportion as they are encroached upon by the interstitial growth. This constitutes the fibroid induration of the heart. It usually occurs in the more superficial variety, as succeeding to a peri- or endocarditis; is most developed near the inflamed membrane; is unequally diffused; shows various stages of advancement in the same specimen, but ultimately leads to a dense fibroid growth, of almost tendinous hardness, and which seriously interferes with the normal movements of the heart. A fibroid induration of syphilitic origin, presenting essentially the same characters as the above, sometimes affects the heart.

Suppurative Myocarditis. This, otherwise known as *abscess* of the heart, is a very rare affection, and probably only occurs in connection with pyæmia. The pus accumulates in depots of varying number and size, and produces atrophic changes in the muscular fibres.

Inflammation of the Pericardium—Pericarditis.

There are three principal varieties of inflammation of the pericardium: the *fibrinous*, *hemorrhagic* and *purulent*.

Fibrinous Pericarditis. This is similar in all respects to other serous inflammations. The inflammation, as a rule, involves the entire surface of the pericardium, but occasionally is limited to the vicinity of the great vessels at the base of the heart. The exudate covers both the parietal and visceral layers of the pericardium, and *is invariably studded with vast numbers of papillary-like eminences.* These latter vary considerably as to size and form, and are occasioned by the alternate contact and separation of the smeared opposing surfaces incident to the heart's action. They have no vascular connection with the pericardium, are therefore not true papillæ, but exudates, which upon separation, expose a smooth,

epithelial-clad, surface. Fibrinous pericarditis occurs in acute articular rheumatism, pneumonia, Bright's disease, and in several of the exanthematous fevers.

Hemorrhagic Pericarditis. This differs from the preceding, in the fact that the vascular loops of new formation penetrate into the exudate. These vessels have very tender walls, in consequence of which extravasations of blood are common, resulting in a red coloration of the exudate. This form occurs in tuberculosis, pulmonary cancer, etc.

Purulent Pericarditis. This is characterized by a purulent accumulation in the pericardial sac, and infiltrating the pseudo-membrane on its surface. It is distinguished by the creamy aspect of the fluids, and a cloudy opacity of the false membrane. It is much less frequent than the other varieties, and depends generally upon a vitiated constitution. By absorption of the more fluid parts a caseation and calcareous transformation may ensue. A few of the more prominent results of pericarditis are :—

1. *Adhesions.* These are seldom universal, and sometimes consist of a close approximation and agglutination of opposing surfaces, sometimes of bridles or bands. They are formed in the same manner as pleuritic adhesions, but are by no means so common.

2. *Prominent Patches.* These, consisting of laminated connective tissues, the result of organization, are sometimes found on the visceral layer. They may become infiltrated with calcareous matter and form—

3. *Calcareous Plates.* These are usually covered on the free surface with a layer of fibrous tissue, but frequently project deeply into the heart muscle.

Inflammation of the Endocardium : Endocarditis.

Endocarditis, or inflammation of the endocardium, is much more frequent than myocarditis. It occurs in acute

rheumatism, in the septic and eruptive fevers, etc. It is confined almost exclusively to the left side of the heart, and to the valves and their vicinity, where it is most marked. Exceptionally, it is found implicating the endocardium at some distance from the valves. The endocardium being a non-vascular structure, and in other respects closely analogous to the structure of the intima of the blood vessels, the inflammatory processes are very like those of the latter, and will be described more fully in the next succeeding pages. These consist in a cellular infiltration and softening of the intercellular substance beneath the endothelium, with subsequent changes, either of a destructive or constructive character. The cellular infiltration and softening are proportionate to the intensity of the inflammation. It is seldom that the surface of the endocardium gives evidence of hyperæmia, although the deeper layers, which are slightly vascular, may do so. The blotched and stained appearance of the endocardium, so frequently witnessed in the septic fevers, is the result of imbibition of the coloring matter from the depraved and disorganized blood. True hyperæmia is distinguished by its arborescent appearance. The valves usually affected are the mitral and the aortic. These are swollen, softened, and less resisting than natural. One surface of the valve—that over which the blood flows—is roughened and studded with granular or bead-like elevations. These have an irregular, somewhat linear arrangement, parallel to and at some little distance from, the free edge of the valve. Similar elevations are sometimes found in the vicinity of the valve. They are all due to a luxuriant growth of the cells beneath the endothelium—the cells being piled up in little heaps. The endothelium probably contributes to their formation. They are frequently covered to a greater or less depth by the fibrin of the blood, which is deposited as it passes over them. They were formerly supposed to consist entirely of fibrinous

deposit, but the microscope has revealed their true nature. These little bodies are very soft and friable in acute endocarditis, but more firm in the subacute and chronic varieties, from being organized. In the latter case they exhibit a fibrillated structure of considerable density, but being lowly organized, are prone to retrograde changes. Owing to the softened condition of the valves in the more intense forms, they are sometimes ruptured by the recoil of blood against them. When not quite so friable, the valve may yield to the pressure of the blood and become pouched or dilated. This constitutes *aneurism* of the valves. The valve yields from the side presented to the blood when closed, or from that side which receives the shock in opposing the reflux of the circulating fluid. Sometimes, though rarely, the softened tissues disintegrate, producing what is called *ulcerative* endocarditis. In this way the valve may suffer more or less loss of substance, or even become perforated. The disintegrated matter being swept into the blood current, may find lodgment in some of the finer vessels and produce embolism, or, if septic in character, septicæmia. Ulcerative endocarditis is, consequently, a serious trouble. The walls of the ulcer are swollen and irregular. Pus is not ordinarily one of the constituents of the ulcerative products, but sometimes exists in small quantities in the deeper structures. In the less intense grades—subacute or chronic endocarditis—the cell production is less rapid, and organization keeps pace with it. In this way the valves become *thickened*, *rigid*, *shortened*, and otherwise distorted, from the deposit and ensuing shrinkage. In like manner, the bead-like elevations on the surface of the valves, by a continual growth and organization, may form larger *papillary excrescences*. So, also, the surface of the valves, on account of the

Fig. 36.

AORTIC STENOSIS.

plastic material which covers them, may become *adherent* to the walls of the heart, or to each other, which adhesion becomes permanent by the organization and fibrillation of the exudate. All these new-formed structures, being of low organization, are prone to fatty degeneration and to *calcareous infiltration.* In the latter event, a bone-like rigidity is sometimes imparted to the valves.

CHAPTER XXX.

DISEASES OF THE BLOOD VESSELS.

Inflammation of Blood Vessels.

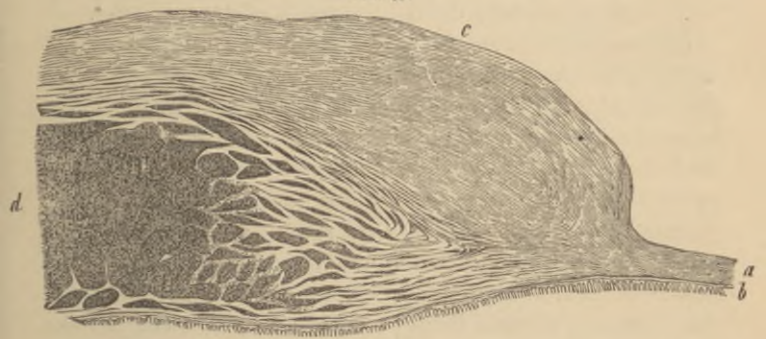
On account of the absence of blood vessels in the internal coat of the arteries and veins, the primary changes of inflammation are confined to the middle and external coats. These changes consist of hyperæmia and cellular infiltration, with more or less intumescence of the vessel walls. If the inflammation be intense and the infiltration great, the outer tunics of the vessel become thickened, soft and friable, the vascular tonicity is impaired, and there results dilatation, and not infrequently, aneurism or rupture. The inner coat being dependent on the more external coats for its nutrition, suffers in proportion to the infiltration and consequent interference with the circulation in the latter. In consequence, its nutrition becomes impaired, sometimes arrested; and then it becomes necrotic. In the latter event the blood coagulates in the vessels, and a thrombus forms.

Causes. The causes of vascular inflammation are principally external violence, the formation of coagula within the vessels, extension from contiguous inflamed structures, and septic matter circulating in the blood.

Atheroma. This is a diseased condition of the arteries, the result of a long-continued low grade of inflammation. The term is used in no very definite sense, but rather indicates a variety of structural changes, resulting from chronic inflammation of the arterial walls. These changes are most marked in the more external layers of the *internal coat* of the arteries. The first step in the process is the infiltration of these layers with inflammatory products, consisting, for the

most part, of small, round cells. These, by their accumulation, produce a bulging inwards of the innermost layer of the intima. These layers yet, for a while, preserve their integrity, and can be stripped off, exposing the diseased tissue beneath. This integrity of the innermost layers of the intima, together with the underlying tumefaction, is highly characteristic of atheroma, and will serve to distinguish it from fatty degeneration of the endothelial and subjacent connective tissue structures. In this latter, the change begins at the interior and extends outwardly, and there is

FIG. 37.



