THE MICROSCOPE

IN

ITS APPLICATION

TO

PRACTICAL MEDICINE.

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BY

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TO

MY FRIEND

HENRY W. ACLAND, M.D., LL.D., F.R.S.,

REGIUS PROFESSOR OF MEDICINE IN THE UNIVERSITY OF OXFORD
AND HON. PHYSICIAN TO H.R.H. THE PRINCE OF WALES.

PREFACE.

THE continually increasing importance of minute microscopical enquiry to those engaged in investigating the nature of disease and promoting the advance of medicine, has rendered it expedient to improve this book and make many additions to it. Although increased professional and other duties have prevented the author from devoting as much time to its revision as he could have wished, and the work is still far from what he desires it should be, the present edition is in many respects an improvement upon the last. The work now contains fifty-eight plates which have been arranged and printed with the greatest care. The text has been revised throughout, and nearly 100 pages of new matter added. In order that these changes might be made without considerably increasing the size and price of the volume, and subjects of the greatest importance to the practitioner fully treated of, it has been necessary to omit the chapters on the structure of the healthy tissues and organs. This is of little importance since this part of the subject is treated of in many other works, and much of what was published in previous editions will be introduced into an enlarged edition of the author's work on the tissues, upon which he is now engaged.

In the hope of making the book more useful to those studying medicine, 'suggestions for taking cases and making post-mortem examinations,' together with forms for recording the results of physical examination, have been introduced.

With the view of enabling the student to acquire with as little trouble as possible correct notions of the appearance of various objects, the number of illustrations in this work has been largely increased. Many of them have been drawn on wood or stone by the author himself. Some experience in medical teaching has convinced him that in many cases careful drawings may be substituted for long descriptions of objects with advantage. He feels that in these days when there is so very much that must be learnt, it is the duty of the teacher to study not only how correct ideas may be conveyed to the student's mind, but how these may be communicated most simply, and most pleasantly.

The author's thanks are especially due to Mr. Sorby for kind assistance in revising the paragraphs upon spectrum microscopic analysis, to Mr. Lockhart Clarke for the directions for preparing specimens of the brain and spinal cord given on p. 24, and to Dr. Tilbury Fox and Dr. Tonge for help in the preparation of the chapter on parasites.

Of the new drawings some have been engraved by Miss Powell and others by Mr. Hart.

61, GROSVENOR STREET,
November, 1866.

PREFACE

TO

THE FIRST EDITION.

A SHORT course of lectures given in the spring of last year, forms the basis of the present volume. To the notes which had been prepared, and which the author had originally intended to print for the use of his pupils, much has since been added, and it is hoped that, in its present shape, the work may afford some assistance to practitioners and students in medicine who employ the microscope in clinical investigation, or in physiological and pathological inquiries.

In the present day, this branch of investigation is being pursued by all who are most anxious to increase our knowledge of the structural alterations taking place in disease, and of adding to our information concerning some of those important processes which interfere with the due performance of the healthy functions of different organs—investigations in which all may find ample employment, and may thus contribute to the advancement of the true interests of their profession, and aid in the elucidation of truths which may ultimately promote the interests and welfare of mankind in a degree not less than they will add to the advancement of science.

Except in cases referred to in the text, the woodcuts, which have been carefully executed by Mr. Davies, have been copied from drawings taken by the author from objects actually under observation.

In preparing the work, the author has to acknowledge the assistance he has derived from the suggestions of many; and he is very desirous of taking advantage of this opportunity of acknowledging how much he owes to his kind friends Dr. Todd, Mr. Bowman, Dr. Johnson, and Dr. Acland, not only for the valuable assistance and

information which he has on all occasions derived from their instruction and advice, but also for the warm encouragement they have constantly afforded him while he was a pupil and ever since.

To his friend, Dr. Conway Evans, the thanks of the author are also due for much kind assistance.

27, Carey Street,
4th April, 1854.

PREFACE

TO

THE SECOND EDITION.