ARTERIAL ATHEROMA.

b. Boundary of media and intima. *a*. Intima. At *c*, the same thickened and hyperplastic; at *d*, broken down to an atheromatous abscess.

no inflammatory deposit beneath the endothelium. The next step in the atheromatous changes consists in a fatty degeneration of the infiltrating cells, and a softening of the intercellular substance. This forms what is called the *atheromatous abscess*, the contents of which are pultaceous, or more fluid in consistence, and of a yellowish hue. When the lining membrane gives way, as it sometimes does, the contents are swept away in the blood current, and an *atheromatous ulcer* results. If, however, the lining membranes persist, the more

liquid contents of the atheromatous abscess may become absorbed, when the microscope will reveal a motley mixture of broken-down elements, molecular and caseous fat, and a varying number of cholesterine crystals. By a still further change this may calcify, forming a *calcareous plate.* Calcareous plates on the interior of arteries are quite common in atheromatous subjects.

When the inflammatory process is very chronic and of moderate intensity, an attempt at organization may result in a *fibroid thickening* of the intima. The organization is, however, seldom complete, the fibrillation being interspersed with more or less fatty debris, the result of degeneration.

Causes. It is probable that any of the causes of arterial inflammation may operate to produce atheroma. Straining of the arterial walls, from continued or oft-repeated exaltation of blood-pressure, is presumably the most fruitful cause. As evidence of the same, atheroma is found to prevail under such *conditions* as are attended by an inordinate increase of blood-pressure, and in such *situations* as receive the brunt of pressure. Thus, it is found that athletes, and others who practice muscular feats, are specially subject to atheroma, as also are the victims of chronic Bright's disease, where, owing to the thickening of the walls of the arterioles, the blood-pressure is greatly augmented. Then again, as to situation, it is very common at the arch of the aorta, and in cases of mitral obstruction in the pulmonary arteries; both of which have a direct relation to the blood-pressure. Syphilis has long been recognized as a cause of atheroma.

CHAPTER XXXI.

DISEASES OF THE LUNGS.

Inflammation of the parenchyma of the lungs is called pneumonia. There are two principal varieties of pneumonia —*croupous* and *catarrhal*. Some writers add a third variety, the interstitial. This latter will receive attention under the head of fibroid phthisis.

Croupous Pneumonia.

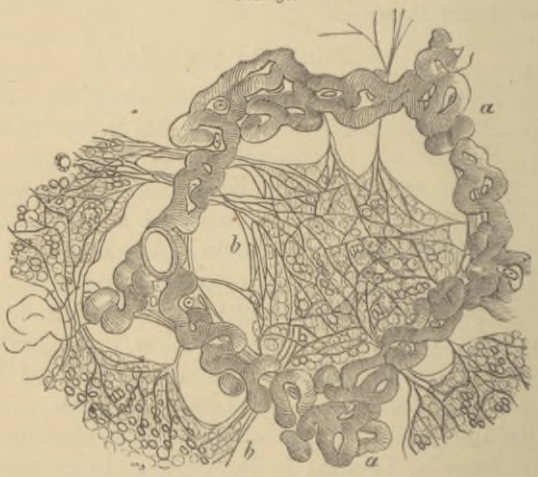
This is the common form of pneumonia to which adults are subject. It is so called because of the real or fancied analogy of the inflammatory process to that of croup. It is also known as *fibrinous* pneumonia, because of the fibrinous exudate; as *lobar* pneumonia, because of the large tract of lung tissue usually involved, there seldom being less than a lobe; as *pneumonitis*, and also by the common name of *lung fever*. Croupous pneumonia is now pretty generally conceded to be a constitutional disease; an essential fever, to which the lung inflammation bears the same relation as the inflamed Peyer's patches do to typhoid fever. The disease involves, by preference, the lower lobes of the lungs, is usually unilateral, and is about twice as frequent in the right as in the left lung. The inflammatory process, for convenience of description, is divided into three stages—the stage of *engorgement*, the stage of *red hepatization* and the stage of *gray hepatization*.

1. *Stage of Engorgement.* This corresponds to the first, or hyperæmic stage of inflammations elsewhere. That is to say, the volume of blood is enormously increased, the circulation is disturbed, and transudation, with more or less extravasation, takes place into the tissues or lung cells. The affected portion is of a dark red color, heavier, less elastic, and more

friable than natural, and pits on pressure. It is also less crepitant than natural, owing to the encroachment on the air cells by the disturbed capillaries. The cut surface yields a frothy, tenacious liquid.

2. *Stage of Red Hepatization.* In this stage the air cells become filled with a sero-plastic exudate, which soon coagulates. This exudate, in coagulating, assumes a finely reticulated appearance, in the meshes of which numerous white

FIG. 38.



RED HEPATIZATION.

a. Alveolar septa with injected capillary vessels. *b*. The exudation.

and a varying number of red corpuscles may be discerned. The white corpuscles are emigrants, there being up to this time no local proliferation. The red corpuscles, the product of ruptured capillaries, imbue the exudate, imparting to it a rusty color. The color of the lung is now of a dark, reddish-brown. It is larger and heavier than natural, and solid throughout. It is soft and friable, pits on pressure, cannot

be inflated, does not crepitate, and sinks in water. All this indicates a complete occlusion of the air cells, their spaces being taken up by the exudate. The cut or torn surface presents a solid and uniform reddish-brown color, or mottled appearance, and is distinctly and conspicuously granular. The granular aspect is occasioned by the partially extruded, somewhat spongy contents of the air cells, made still more prominent by the slight elastic pressure of the lung tissue. At this stage the resemblance to the liver tissue is very striking; hence the name, red hepatization. Neither the walls of the alveoli nor their epithelium suffer any marked changes. The pleural surface often bears the marks of the ribs, on account of the swollen and boggy state of the lung. It also participates in the inflammatory process, being hyperæmic, opaque, and coated with lymph.

3. *Stage of Gray Hepatization.* This is characterized by a marked change in the character of the exudate. This consists of a notable increase of the corpuscular elements and a corresponding diminution in the fibrinous. There is not only a rapid and continuous influx of emigrant corpuscles, but also a local proliferation. The epithelial cells of the alveolar walls, which up to this time displayed only a cloudy swelling, now take on active proliferation, and add their progeny to the swelling multitude of embryonic cells which now crowd the alveolar spaces. A rapid degeneration now ensues. The fibrinous reticulum has already been melting away, and now the cellular elements fall quickly into fatty degeneration, presenting every phase of that process, from the granular corpuscle to molecular fat. The lung now assumes an entirely different aspect. It is, if anything, larger, heavier, denser, than before. It is more pliable and less elastic, its cut surface less granular, and oozes a puriform liquid. But the most conspicuous change is in the color; instead of the reddish-brown of red hepatization, it is now gray, or yellowish-white. This

change in color is due in part to the extrusion of blood by the pressure of the exudate, and in part to the fatty degeneration of the latter. Whilst the epithelium of the alveolar walls suffers great change in this, the third stage, the walls themselves suffer but little. A slight infiltration, with here and there a wandering cell, is about all. In tracing the course of croupous pneumonia through its three stages, it must be borne in mind, that while one stage follows the other in the order named, they do not necessarily run their courses at different times. It is not unusual to observe in the same lung areas of red and gray hepatization lying side by side, or even a lung in which all three stages are represented; the process beginning in one part whilst declining in another.

FIG. 39.

CROUPOUS PNEUMONIA.

Terminations. The terminations of croupous pneumonia are in resolution, abscess, gangrene or chronic pneumonia.

Resolution. This is the common mode of termination. By the continued degeneration of the inflammatory products, they become liquefied and capable of being absorbed. A considerable part of them are also expectorated, and in their removal open the way for the restorative processes to follow. The alveolus being empty, the air again penetrates to the

cell, and the pressure of the exudate being removed, the blood returns to the capillaries. The epithelial cells are replaced, the sodden tissues yield up their infiltrates, and gradually everything returns to its normal state.

Abscess and Gangrene. In constitutions much debilitated by the abuse of alcohol or by bad hygienic surroundings, the squalor and misery incident to abject poverty or a depraved life, the natural termination of croupous pneumonia is sometimes thwarted, and there results a destructive lesion of the lung tissue proper. This may assume either the form of an abscess or of gangrene. The *abscesses* are usually single, never numerous, and are more common in the upper than the lower lobes. They discharge into a bronchial tube, or more rarely, externally, fill up by granulations, and eventually cicatrize. They sometimes become encapsulated and undergo a cheesy or calcareous change. The *gangrene* is usually limited in extent, and after the discharge of the necrotic debris, which is effected in the same manner as in the case of the abscess, it heals, likewise in the same manner. Cases terminating in abscess or gangrene often never reach the reparative stage—the patient succumbing to depraved constitution and the exhaustive processes engendered thereby.

Chronic Pneumonia. Occasionally the disease does not run the typical course portrayed above. The exudate does not undergo the retrograde changes necessary to its removal, or does so imperfectly. There is a deficient activity of the absorbents, vicious matters are engendered and remain to fret the already sorely-vexed tissues. As a consequence, the inflammatory process continues, but does not confine itself to the alveolus; it invades the connective tissue stroma of the alveolar walls, and the interlobular structures.

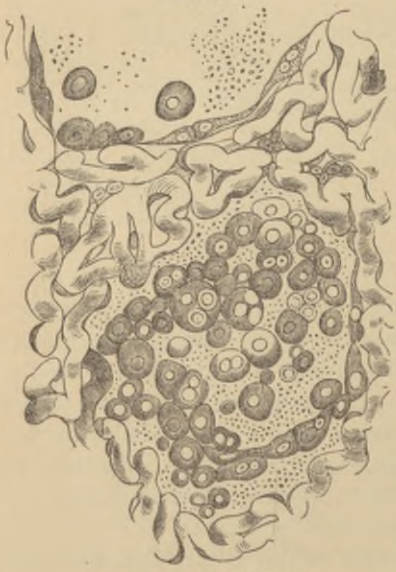
A slowly progressive growth of this tissue takes place, by which it encroaches upon the space allotted to the air cells, becomes indurated and assumes a fibrous character. This

constitutes the condition known as *chronic* or *interstitial* pneumonia. This termination is comparatively rare.

Catarrhal Pneumonia.

Catarrhal pneumonia is a catarrhal inflammation of the lungs. It is always associated with, and generally consecutive to, bronchitis. Other names have been applied to the disease, the most common of which are *broncho-pneumonia* and *lobular pneumonia*. The former indicates the intimate association of the bronchial and alveolar inflammation; the latter, the peculiar and scattered distribution of the inflamed patches and the tendency to involve individual and scattered lobules rather than lobes. The catarrhal nature of the affection is evidenced by the early and marked changes impressed upon the alveolar epithelium and the co-existing bronchitis. As in croupous pneumonia, the catarrhal form is characterized by consolidation of lung tissue, by the accumulation of inflammatory products within the air cells. In this case they are, however, mostly derived from the alveolar epithelium, whereas in that they consist, for the most part, of exudates and migrated corpuscles. Exudation and cell migration, nevertheless, take place in

FIG. 40.



CATARRHAL PNEUMONIA.

catarrhal, as well as croupous, pneumonia; but it is the usual preponderance of the local production that stamps the disease as catarrhal.

Causes. Catarrhal pneumonia is a disease of the extremes of life, affecting, by preference, the very young and the very old. In this respect it is complementary to croupous pneumonia, which prevails in the intervening period. The primal cause of catarrhal pneumonia is to be sought in that proneness to epithelial proliferation incident to youth and decrepitude, and to those imbued with the scrofulous and phthisical diathesis. This tendency is aggravated or engendered by certain diseases, as measles and whooping-cough, and by vital depression from other causes. The alveolar is almost invariably consecutive to the bronchial inflammation, and when not, may be regarded as having been provoked by the same cause that gave rise to the latter. As consecutive to bronchitis, it may arise either by direct extension or as a result of bronchial occlusion.

1. *By Direct Extension.* The propagation by direct extension needs no special comment. In this, the inflammation travels downward, along the mucous membrane of the bronchial tube, and, arriving at its terminus, passes over to the alveolar epithelium. The frequency or rarity of the process is a much disputed question, being by some regarded as the most, by others as the least, common of the modes by which alveolar inflammation is incited.

2. *From Bronchial Occlusion.* The finer bronchial tubes often become occluded, from the inflammatory tumefaction of their mucous membrane, and from their more or less abundant, thick, tenacious secretions. The evils resulting from impaction are manifold, the most important of which are collapse of the air cells, or their impaction with bronchial secretions, and more indirectly, inflammation and emphysema. The conformation of the bronchial tube being tapering,

the relations subsisting between it and the air cells are such as to permit of the escape of the residual air of the cells, even when so occluded as to prevent the entrance of inspired air. As the result, the air cells become exhausted, and either collapse, or, by a suction power, fill themselves with the bronchial secretions. Both these conditions, singly or combined, tend to provoke alveolar catarrh; the latter, by direct irritation, and the former, by disturbing the circulation. The pulmonary circulation is powerfully aided by the rhythmical expansion and contraction of the air cells in the respiratory act, and by the aeration of the blood, which occurs at the same time. In the collapsed area these factors are wanting, and there is superadded more or less distortion of the capillary network. The result is a blood stasis and congestion, quickly passing over into inflammation, with its attendant epithelial proliferation, œdema and cell migration.

Morbid Anatomy. The picture of catarrhal pneumonia is exceedingly diversified, in which are blended the features of collapse, of alveolar impaction, of emphysema, and of inflammatory foci. The *collapsed* portions are depressed, dark blue and non-crepitant, and, in the earlier stages, consist of scattered groups of empty vesicles, of a conical shape, with their apices toward the occluded bronchiole. Later, by multiplication and coalescence, they become less regular in outline, and, as they begin to inflame, become purplish-blue, softer, infiltrated, œdematous and less clearly demarkated from the surrounding tissues. The collapsed areas may remain separate throughout as distinct nodules, may form larger, irregular tracts, or involve an entire lobe. The favorite site is in the lower posterior portion of the lung, where the inspiratory act is least free. It may, however, occur in any part of the lung. The collapse of one portion of the lung is apt to cause emphysema in contiguous parts, as the vacuum produced by the collapsed cells is

occupied by the undue expansion of the pervious ones. The inflamed lung tissue is of a reddish-gray color, soft, friable, easily lacerated, and, on section, presents a tumid, smooth, or faintly granular surface, from which exudes a mucoid, muco-purulent or more distinctly purulent matter. This matter represents the contents of the bronchi and air cells, and is usually tinted. The former, examined microscopically, shows a more or less intimate admixture of cells and mucus; the latter is more variable in its composition. In typical cases it is found to consist, principally, of large epithelial cells, the offspring of the alveolar epithelium, intermingled with a variable quantity of exudate, and smaller emigrant corpuscles. Exceptionally, these latter elements predominate, and then the inflammation partakes more of the croupous character. Many of the air cells are found to be occupied in part or exclusively by the *products of bronchial inflammation*. In this case, unless other signs of inflammation be present, as, for instance, the proliferation of the alveolar epithelium, as evidenced by the presence of large epithelial cells, it is not to be regarded as an inflammatory consolidation, but simply an impaction from the inhalation of bronchial secretions. This condition is quite common, and frequently mistaken for alveolar inflammation. At a later period, the inflamed area takes on the aspect of gray hepatization; it is paler, dryer, and somewhat cheesy. The inflammation of catarrhal pneumonia may assume throughout a nodular, discrete form, extend in the form of irregular tracts, or uniformly involve an entire lobe. It is not uncommon to find in the same lung, or in parts of the same lung, the heterogeneous complexion imparted by the reddish-gray of inflammation, the shrunken aspect and dark blue color of collapse, the vesicular bulging of emphysema, and the consolidation from impaction with bronchial secretions.

Termination. The fatality of catarrhal pneumonia is large

—fully fifty per cent. of the cases ending in death. In cases not so ending, the terminations are in *resolution*, slowly progressing *interstitial inflammation* or *disintegration*. The first is the most frequent. Resolution, in this instance, however, is a much slower process than in croupous pneumonia. It is effected by fatty degeneration, absorption and expectoration of the alveolar contents. In the meantime structural changes are apt to occur in the alveolar walls and smaller bronchi. Both are thickened, somewhat indurated and pigmented, and the latter more or less dilated. When the disease pursues a chronic course, the thickening, induration and dilatation become more marked, and a permanent emphysematous condition of the vicarious parts becomes established. Disintegration is not common, and when it does occur, runs about the same course as described under the head of croupous pneumonia. Catarrhal pneumonia is a frequent precursor of pulmonary phthisis.

Phthisis Pulmonalis.

Phthisis pulmonalis, or Consumption, is an inflammatory disease of the lungs, characterized by consolidation, and resulting in disintegration or induration. Three principal forms are usually recognized, known respectively as the tubercular, the caseous and the fibroid. The first is so called because the initial lesion consists in the deposit of tubercles in the substance of the lungs; the two latter because of the characters impressed on the lung tissue as the result of inflammatory changes. As, however, the original lesion may consist of tubercular deposits, of those peculiar to croupous, catarrhal or other form of pneumonic inflammation, and as caseation or fibroid induration may follow either of these, it is better not to recognize distinctive forms based on these conditions. In the first place, in order to a proper understanding of the subject, it is necessary to bear in mind that

pulmonary phthisis is not a distinct and separate disease—that it is, in fact, the result of various inflammatory affections of the lungs, and that its tendency to result in disintegration or induration is only partially attributable to the character of the initial lesion. Tuberculosis, however, is inherently destructive. On account, therefore, of the wide differences in the nature and tendencies of tuberculosis and other forms of pneumonic inflammation, any of which may result in pulmonary phthisis, we have thought it expedient to recognize two forms, the *tubercular* and the *pneumonic*.