The author has endeavoured to increase the usefulness of the work and render it as practical as possible. With this view it has been revised throughout, and many of the articles have been entirely re-written. Much that related merely to manipulation in the first edition, will be found in "How to Work with the Microscope," and has, therefore, been omitted in the present one. In place of this, much matter bearing more exclusively upon Medicine has been introduced, and upwards of sixty new and original woodcuts have been inserted.

27, Carey Street,
October 1, 1858.

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PLATE LVIII.—Forms of Female Chest for recording Physical Signs, &c.

TO THE READER.

THIS work may be 'read' by studying the drawings with occasional reference to the text. A description of each figure is appended to it, and in many cases the section or page in which the subject is treated of is noted. The author is of opinion that the student will obtain more correct views by the attentive examination of well executed figures than by reading very lengthy descriptions, and experience has convinced him that the subjects discussed in this volume can be properly taught only by the exhibition of actual specimens and careful drawings.

PART I.

THE APPARATUS NECESSARY FOR THE EXAMINATION OF OBJECTS OF CLINICAL IMPORTANCE, OF THE PRACTICAL OPERATIONS REQUIRED FOR THEIR DEMONSTRATION AND OF RECORDING THE APPEARANCES OBSERVED.

CHAPTER I.

Of the Apparatus necessary for Microscopical Investigation.—Method of submitting a portion of Tissue or other Object to Microscopical Examination.—Of the Medium in which Objects should be Examined.—Great caution necessary in drawing inferences from Microscopical Appearances.—Of Drawing Objects.—Camera Lucida.—Steel Disc.—Glass Reflector.—Of Drawing Objects which it is intended should be Engraved.—Of making Lithographs.—Of ascertaining the Magnifying Power of Object Glasses.—Of Measuring the Diameter of an Object.—Standards of Measurement.

In this work I shall only allude briefly to the kind of instrument and apparatus required by the student for pursuing microscopical enquiries in connection with clinical medicine. The principal forms of microscopes, the different pieces of apparatus and the methods of using them, have been already described in "How to Work with the Microscope," and frequent references have therefore been made to the different sections of that work; but, for sake of brevity, the following mode of reference has been adopted throughout this book—H. to W., § .

Microscope and Accessory Apparatus.

1. Microscope.—In the *simple microscope* the magnified image of the object passes at once to the eye of the observer. The *compound*

microscope is the only one now used for microscopical research. In this instrument the object is magnified in the first instance by the *object glass*. This magnified image is again magnified by the *eye-piece*. The image then is of course inverted, which inconvenience may be obviated, if desired, by causing it to pass through another set of lenses termed the *erector*.—H. to W., § 3.

The *Student's Microscope* should have a large stage, firm tripod stand, coarse and fine adjustments, double mirror, and arrangement for inclining the body. With two powers and bull's-eye condenser the instrument costs from five to ten guineas.* Some forms of students' microscopes are referred to in "How to Work with the Microscope," §§ 15, 16, where the chief points to be considered in choosing a microscope are enumerated.

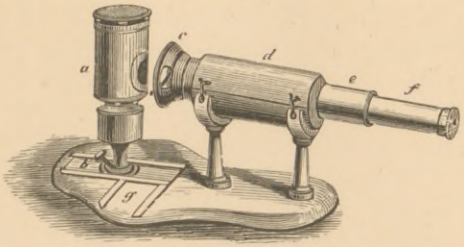
2. The Clinical, Pocket, Travelling and Class Microscope—Is an instrument devised by me some years since, which I have found very useful for general observation in the fields, and also for medical work and for class demonstration. This form of microscope is composed of draw-tubes, like a telescope, of which there are three, tube *a* (fig. 3, pl. I) carries the eye-piece, is four-and-a-half inches in length, and slides in tube *b*, which is of the same length, but only slides up to its centre in the outer tube *c*. Tube *b* carries the object-glass. The tube *b* can be fixed by the aid of a screw-ring, *d*, at any height, according to the focal length of the object-glass. This arrangement prevents the risk of the object-glass being driven through the preparation while being focussed. A screw clamp is attached to the lower part of the body for fixing the preparation in any particular position. There is also an aperture for admitting light to opaque objects. The preparation is held in close contact with the flat surface at the end of the microscope by pressure of a spring (fig. 9), which allows the requisite movements to be made with the hand.

That part of the object which it is desired to examine can be easily placed opposite the object-glass if the instrument be inverted. Next, the focus is obtained by a screwing movement of the tube *b*; and if it be desired to examine any other parts of the object, this is easily effected by moving the slide with one hand while the instrument is firmly grasped by the other. Delicate focussing is effected by drawing the tube *a* up and down, a movement which alters the distance between the eye-piece and the object-glass.

Any object-glass may be used with this instrument. I have adapted various powers, from a *three inch*, magnifying *fifteen diameters*,

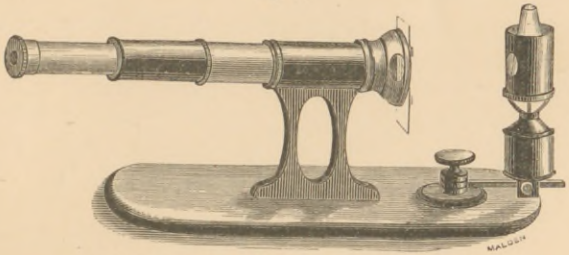
* Students' microscopes are now made by almost all microscope makers. To Mr. Salmon the credit of being one of the first to make a well-arranged cheap microscope is due.

Fig. 1.



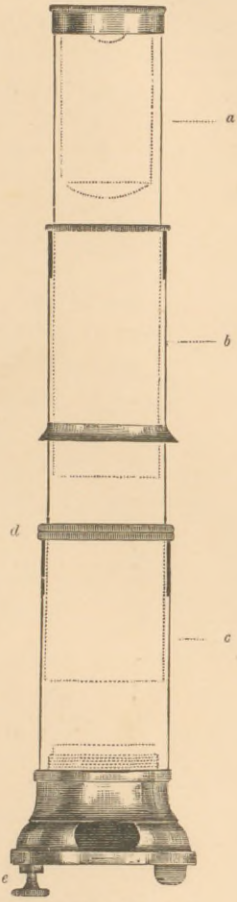
Clinical microscope, with stand, arranged for class purposes, with lamp. § 2.

Fig. 2.



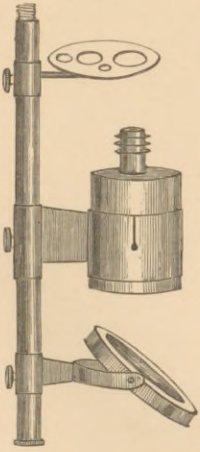
Clinical microscope, with stand and lamp, improved by Mr. Highley. § 2.

Fig. 3.



Pocket or clinical microscope, half the real size. *a*, tube with eye-piece. *b*, tube carrying object glass. *c*, tube in which the last slides, with stage. *e*, clamp for fixing preparation. § 2.

Fig. 4.

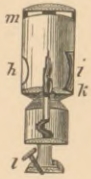


Arrangement for adapting diaphragm mirror and condenser to 'clinical microscope.' § 2.

Fig. 5.

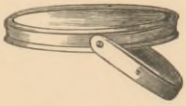
Mirror for clinical microscope. § 2.

Fig. 6.



Lamp *h*, aperture with mica. *k*, diaphragm. *l*, screw for fixing lamp § 2.

Fig. 7.

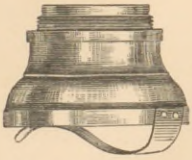


Mirror employed for examining objects by transmitted light. § 2.

Fig. 8.

Sectional view of cell.

Fig. 9.



The stage, side view, showing position of the spring. § 2.