1. *Tubercular Phthisis.* This is the natural result of pulmonary tuberculosis. It is that form in which the initial lesion consists in the development of tubercles in the lung tissue. These tubercles are of inflammatory origin, and are of two kinds, the gray and the yellow. The *gray* tubercles consist of minute spheroidal bodies, of a grayish, translucent aspect, and of a firm consistence. They are, on an average, about the size of a pin head, and are more or less thickly, but irregularly, disseminated. The appearance and consistency vary according to the age; being softer, whitish and more opaque as they grow older. They consist of minute and distinctly circumscribed outgrowths from the connective tissue stroma of the lungs. Their favorite site is at the junction of the alveolus with the bronchiole, from whence they extend in various directions—into the alveolar and bronchial walls, and into the interlobular tissue. Examined microscopically, they present the characters of tubercle elsewhere described, viz.: an adenoid structure, in which may be recognized one or more giant cells centrally, surrounded by a more or less distinctly marked reticulum, the meshes of which are occupied by small lymphoid corpuscles. The gray tubercle usually inhabits the connective tissue stroma of the lung, but it is sometimes found occupying the alveolar cavity. Here, however, it is much more massive, and consists of one

or more large, branched and multinucleated cells for a nucleus, around which are grouped, concentrically, the lymphoid cells, which not only fill the alveolus, but extend into the walls of the same. The large cells are probably the offspring of the alveolar epithelium. The tubercular deposit is more frequent in the left than the right lung, and in the apices than in other parts of the lung. Sooner or later, it involves the greater portion of both lungs; sometimes by a gradual advancement, sometimes by a rapid, almost simultaneous, growth in all parts. The intervening lung tissue usually appears healthy so long as the tubercles maintain their pristine condition, but, with the advent of retrogressive changes in these, the lung tissue exhibits congestion, œdema and inflammation. The *yellow* tubercles are much larger, softer, less clearly defined and more irregular in outline, than the gray. They are yellowish, opaque, cheesy and friable, and not infrequently present the characters of gray tubercle at the periphery. They consist, in fact, of aggregations of gray tubercles, or of the products of non-tubercular inflammation which have undergone the caseous change. They are found, most frequently, occupying the alveoli, where they exhibit the various characters of a tubercular or pneumonic consolidation in various stages of advancement. Yellow and gray tubercles are often found associated in the same lung, the former tending to rapid, and the latter to more gradual, degeneration.

2. *Pneumonic Phthisis.* Croupous or catarrhal pneumonia, more especially the latter, may terminate in phthisis. If from any cause the inflammatory process is perpetuated, as from inherent weakness of the lung tissue, the persistence of an undue irritation, or the arrest of the process of resolution, inflammatory changes soon appear in the alveolar walls. These become infiltrated with young cells and suffer in their physical properties accordingly. The contents of the alveoli are variable, according to the nature of the initial affection

and the age of the products. Thus they may consist mainly of epithelial products, of migrated corpuscles, or of bronchial secretions variously blended, and exhibit any of the stages of retrogressive change as pointed out under the respective heads to which they belong. It will be remembered that the inflammatory infiltrate is not confined to the alveoli, but extends in an unbroken mass into the alveolar walls, and even into the interlobular tissues, so that, in some cases, it is difficult to distinguish what was the cavity and what the walls of the same. By keeping this in mind, it will be easy to see how a degeneration commencing in the alveolus may be continued right on into the walls of the same, and so on as far as the infiltration extends.

Terminations. Pulmonary phthisis terminates either in *disintegration* or in *fibroid induration.*

Disintegration. This is the more frequent. It consists, for the most part, in a fatty infiltration of the inflammatory products, and a necrosis of the proper structures. The process commences usually in the centre of the alveolar contents, and presents the ordinary characters as seen in croupous and catarrhal pneumonia. Extending outwards, it not only reaches to, but involves the alveolar walls and adjacent parts, until variously-sized depots are formed. These are enclosed in ragged and irregular walls, which subsequently become smooth by the continued melting away of shreds and projections. The contents of these cavities is a caseous matter, or a puriform, though not a purulent liquid. This may be discharged by opening into a bronchus, or if not discharged, and accessible to the atmospheric air, becomes putrid. In the latter event it becomes very offensive. It sometimes becomes encapsuled, and by absorption of the liquid contents becomes *caseous*, or more rarely, *calcified.* By coalescence of these cavities, they may assume almost any magnitude or configuration.

Fibroid Induration. In other instances, the new-formed elements, instead of breaking down, develop into a quasi-fibroid tissue. This constitutes fibroid induration, and gives rise to what is called *fibroid phthisis.* Here the alveolar walls become thickened and indurated, and encroach on the alveolar spaces. In some cases, these latter are entirely obliterated by the growth and subsequent contraction of the fibroid tissue. More frequently, however, the fibroid growth takes place in the interlobular tissue, and this is often associated with a disintegration of the substance of the lobule, so that the fibroid induration forms a barrier to the disintegrative process. It is this that so frequently constitutes the walls of the cavities in pulmonary phthisis. In proportion to the prevalence of disintegration or fibroid induration, will the lung be soft, friable or diffluent, on the one hand, or hard and resisting on the other. When both are conjoined, as they frequently are, the indurated tracts are easily distinguishable from the softened by the sense of feeling.

That which determines a disintegration of lung tissue, on the one hand, and a fibroid induration on the other, is precisely analogous to what obtains elsewhere. It all depends on the facilities for preserving the nutrition of the parts, and will be influenced by the rapidity and amount of cell production, and the condition of the circulation. In pulmonary phthisis there is, usually, not only a stuffing of the alveoli with inflammatory products, but also a dense cellular infiltration of the alveolar walls. As a consequence, the blood vessels are strangulated, and the blood supply cut off. Not only is there a necessity for more blood, in order to supply the enormously increased living elements, but therewith an actual diminution in the blood supply. But further, in the ordinary pneumonic process, the alveolar contents are removed by absorption, as they liquefy, and thus permit of the free return of the blood to the needful lung tissue. Here,

however, there is no absorption, on account of the intra-mural pressure, consequently no relief, and the necrotic process continues into and through the alveolar walls, and as far outward as the dense infiltration extends. This may include one lobule or a number of adjacent lobules, but it is usually arrested somewhere by the interlobular tissue, for the reason that interference with the circulation here is less likely to occur. On the other hand, if the inflammatory action be less intense, if the cellular infiltration be less rapid and abundant, and the blood supply less disturbed, the new-formed elements may survive, and surviving, organize. This organization takes the form of an imperfectly developed fibroid tissue, in the midst of, and interlacing with, the proper tissues of the alveolar walls and the interlobular tract. There results a thickening, induration, and more or less pigmentation of these structures, which, together with the subsequent contraction so distinctive of new-formed fibrous tissue, partially or entirely obliterates the alveoli, and converts the lung into a dense, impervious solid.

It will be seen, therefore, that fibroid induration, so far as the breathing function is concerned, is almost as pernicious in its results as pulmonary disintegration.

As before intimated, it is in the interlobular tissue, more especially, that we look for the evidences of fibroid induration, because of the ordinarily less dense infiltration, and the more efficient blood supply; although it may and does occur in the alveolar walls.

CHAPTER XXXII.

DISEASES OF THE LIVER.

Normal Histology.

A brief review of the normal histology of the liver will conduce to a better understanding of the pathological changes to which it is prone. The liver consists of three histological factors; the blood-vessels, cells and connective tissue. From the peculiar manner of distribution of the blood vessels, they constitute a framework by which alone the arrangement of its component parts may be recognized. The cells and connective tissue fill in the interstices of this framework, to complete the structure. By this arrangement of the blood vessels we have the liver divided into smaller regions, known as *lobules*. These lobules are egg-shaped bodies, and are clearly marked off by a vessel passing up through the centre lengthwise, and by other vessels coming from an entirely different direction and which ramify over its surface. The central vessel, which is the *hepatic vein*, sends its branches towards the surface, and the surface vessels, branches of the *portal vein* and *hepatic artery*, send their branches inwards; both meeting midway. The cells, disc-like in form, fill in the spaces between the vessels, and are arranged in radiating lines from the centre to the periphery. The connective tissue fills in the spaces between the different lobules. The aggregation of these lobules, with their complement of vessels, and the intervening connective tissue, constitutes the liver. As will be seen from the above, each lobule has two vascular zones; a central zone, occupied by the hepatic vein and its rootlets, and an external zone, occupied by the portal vein and its branches. Some writers add a third zone, intermediate between the other two, and which

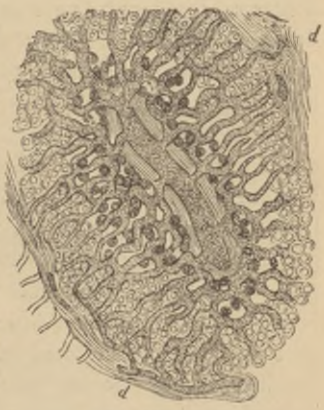
is supplied by the hepatic artery. This arrangement of the vessels in the lobule should be constantly kept in view, as it is the key to not a few of the pathological phenomena hereafter brought to notice.

Atrophy of the Liver.

Atrophy of the liver presents under three forms; simple, red and yellow. The first, as its name implies, is a pure, simple atrophy; the others are rather degenerative in character, but not falling under the head of any of the ordinary forms of degeneration, are included here.

Simple Atrophy. Simple atrophy affects only the liver cells; the other components of its structure—connective tissue and blood-vessels—undergoing no change. The cells become reduced in size and dusted with a yellow or brown pigment. They still, nevertheless, preserve their individuality. As a result, the whole organ becomes shrunken, brown, leathery, tough, dry and anæmic. The connective tissue is relatively, but not actually, increased, which, together with the shrinking of the cells, accounts for the physical characters of the atrophied liver. Simple atrophy is found in cases of general wasting, and is due to the same causes.

FIG. 41.



RED ATROPHY.

a. The lumen of the central vein of a hepatic lobule. *d*. Interlobular connective tissue, increased.

Red Atrophy. Red atrophy, otherwise known as *pigmentary infiltration*, and so-called from the deep red coloration of the organ, is the result of venous hyperæmia. It occurs in those

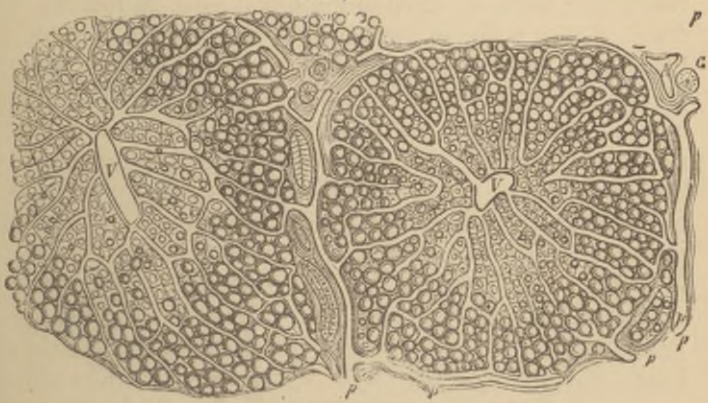
diseases of the heart and lungs which interfere with the venous circulation. The blood is thrown back on the hepatic vein and its branches, which, as a consequence, become turgid, greatly dilated, and pressing upon the cells in their vicinity, produce atrophy. Red atrophy is most conspicuous in the centre of the lobule—*the zone of the hepatic vein*—thence gradually shading off toward the periphery. A fatty degeneration of the more external part of the lobule often accompanies red atrophy of the centre. This gives to the lobule a mottled aspect, and constitutes what is known as *nutmeg* liver. The red atrophied liver is large and tense, from the amount of contained blood, firmer, from the absence of cells and relative or actual increase of connective tissue, and presents on its surface arborescent furrows in the course of the hepatic vein and its branches, which mark the line of destruction of the liver cells. Cut into, the most striking appearances are the deep red color, the amplitude of the vessels, and the thickness of their walls.

Yellow Atrophy. Acute yellow atrophy is regarded, on the one hand, as being the effect of a diffuse, parenchymatous inflammation, and, on the other, as being a rapid degenerative change without inflammation. The latter is the more generally accepted. The cause is supposed to be a specific poison, the nature of which is entirely unknown. The liver is small, soft, flabby, the capsule wrinkled and rugose, and the entire organ imbued with a deep yellow, biliary tinge. The cellular elements are entirely destroyed, presenting a mass of stained, granular and fatty molecules. The connective tissue is swollen and infiltrated, the blood vessels occluded. It is a disease of young adult life, especially affects females, and more particularly the pregnant. It commences insidiously, runs its course rapidly, and ends fatally.

Fatty Infiltration of the Liver.

Fatty infiltration of the liver occurs, to a slight extent, physiologically. After a full meal abounding in fats, the liver cells are found to contain fat globules in greater or less abundance. The fat is taken up by the portal vessels and carried to the liver, and is found in transit through the liver cells from the portal to the hepatic vein. This soon clears away in the intervals of digestion. It is only when the infiltration is excessive and persistent that the condition becomes pathological. This obtains, when the supply of fat exceeds

FIG. 42.



FATTY LIVER.

V. Lumina of the central veins. *P.* Interlobular branches of the vena portæ. *A.* Arterial branches. *G.* Biliary ducts.

the requirements of the system, or when the combustion is below the average, or when both conspire. High living, the indulgence in alcoholic drinks, and indolent habits, contribute to fatty liver, as well as to general obesity. Other causes are to be sought in the deficient oxydizing power of the blood, whereby the fat is not consumed. A venous stasis by excluding arterial blood, pulmonary trouble by preventing oxygena-

tion of the blood, and a deficiency of red blood corpuscles, by lessening its capacity for oxygen, all operate in this way. Heart disease, tuberculosis, chronic alcoholism and general anæmia, are, severally and usually, attended by fatty liver.

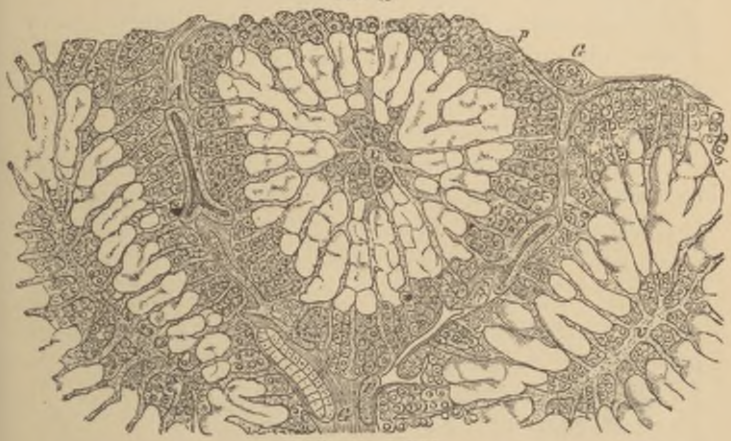
The liver cells thus become a storehouse for the surplus fat. The fat is delivered to them from the portal vein, as in the physiological state, and as the portal branches surround the lobule, the first indications of the infiltration are at the periphery—*in the portal zone*. Little by little the infiltrate finds its way toward the centre of the lobule, until, in extreme cases, the entire lobule is filled. It seldom, however, reaches that extent, being confined to the portal zone, or forming a marginal ring at the very outskirts of the lobule. The fatty liver, according to the extent of infiltration, is larger, plumper, heavier, than natural, but withal, of lighter specific gravity. It is doughy, and pits on pressure; the indentation slowly disappearing. It is anæmic, of a yellowish or yellowish-brown hue, or mottled. The anæmia is much more pronounced in death than during life, because the tense and somewhat elastic tissues gradually empty the vessels after life is extinct. Cut into, the appearance denotes a uniform or zonular infiltration of the lobules. When zonular, the appearance is not unlike the inner surface of a nutmeg; another instance of nutmeg liver. By scraping the cut surface with the edge of the knife, grease will be found on the blade.

Amyloid Infiltration of the Liver.

Amyloid infiltration of the liver commences in the *intermediate* or *hepatic artery zone* of the lobule. The starting point is in the minute branches of the hepatic artery, but, instead of extending to the capillaries, it passes over to the adjacent hepatic cells. It now, by preference, moves inward towards the centre, but also, eventually, outward toward the periphery, so that in the worst cases the entire lobule becomes

involved. The infiltrated cells enlarge, assume an irregular, clumsy, bloated appearance, become translucent and homogeneous, and tend to fuse together. In proportion to the extent of infiltration, the organ increases in size, weight, and specific gravity. The capsule is smooth and tense, from distention. The organ is heavy, firm, elastic, and the thin edge of the same is swollen and rounded; though, owing to the uniform diffusion of the infiltrate, the natural configuration is in the main preserved. It is anæmic, grayish translucent, waxy. The increase in size is sometimes great, almost to the

FIG. 43.



AMYLOID LIVER.

A. Interlobular artery with amyloid walls. *G. G.* Biliary ducts. *P. P.* Portal vessels. *V. V.* Interlobular veins.

filling of the abdominal cavity. The anæmia is from the elastic pressure on the vessels of the tense, overfilled parenchyma. The capillaries are pervious, however, and may be easily injected at any stage of the disease. The cut surface, in the worst forms of the disease, is dry, bloodless, uniform, smooth, and wax-like; everything being fused into one homogeneous mass. In the lighter forms the normal struc-

tures alternate with the abnormal, the boundary lines of the lobules are still discernible, and the whole presents a mottled aspect. It is not uncommon to find amyloid and fatty infiltration going together; the fatty change being confined to the peripheral, and the amyloid to the intermediate zone. This imparts to the lobule a striking appearance, in which the waxy translucence of the intermediate zone stands out in bold contrast to the normal tissues in the centre on the one hand, and the whitish opacity of the periphery on the other. The intumescence of the secreting structures, together with the prevailing ischæmia, interfere materially with the function of the liver. The bile that is secreted is thinly fluid and scanty in quantity. There being no actual occlusion of the hepatic vessels, ascites does not occur.

Inflammation of the Liver.

Inflammation of the liver may affect chiefly the parenchyma or the interstitial tissue; although it is never confined entirely to one or the other.

PARENCHYMATOUS HEPATITIS.

Parenchymatous hepatitis is diffused and general, or localized. General diffuse hepatitis, if we exclude acute yellow atrophy, is a disease of the tropics. Its pathology is very imperfectly understood, though its morbid appearances are very analogous to those of acute yellow atrophy.

Localized Parenchymatous Inflammation. This form results in hepatic abscess. These abscesses may be many or few in number, of large or small size, and by coalescence give rise to purulent depots of irregular outline. These depots in some instances are of such extent as to convert an entire lobe, or even the greater portion of the organ, into one purulent and disorganized mass, enclosed within the capsule. The central portion of the right lobe is the favorite seat of hepatic abscess, yet it may begin in any portion of the liver substance.