[To face page 2.

to a *twelfth*, magnifying *seven hundred diameters*, and I feel sure that even higher powers may be used.

For transparent objects, ordinary daylight or the direct light of a lamp may be used. For opaque objects and for ordinary reflected light examinations, sufficient illumination is obtained from an ordinary wax candle or small lamp placed at a short distance from the aperture just above the object.

I constantly use this little microscope in clinical teaching. Various urinary deposits, specimens of sputum, &c., may be examined by the patients' bedside, and their characters demonstrated to the class, and it is most convenient for all ordinary microscopical work in the wards. It may be used either with or without its stand. The arrangement of the stand, with its lamp, mirror, diaphragm, condenser, &c., will be at once understood by reference to figs. 1, 2, 4, pl. I. These microscopes can be purchased for twenty-five shillings, without powers; and with the stands they will probably cost not more than three pounds each. (See also H. to W., § 21.)

3. Eye-pieces—Negative and Positive.—The eye-piece ordinarily used is the *negative* or *Hughenian* eye-piece. It consists of two plano-convex glasses, the *flat* surfaces of which are directed upwards. The glass nearest the eye being the *eye-glass*, and the one at the greater distance the *field-glass*.

In the *positive eye-piece* the convex surfaces of the glasses are directed towards each other. This latter eye-piece is only used when it is necessary to see distinctly some object in the eye-piece, as an instrument for measuring, at the same time that the object itself is in focus. The positive eye-piece is not now used in observation.

4. Object-glasses.—1. *The inch*, magnifying from 30 *to* 40 *diameters*, the glasses of which can be removed one by one, so that lower powers can be obtained. 2. *The quarter* of an inch, magnifying about 200 *diameters*. These glasses should *define well*, the field should be *perfectly flat* and free from *coloured fringes*, and they should admit a sufficient amount of light. The object-glasses used in the best instruments are of English manufacture, but some of those furnished with the cheap microscopes are made on the continent, and although much less expensive, the defining power of many of them is very good, insomuch that they are practically useful for all ordinary work. A good English quarter cannot be purchased for less than five pounds, but these foreign objectives can be obtained for from ten to thirty shillings. The higher object-glasses which are useless without considerable practice are the *twelfth*, *sixteenth*, *twenty-fifth* and *fiftieth*. The first of these magnifies about 700 diameters, the last nearly 3,000. These high objectives, now made

by Messrs. Powell and Lealand, are most valuable glasses, but the student is recommended not to attempt to use them until he is perfectly familiar with the management of the lower powers and has had great experience in manipulation and the preparation of objects.

5. The Diaphragm—Is a circular plate with holes in it of different sizes. By it the circumferential rays of light reflected from the mirror may be cut off.—H. to W., § 13.

6. The Bull's-eye Condenser.—This instrument is required for condensing the light on the object in the examination of opaque preparations, and for dissecting under the influence of a strong light. —H. to W., § 25.

7. Achromatic Condenser.—Employed in the examination of objects by transmitted light.—H. to W., § 32.

8. Lamps for Artificial Illumination.—A small French moderator forms an excellent lamp for microscopical work. The German lamps lately introduced by Mr. Pillischer give an excellent light and can be easily arranged at any desired height. To microscopists provided with gas, I recommend the Argand gas lamp designed by Mr. Highley.—H. to W. §§ 39, 40. But the lamp which I find upon the whole most advantageous for microscope work, even when the 1-50th of an inch object-glass is used, is one of the small paraffin lamps with a round wick, now commonly sold for *1s. 6d.*

Apparatus for Drawing and Measuring Objects, and for ascertaining the Magnifying Power of Object Glasses.

9. Neutral Tint Glass Reflector.—This fits on the eye-piece, the microscope being arranged horizontally.—H. to W., § 44.

10. Common Hard Pencils, *steel pens, Indian ink, fine Bristol board, tracing paper, retracing paper.*

11. Stage Micrometers *divided into* 100*ths and* 1000*ths of an inch.* —H. to W., § 60.

Instruments and Apparatus for general purposes.