Parenchymatous hepatitis first manifests in a cloudy swelling of the cells. They become enlarged, rounded in contour, and studded with granules similar to those normally existing. The cells become more or less separated one from another, and tend to become disarranged, so that they no longer present the regular linear arrangement in rows, as seen in the healthy state. Free nuclei, granular matter, spindle-shaped forms, leucocytes and pigment, occupy the spaces between the cells. As the trouble advances, the cells undergo atrophic changes, either of a simple kind, wasting away imperceptibly, or take on a fatty, amyloid, or pigmentary change, previous to complete disintegration. If suppuration is to ensue, all available space around and between the cells is packed with leucocytes, which soon take on the characters of pus cells. These leucocytes migrate from the adjacent blood-vessels. The hepatic cells take no part in the production of pus; do not proliferate, but simply languish and disintegrate under the oppression and disordered nutrition of the inflammatory act. Once formed, the hepatic abscess may continue to advance, extending its borders until, reaching the surface, it discharges, or becoming encysted, remains dormant. It may discharge in various directions, the most common sites being through the integument at the ensiform cartilage, into the pleural or peritoneal cavities, or into the intestinal canal. The encysted abscess sometimes undergoes caseation and absorption, sometimes calcification. If emptied by absorption, the walls of the abscess draw together, until finally a faint linear scar is all that remains.

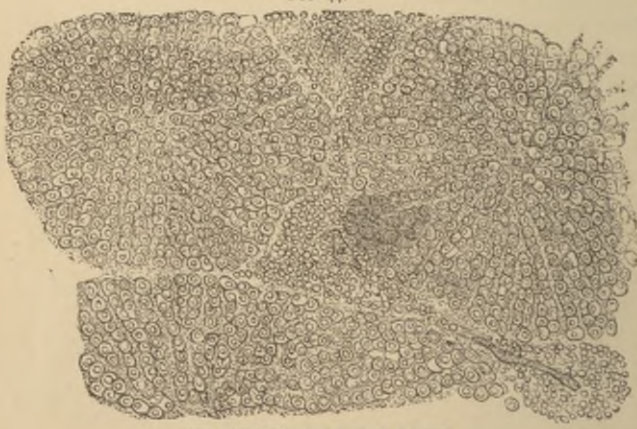
Causes. The causes of hepatic abscess are for the most part obscure. It not infrequently follows injuries of the head or long bones. In these instances it is attributed to an embolus originating at the point of injury, being wafted by the blood current into the hepatic structures. It is quite often coincident with dysentery, but whether, as some suppose, in

consequence of a poison furnished by the ulcerated bowel and carried to the liver on the portal stream, or as the result of the same cause which led to the dysentery, is not known. Multiple hepatic abscess every now and then follows in the wake of pyæmia. These are the results of poisonous emboli finding lodgment in the hepatic vessels. The poison of malaria, especially if combined with a tropical clime, strongly predisposes to hepatic abscess. Direct injury to the liver, such as blows on the hypochondrium, is not a common cause.

Interstitial Hepatitis.

Interstitial hepatitis is an inflammation of the interstitial or connective tissue of the liver. The connective tissue forms a

FIG. 44.



INFLAMMATION OF THE LIVER.

a. Lumina of interlobular vessels, in whose environs there is a small-celled infiltration.
v. Lumina of intralobular vessel.

matrix for the portal vein, and accompanying vessels, and also envelops the individual lobules. The inflammation may be general and diffuse, involving simultaneously all the interstitial tissues, or partial, which is the common form.

It usually commences in the vicinity of the small portal branches, and extends outward along the larger branches. It also at times extends in the opposite direction, following the finer ramifications of the portal vein into the lobule. The first step in the process is the production of embryonal connective tissue. This is highly vascular, being supplied by offshoots from the hepatic artery. Owing to the increase of new formed tissue, and the increased afflux of blood, the liver is enlarged and hyperæmic. As the disease advances the new formation increases, the line of connective tissue extends and widens, and gradually acquires a fibrous or cicatricial character. It now begins to contract, and inaugurates a series of troubles which will be considered in detail. First, as the result of contraction, the liver becomes much reduced in size, it also becomes firmer, dryer, anæmic, and because of the irregular distribution of the new formed product, more or less altered in contour. The capsule is thickened and the surface studded with nodular elevations. On account of the latter, which has a fancied resemblance to the head of the hob-nail, it is known among the English as the *hobnailed liver*. Cut into, the knife meets with a fibrous resistance, and the cut surface presents a dry, anæmic, tawny red appearance. It is also covered with granular elevations.

Examined microscopically, the interstitial tissue will be found to be greatly increased in quantity and altered in quality, being in many situations of a cicatricial hardness. It shows as broad interlacing bands surrounding the lobules, and even, at times, penetrating them between the cells. In this manner, by a gradual but irresistible contraction, the parenchyma is jugulated and the cells atrophy, degenerate and disappear. The form of degeneration is, for the most part, fatty, and affects primarily the peripheral cells of the lobule, because they are most exposed to pressure. It subsequently extends to the others. All the vessels of the liver

suffer constriction, but more especially the branches of the portal vein, and, to a less extent, the radicles of the hepatic vein. The nutrient vessels of the interstitial tissue become obliterated as the cicatrization advances. Impediment to the portal circulation leads to portal congestion. As a consequence, the spleen is enlarged and gorged with blood, transudation takes place into the intestinal canal, causing diarrhœa; into the peritoneal cavity, causing ascites; and, occasionally, the pressure on the portal radicles is so great as to cause their rupture, with hemorrhage into the bowel, as manifested by tarry evacuations. The pent-up blood in the abdominal cavity seeks an outlet by devious collateral channels; hence the prominence of the superficial abdominal veins. The constriction of the bile duct, though seldom so great as to completely arrest the flow of bile, is yet sufficient to prevent its free escape, which results in pigmentation of the hepatic tissues. It is on account of the tawny red cast thus imparted that the name *Cirrhosis* was applied to the disease by the French. But, inasmuch as all cases do not present this red coloration, the name is inappropriate. *Sclerosis*, as indicating the density and fibrous character of the liver, is less objectionable. The granular aspect of the cut surface and the nodular appearance of the exterior are both due to the contraction of the interlacing bands of the connective tissue and the forced elevation of the parenchyma. Exceptionally, cases of interstitial hepatitis are found, in which the liver is not reduced in size, but actually larger than natural. The surface is smooth and not nodular, and the interior does not present the fibrous consistence, the granular elevation, nor the dryness of the ordinary form.

This, the so-called hypertrophic cirrhosis, represents a diffuse and general interstitial growth. The characteristic evidences of contraction and cicatrization are wanting, because death ensues before that stage of progress.

Causes. The one great cause of interstitial hepatitis is the abuse of alcoholic stimulants, these being absorbed by the portal radicles and carried directly to the liver. The constant irritation thus kept up by habitual indulgence leads to inflammatory growth of the interstitial tissue. For obvious reasons, adult males are most frequently affected. Hereditary syphilis is supposed to predispose to it.

There is but one termination to interstitial hepatitis, and that is death.

CHAPTER XXXIII.

DISEASES OF THE KIDNEYS.

To differentiate between the healthy and diseased kidney is not always easy. This is not from any difficulty in recognizing the typical healthy kidney, but from morbid appearances so frequently met with at the autopsy, the result of ante- or post-mortem influences, and yet independent of renal disease.

The typical healthy kidney, aside from being of the proper size, weight, color and consistence, has a thin, translucent capsule, whose surface is covered with a delicate, barely perceptible, vascular network, and which is easily detached without violence to the underlying structures. The kidney structure examined microscopically appears to be made up entirely of Malpighian bodies, tubules and blood-vessels, and unless these latter contain blood, or be injected with coloring matter, even they are not to be differentiated from the tubules. It requires special and painstaking preparation to demonstrate the interstitial substance. If a tube be examined critically, it will be found to be lined with epithelium, the cells of which are clear, transparent, and distinctly nucleated. The lumen of the tubule is pervious and of regular outline. So impressible, however, is the renal epithelium to ante-mortem influences, and so quickly does it yield to post-mortem changes, that it is rather the rule than otherwise to find it more or less altered, even in the absence of pre-existing disease of the kidneys. The cells may be variously colored. They may be fatty, granular, nebulous, crumbling, opaque, or variously degenerated. They may be more or less detached, hanging loosely or occupying the

lumen of the tubule, and yet not signify renal disease. The coloring may result from a depraved condition of the blood, with liberation of its coloring matter, or from bile. The decomposition may have occurred after death, while fatty infiltration, which is indeed quite common to the renal epithelium, is not incompatible with functional integrity.

If, however, the tubule be perceptibly dilated throughout or at points, if its lumen is filled with albuminous matter, if the epithelium is excessive in quantity, or if the tubule have no epithelial lining, it indicates disease. So, also, if the interstitial substance be so abundant as to be easily recognized, or the capsule be opaque, thickened, and adherent, or if the organ has undergone marked change in size, form, color or consistence.

Amyloid Infiltration of the Kidney.

Amyloid infiltration of the kidney primarily and conspicuously affects the small blood vessels. It commences in the vascular tuft of the Malpighian body, and extends outward along both the afferent and efferent vessels.

Its manifestations are confined, for the most part, to the cortex, but in the more advanced stages of the disease it follows the course of the vessels into the pyramids. The primary effect of the infiltration is a swelling and translucency of individual elements—cells, fibres, etc., which finally fuse into an indistinguishable mass. This is most conspicuous in the muscular layers of the vessels, because they are the first and most prominently affected, but other layers also become affected, until in the end all boundary lines are effaced, and the vessel walls are rendered homogeneous. The infiltrate now permeates the intertubular connective tissue, separating the tubules one from another, and imbedding them in a waxy matrix. The effect of all this is, to first increase the size of the Malpighian bodies, by increasing the size of the blood

vessels composing them. The vessel walls are not only thickened, but also altered in quality. The result is, a narrowing, sometimes an occlusion, of the lumen of the vessels, and an ever increasing anæmia of the structures in consequence. The altered vessel walls favor transudation and the escape of albumen. This accounts for the abundance of albuminous urine so characteristic of the earlier stage of this disease, and this—the albuminous urine—entitles it to be ranked as one of the forms of Bright's disease. If there be no complication, the tubules and the tubal epithelium are at first perfectly normal. After a while, owing to the imperviousness of the blood vessels, they begin to suffer for the want of blood. Fatty degeneration and atrophy of the tubal epithelium ensue. The tubules themselves being crowded upon by the infiltrate, are wont to shrivel and decay, or being obstructed at points, become dilated by the accumulating secretions above, forming cysts. In this, the last stage, the urine becomes diminished, for the twofold reason that the blood vessels do not admit of sufficient blood to supply the secretion, and that the tubules are in a great measure obstructed, abolished, or otherwise disqualified for service. It is rare for the tubule, or the tubal epithelium to become infiltrated, but it is less rare to find an amyloid cast occupying the lumen of the tubule. The origin of these amyloid casts is obscure. By some they are supposed to represent an amyloid infiltration into the lumen of the tubule, by others a fibrinous cast, or an exudate, or tubal epithelium, which has suffered the amyloid change.

The amyloid kidney is enlarged, hard, firm, and of a light yellowish color. The capsule is thin and easily detached. On section, the principal changes will be found to have occurred in the cortex. It is thickened, bloodless, homogeneous, translucent, waxy in appearance and consistence. The pyramidal portion is hyperæmic. This is especially the case

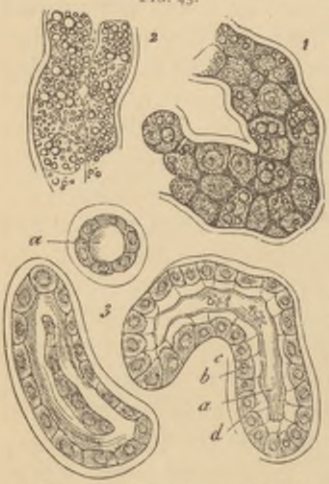
at the base of the pyramids in the vicinity of the larger vessels, which are not so subject to the amyloid change. The pyramids themselves may show more or less of the amyloid change, but only in the more advanced cases. Yellowish-white streaks or lines are now and then to be seen traversing the polished, waxy surface of section. These are the tubules which have undergone fatty degeneration. In the more advanced stages of amyloid degeneration there is scarcely the possibility of mistaking it. Not so in the earlier stages, when a slightly increased anæmia, a little alteration in hue, and some induration, is all that is appreciable. Here, it would be easy to go astray. The application of the iodine solution now, either by pouring it over the cut surface, or by immersing thin sections in the same, brings out the Malpighian bodies like so many stars. They appear as disseminated points of a deep, mahogany red. Later, when the infiltration has become more general, the application of the test reveals in a striking and beautiful manner the arborescent tracings of the blood vessels. These, in their mahogany red, stand out as boldly from the pale yellow which makes up the background, as though they had been injected. Amyloid infiltration is not infrequently associated with parenchymatous or interstitial nephritis. In the former case there will be superadded a catarrhal proliferation of the tubal epithelium, with stuffed tubules and various urinary casts; in the latter, an overproduction of the interstitial tissue, with its subsequent contraction and a consequent atrophy and distortion of the kidney.

Parenchymatous Nephritis.

Parenchymatous nephritis, otherwise known as *acute degenerative nephritis* and *tubal nephritis*, is an inflammation of the tubules of the kidneys. It occurs in two forms: as an acute, suddenly developed ailment, running its course rapidly and with violence, and as an insidious, slowly progressive but

more destructive malady. As, however, the morbid changes in the two forms differ only in degree, it will be better to consider them conjointly. Parenchymatous nephritis is characterized by hyperæmia, exudation into the tubules, and cloudy swelling of the tubal epithelium, followed, in most cases, by some degree of degeneration. The hyperæmia is generally well marked at the onset, at which stage capillary hemorrhages into the tubules are apt to occur, and the blood appears in the urine. This imparts to the urine a more or less red, dark or smoky appearance, according to the quantity. The blood corpuscles may be recognized by the microscope. Not infrequently the blood coagulates in the tubule, forming a mould or cast of its lumen, which being voided in that form constitutes the *blood cast*, which is of much value as indicating its place of origin. When one sees a blood cast in the urine, he knows that it comes from the renal tubule; that it signifies a hemorrhage into the same, and that in all probability it signifies the early stage of tubal nephritis. In parenchymatous nephritis the exudation takes place into the lumen of the tubule, just as in pneumonia it takes place into the lumen of the air cell. It differs in quantity and quality. It is sometimes rich in cells, at others consists largely of a coagulated fibrinous material. This latter frequently fills the tubule, and coagulating, forms a

FIG. 45.



1. Cloudy swelling and commencing fatty degeneration of the epithelia of the convoluted urinary tubuli. 2. Advanced fatty degeneration. 3. Formation of fibrinous cylinders. *a*. Cross-cut of a urinary tubulus with a gelatinous cylinder filling the lumen. *b*. Epithelium. *c*. Tunica propria. *d*. Renewed production of colloid at the surface of the epithelial cells, which elevates the older.

cast of the same. These casts being pliable and slippery are easily pushed forward by the secretions from behind, and being voided with the urine, are recognized as *hyaline casts*. They are sure indications of tubal nephritis, and are, without much doubt, exudates. Some pathologists look on them as being metamorphosed epithelial cells, but they are constantly found impacting the tubule when the epithelial lining is perfect. Being adhesive, as well as slippery, the surface of the exudate often becomes covered with cells in its passage along the tubule, which imparts to it a granular aspect. These are the *granular casts*. The epithelial cells lining the tubules also participate in the morbid action, and it is here that the most important and notable changes transpire. This consists at first of a cloudy swelling, in which the cells become greatly distended and their nuclei obscured by a granular matter. These granules are indifferent to the action of ether, but disappear under the influence of acetic acid. This proves them to be not fatty, but rather albuminous, and argues, as some pathologists suppose, not a degenerative, but a formative change. They look upon the granular matter as nutritive material, which has been taken up under the stimulus of inflammation. The swollen epithelium narrows the lumen of the tubule, at times even to complete obstruction, and bulges its walls outward in an irregular and varicose manner. The young cells of the exudate occupying the lumen now degenerate

FIG. 46.

FIBRINOUS CYLINDERS.

a. Within a urinary tubulus. *b*. *c*. From the urine, more or less richly covered with molecules of fat.

and break down, the epithelial cells here and there pass over into fatty degeneration, and the tubule at points becomes blocked with this mass of debris. Recovery may take place at this stage, the degenerated elements being in part voided in the urine and in part absorbed, and the lost epithelium restored. If, however, the disease continue, as in the lingering form it does, the interstitial substance becomes involved, becomes thickened and sodden, from infiltration, and swarms with migrating cells. The walls of the tubule also become thickened, and the tubal epithelium passes over more abundantly into fatty degeneration. It becomes detached and expelled, leaving the tubules without lining. The work of destruction continues, the fatty metamorphosis extends to the new-formed elements of the interstitial tissue, and the organ, no longer capable of maintaining a structural integrity, ceases to functionate. The result of all this is, to produce marked changes in the appearance and properties of the kidney. The morbid process affects more especially the convoluted tubules, and consequently the resulting changes will be for the most part confined to the cortex. The kidney as a whole is enlarged, sometimes greatly so, and in the earlier stages of the disease markedly hyperæmic. As the disease advances and the tubules swell, the blood vessels occupying the intertubular spaces are pressed upon, and the blood forced into the pyramids and Malpighian bodies. As a consequence, the cortical substance becomes anæmic and the pyramids hyperæmic. The pent-up blood in the Malpighian bodies renders them conspicuous as bright red spots in the midst of an almost uniform buff gray. Later on, as fatty degeneration assails the epithelium of the tubules, the course of degeneration is betrayed by blotches or convoluted lines of whitish opacity. Still later, the whiteness of degeneration may become more diffuse, and even pass over into the interstitial substance. The capsule of the kidney is much

thinned by distention, and when incised bursts asunder and is easily stripped off, exposing the smooth, pale surface of the cortex. When cut into, the increased size of the organ is found to depend almost entirely on the thickening of the cortex. The size, color, and smoothness of surface incident to the kidney affected with parenchymatous inflammation has won for it the name of large, smooth, white kidney, and it constitutes one of the forms of Bright's disease. Eventually, from the loss of epithelium, the collapse of tubules and contraction of the interstitial substance, the kidney may suffer some degree of atrophy.