12. Wire Retort Stand for supporting watch-glasses, &c., pl. III, fig. 12.—H. to W., § 70.

13. Tripod Wire Stands, pl. III, fig. 13.

14. Spirit Lamp, pl. III, fig. 12.—H. to W., § 69.

15. Evaporating Basins.

16. Watch-glasses.

17. Thin Glass, cut in squares and circles.

18. Plate Glass and Common Glass Slides, all three inches by one inch. No other sizes should be used.

FOR MAKING DISSECTIONS, AND FOR CUTTING THIN SECTIONS OF SOFT AND HARD TISSUES.

19. Common Scalpels.

20. Double-edged Scalpel, pl. IV, fig. 20.

21. Scissars, ordinary form, and a small pair with curved blades, pl. III, figs. 15, 16, 17.

22. Needles, mounted in handles, for dissecting. The handles of crochet needles are convenient for holding the needles, some of which may be flattened near the points, so as to serve for delicate knives.

23. Forceps.—One pair of ordinary dissecting forceps, and one pair with curved blades, pl. III, fig. 18. *Forceps for sputum*, fig. 19.

24. Glass Dishes, of various sizes, from an inch to two inches in depth, for dissecting under water.

25. Loaded Corks, pl. IV, fig. 25.

26. Fine Pins.

27. Saw, with fine teeth, for cutting thin sections of bone and other hard tissues, pl. IV, fig. 24.

28. Hones, for grinding sections of bone thinner, and for polishing them.

29. Strong Knife for cutting thin sections of bone, &c.

CEMENTS, PRESERVATIVE FLUIDS, AND APPARATUS FOR MOUNTING OBJECTS IN AIR, AQUEOUS FLUIDS, AND BALSAM.

30. Brunswick Black, containing a few drops of a solution of India-rubber in coal naphtha. Bell's cement for glycerine preparations.—H. to W., § 90, 91.

31. Spirit and Water.—H. to W. § 99.

32. Glycerine (Price's).—H. to W., § 100.

33. Gelatine and Glycerine.—H. to W., § 106.

34. Solution of Naphtha and Creosote.—H. to W., § 102.

35. Carbolic Acid and Water.

36. Chromic Acid.—H. to W., § 104.

37. Turpentine. Canada Balsam.

38. Cells of various sizes.

39. Small Glass Shades, *to protect recently mounted preparations from dust.*

FOR THE SEPARATION OF DEPOSITS FROM FLUIDS.

40. Conical Glasses, pl. V, fig. 27.

41. Pipettes, pl. V, fig. 29.

42. Wash-bottle, pl. V, fig. 28.

43. Animalcule Cage, pl. V, fig. 30. **Glass Cell,** fig. 31.

FOR MAKING INJECTIONS.

44. Injecting Syringe, holding from half an ounce to an ounce, pl. V, fig. 32.

45. Pipes of various sizes, pl. V, fig. 33.

46. Corks for stopping the pipes, pl. V, fig. 34.

47. Needle for passing the thread round the vessel, pl. V, fig. 37.

48. Bull's-nose Forceps, for stopping vessels which have been divided, pl. V, fig. 36.

49. For making Blue Injection. — *Ferrocyanide of potassium.* "*Muriated tincture of iron,*" *or the* "*Tincture of Perchloride of Iron,*" *of the British Pharmacopœia. Glycerine* and *spirits of wine* for preparing the *Prussian blue injecting fluid* (§ 97).

CHEMICAL ANALYSIS IN MICROSCOPICAL INVESTIGATION.

50. Platinum Foil.

51. Test Tubes and Rack.

52. Small Tubes, about an inch or an inch and a half in length.

53. Stirring Rods.

54. Evaporating Basins.

55. Watch-glasses.

56. Small Glass Bottles with capillary orifices.

57. Wire Triangles, tripods.

58. Small Retort Stand.

59. Small Platinum Capsule.

60. Small Flasks.

61. Platinum Wire.

REAGENTS.

62. Ether.

63. Nitric Acid.

64. Acetic Acid.

65. Ammonia.

66. Solution of Potash.

67. Solution of Soda.

68. Nitrate of Silver.

69. Nitrate of Barytes.

70. Oxalate of Ammonia.

71. Iodine Solutions.

72. Test Papers.

*** The instruments and apparatus above enumerated, may be obtained of Mr. Matthews, Portugal Street, Lincoln's Inn; Mr. Highley, Green Street, Leicester Square; Mr. King, 190, Great Portland Street, W. They are also furnished by most instrument makers. Many have been figured in "How to Work with the Microscope," and figures of some of the most important have been repeated here.

Of Examining Objects.

It is not within the limits of the present work to describe the anatomy of tissues in a healthy and diseased state, but I shall describe the methods for demonstrating the anatomy of healthy and diseased structures, which appear to me the most useful. Where any particular method of investigation is required to demonstrate the minute anatomy of a tissue, it will be my endeavour to give an illustration of it. The student will, I hope, by reference to other works, be enabled without much difficulty to fill up for himself those deficiencies which limited space will not permit me to supply.*

73. Method of submitting a portion of Tissue, or other Object, to Microscopical Examination.—Objects may be examined by transmitted and by reflected light. By the former we learn the nature of the texture and internal arrangement of tissues, while by the latter mode of examination we can only recognize peculiarities of the surface.

For examination by transmitted light, an object must be sufficiently thin and transparent to permit light to pass through it, while thickness and opacity present no impediments to examining its surface by throwing the light down upon it (reflected light).—See H. to W., § 23 to § 29. In order to subject a portion of tissue or any substance to examination by transmitted light, one usually proceeds as follows:—A glass slide is carefully cleaned, and the thin section of tissue which has been removed by the aid of forceps and scissars, or a scalpel, placed in the centre; a drop of clean water, serum, glycerine, or other liquid, is then added, and the whole covered with a clean square or circle of thin glass. If the under surface of the thin glass be gently breathed upon, it becomes wetted more easily. The substance may be teased out with needles, pressed, or unravelled if necessary before covering it with the thin glass. If the substance be covered with much soft pulpy matter, or débris produced in the process of cutting the section, it may be slightly washed in water before being placed upon the slide, or a jet of water from the wash-bottle may be forced upon it. Thin sections will require to be laid flat upon the slide, with the assistance of needles and forceps.

74. Of the Media in which Objects should be Examined.—With reference to the medium in which any particular object is to be examined, but few rules can be laid down. Many structures may be examined in water, but it should be borne in mind that this fluid

* The Archives of Medicine, and Papers in the Phil. Trans. The Physiological Anatomy and Physiology of Man. The Structure of the Tissues, &c.

often alters the character of the tissue very much. Generally, tissues should be submitted to examination in a medium which closely resembles that which surrounds them during life in density and fluidity. Thus, albumen and water form a very useful fluid for examining many structures. In a fluid of this kind, made to resemble as closely as possible in density and in chemical composition the fluid which bathes the tissues during life, we may conclude that the appearances observed are natural, and not produced artificially. There are, however, many cases in which it is desirable to examine a tissue in a medium of much greater density that that with which it is ordinarily surrounded. There are many highly refracting structures which require immersion in a highly refracting medium before their arrangement can be made out. When a section of a tissue appears thick and opaque in water, immersion in such a medium often renders it perfectly clear and transparent. White fibrous tissue, although so opaque, even in very thin layers, as to prevent structures embedded in it from being visible, may be made perfectly clear and transparent by being immersed in syrup or in glycerine. Of these fluids glycerine is the most convenient, and can be easily diluted to any required strength. When employed dilute, it is well to place a piece of camphor in the bottle in which it is kept, which prevents it from becoming mouldy. In the investigation of morbid growths, great advantage will be gained by the use of glycerine, but when fibrous tissue is present, its characters must be made out in water, or in a fluid of very moderate density; and in observing the appearances of a structure in glycerine, allowance must always be made for the greater transparency of the fibrous tissue. The composition and method of using different preservative solutions are fully discussed in "How to Work with the Microscope," and, therefore, need not be again referred to here.—H. to W., § 19 to 113.