Causes. The acute form is usually attributable to some irritant, which being eliminated by the kidney, exerts a deleterious influence in its passage. This may consist of the poison of an infectious disease, as scarlatina, typhoid fever, erysipelas; or of a substance used medicinally, as copaiba, turpentine, cantharides. Scarlet fever stands first in the list of causes, sudden suppression of perspiration by exposure to cold being next. It also occurs in pregnancy, especially first pregnancies, too frequently to be regarded as a mere coincidence. It is a disease of youth and young adult life, being rare in infancy and after the age of forty.

The light-haired, pale, full and flabby are peculiarly liable to it.

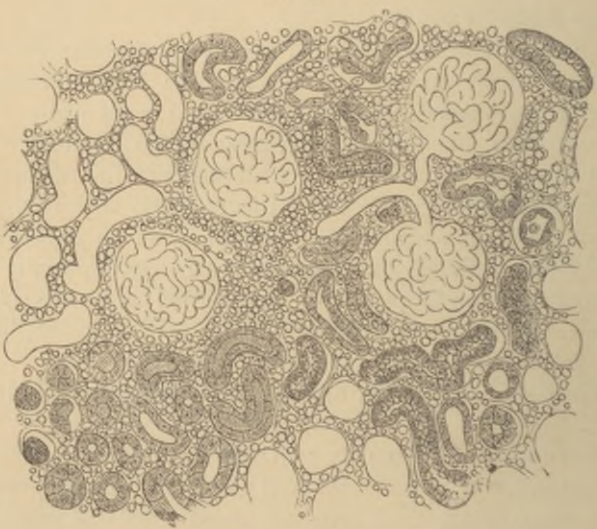
The chronic form usually comes on in the course of some chronic ailment, in which the vital powers are much depressed. The most common of these are chronic malarial poisoning and the poisoning of lead, mercury and alcohol. It occurs in cases of prolonged suppuration and in syphilis.

It is a disease of much gravity, the chronic form generally resulting in death. The prognosis of the acute form is much more favorable.

Interstitial Nephritis.

Interstitial nephritis is an inflammation of the interstitial or connective tissue of the kidneys. Various other names have been applied to the disease, such as *renal sclerosis*, *renal cirrhosis*, *granular kidney*, *contracted kidney*, etc., which rather represent the changes wrought by the disease, than indicate its character. Interstitial nephritis commences in an infiltration of the interstitial tissue with small, round cells, which

FIG. 47.



INTERSTITIAL NEPHRITIS.

at first is attended by more or less hyperæmia. The cellular infiltration, as also the degree of hyperæmia, vary in different cases, but the disease being by nature one of the most insidious and slowly progressive, neither is apt to be intense.

The infiltration, while usually broadly diffused throughout the interstitial tissue, does not affect all parts alike. Here,

as in parenchymatous inflammation, it is the cortical portion that suffers most, and even in it, there are areas of greater or less intensity—some in which the infiltration is abundant, others in which it is light or even wanting. It is always more abundant immediately surrounding the Malpighian capsule, and in the vicinity of the blood vessels than elsewhere. As in all connective tissue new formations, the infiltrate is at first soft, cellular and amorphous. It subsequently becomes condensed and dry. It may or may not become fibrillated, and very seldom indeed presents the characters of cicatricial tissue. In this respect it differs widely from the connective tissue growths occurring elsewhere, which naturally tend to cicatrization. If the infiltration be rapid and abundant, the interstitial substance will be proportionally much increased in volume, it will be soft and succulent, and the entire organ will be much increased in size. If on the other hand the infiltration be slow, condensation or fibrillation will keep pace with the deposit, and the organ will not enlarge. Ultimately in either case, hardening and contraction of the interstitial substance supervenes, which, with a gradually tightening embrace, jugulates blood vessels, tubules, and Malpighian bodies. First, the blood is forced out of the intertubular vessels into the Malpighian bodies and pyramids; then, as the trouble advances the Malpighian bodies are themselves emptied, and the blood driven from the cortical region takes refuge in the medulla and the superficial parts—the capsule and its adipose investment. The tubules now suffer in a twofold manner; from a want of blood and from pressure. The result is degeneration of the tubal epithelium and atrophy, and annihilation of the tubules. It is a curious fact, that attending interstitial nephritis, and in some obscure way related to it, the walls of the smaller arteries are hypertrophied. This affects more especially the muscular layer, and is not confined to the renal vessels, but extends throughout the system. As a result of this, and to

overcome the resistance offered by it, the left ventricle of the heart becomes hypertrophied. It will be seen now how such a combination, reinforced by ill-nourished and weakened vascular walls, would lead to hemorrhages, for which this disease is noted. The appearance of the kidney affected with interstitial inflammation will depend on the stage at which it is examined, the rapidity and abundance of interstitial growth, etc. In the early stages, especially if the growth be rapid, the capsule is soddened and thickened, but not adherent, the cut surface slightly granular, the medulla and capsule hyperæmic. The cortex may be redder or paler than natural, but the Malpighian bodies are always somewhat heightened in color, from engorgement. Later, the kidney shrinks, the capsule is thickened and adherent, the surface of the organ is distinctly granular, the cut surface granular, tough and resisting. The cortex is usually much reduced in thickness and anæmic, the color being a yellowish-gray. Now and then it will be found to have a deeper cast than natural. In the process of shrinking the kidney is not only reduced in size, but by a retraction of the hilum the cavity of the renal pelvis is enlarged. Examined microscopically, the tubules in great part will be found atrophied, shrunken, or to have disappeared altogether. In their stead will be found the exaggerated interstitial tissue, which now traverses the cortex in broad tracts. Indeed, the cortical portion now appears to consist of little else than connective tissue in which are imbedded numerous Malpighian bodies, and some isolated tubules in all stages of atrophy, and containing degenerated elements. The tubules are frequently constricted in such a way as to prevent the escape of urine. This causes retention and the formation of cysts. The Malpighian capsule is in this way converted into a cyst. The Malpighian bodies, though in the early stages usually hyperæmic, often become notably smaller in the latter stages, from compression, or are even converted into

dry, solid globules. They are drawn nearer together in the process of contraction, so that greater numbers occupy a given space than before. The perfectly transparent *hyaline casts* so characteristic of this affection result from the colloid metamorphosis of the contents of the tubules. These casts not only appear in the voided urine, but are often found occupying the convoluted tubules after death. They are detected with difficulty, owing to their perfect transparency, and are to be differentiated from the hyaline casts of parenchymatous nephritis, which are much more refractive. Interstitial nephritis constitutes the most chronic form of Bright's disease, is very insidious in its approaches, very slow in its progress, and almost uniformly fatal in its results. The cause of death is uræmic poisoning or hemorrhage, but very frequently some intercurrent disease. The hemorrhage either produces exhaustion, by repeated bleeding, or causes death by effusion into some vital organ, as, for instance, the brain.

Causes. Interstitial nephritis is a disease of middle life, being rare before twenty and most frequent at or about fifty. Males are affected much oftener than females, the proportion being as three to one. The gouty diathesis predisposes to it. Workers in lead are especially prone to it. Possibly also slow poisoning by other metals may develop it. Its frequency after gonorrhœa has led to the belief that a relationship subsists between the latter and interstitial nephritis. Whether this, the latter, results from transference of the catarrhal affection along the urinary tract to the kidneys, or as a result of medicine taken for its cure, has not yet been determined.

Suppurative Nephritis.

Suppurative nephritis is an inflammation of the kidney resulting in abscess. It is more intense than either of the varieties above considered, and affects both parenchyma and interstitial substance. It commences, as a rule, in the tubules,

as a catarrhal affection, but speedily also involves the interstitial substance. The result is a blending of the phenomena of interstitial and parenchymatous nephritis. The tubal epithelium undergoes the various phases of cloudy swelling, fatty degeneration and disintegration; the interstitial substance is densely infiltrated and finally breaks down into purulent depots. The kidney is at first enlarged and hyperæmic, the redness of hyperæmia forming the groundwork, which is interspersed here and there with blotches or striations of a yellowish-white color. These blotches and striations, when taken together, are found to have a pyramidal outline, and to occupy the position of the pyramids, but extend from the apex of the same to the capsule, to which they are firmly attached. They represent the territory of infiltration. At various intervals throughout this territory occur larger and smaller depots of pus. By continual enlargement and coalescence, the entire kidney may become purulent, a bag of matter enclosed within the capsule being all that remains to attest its former existence.

Causes. Suppurative nephritis, as a rule, arises by extension upward from the inflamed urinary passages. The inflammation passes from the renal pelvis into the tubules, and thence diffuses. It may originate in the renal pelvis, from the presence of a renal calculus, or from the passage of irritating substances through the kidneys; but more frequently is secondary to an inflammation of the bladder, associated with retention of urine. Paralysis of the bladder and urethral obstruction are frequently followed by decomposition of urine and catarrhal inflammation of the bladder, which in turn is liable to be transmitted to the kidney. The urine in these cases abounds in bacteria, and these latter are found in suppurative nephritis, filling the tubules and subsequently occupying the interstital spaces, having passed through into the connective tissue. These by some are supposed to be the sole

cause of suppurative nephritis. Stone in the bladder, surgical operations on the urinary organs, pyæmia and certain other infectious diseases, are occasionally followed or attended by suppurative nephritis. These are all reconcilable with the theory of bacteric origin.

Other names used to distinguish this disease are *renal abscess*, *pyelo-nephritis;* and when the result of surgical operation, *surgical kidney*.

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