75. Of making and recording Observations, and of drawing Inferences from Microscopical Appearances.—The difficulty of making out the structure of many organs and tissues is great, and very considerable practical experience is required to demonstrate distinctly the anatomical characters of a healthy texture. These difficulties are much increased in the examination of morbid growths. When chemical reagents are applied, the effects must be very carefully observed, otherwise there is danger of mistaking the change of character produced by the application of the reagent, for a morbid alteration. Even the addition of a drop of water often materially alters the microscopical characters of a tissue. It is only by very frequent and careful examination of morbid growths, that the

observer can hope to recognize and interpret their characteristic appearances, and it should only be with the utmost caution, and after long familiarity with microscopical examination generally, that he should attempt to pronounce an opinion with reference to the nature of a morbid growth. Without extensive observation and great care, he will run the risk of bringing discredit not only upon himself as an observer, but also upon microscopical investigation generally. The opinion is much too common that a good instrument and the necessary apparatus are alone required to make a microscopical observer, and it is well that every one should guard himself in the outset against so fatal a mistake. Every one must educate his eye for himself, and although he will undoubtedly receive some assistance from the teaching of others, from books and faithful drawings, he must not depend upon these, but must trust chiefly to his own energy and perseverance. No one who does not at once make up his mind to give up a good deal of time to the pursuit, can ever become an observer, or learn how to avoid making great mistakes; and he who cannot, or is unwilling to spend considerable time in work had better not take up the subject at all. A good knowledge of drawing, of the stethoscope, of the ophthalmoscope, and indeed of any other investigation accessory to medical research, requires far more devotion than is implied in the mere sacrifice of the money which is necessary for the purchase of books and instruments. So it is with the microscope; and he who has the largest means at his disposal for obtaining the most costly instrument made, and all the books published on the subject, with the advantages of the best tuition, is not more likely to become a useful, earnest labourer in this field of inquiry, than the student who spends his five pounds in a simple instrument, without any unnecessary luxurious arrangements—with a conviction that the study is real, and worthy of attention, and with a determination to set to work honestly and zealously with the hope of being one day able to add his work to that of men who have worked before him, whose lives and labours he respects and honours.

The student is recommended to examine very frequently the structure of the kidney and liver in man and many of the lower animals, because these organs are very often the subjects of investigation in cases of disease; the changes in structure which they undergo having received a large share of attention.

Of Drawing, Engraving, and Measuring Objects.

76. Of Drawing Objects.—It may almost be said that all progress in our knowledge of minute structure, both in healthy and diseased

tissues, depends upon the drawings which are made. It is almost hopeless for an observer to attempt to describe what he sees in words, and such descriptions, however detailed they may be, cannot, to any advantage, be compared with those of others. On the other hand, a truthful drawing of what a man has seen lately, may be compared with others which may be made a hundred years hence, although the means of observation will be far more perfect than they are at present. Much will be learned by such comparisons. I am sure that an honest inquirer cannot be of greater use in his time than by making good drawings of what he has seen;—they will be of far greater help to our successors, than any amount of description we can write for them, and we may feel sure they will look at our drawings if they are honest copies of nature, while we all know that comparatively very little of what we write will be read when the whole aspect of this department of science shall be changed.

Although the method of drawing objects has been fully discussed in "How to Work with the Microscope," the subject is so important that I think it desirable to give some brief directions here.

In delineating an object magnified by the microscope, it is important to copy it correctly, both as regards the relative position of the several structures to each other, and also with respect to size. To copy the size exactly will be found extremely difficult by the eye alone, but there are several ways of proceeding by which accuracy may be ensured. Some of these I shall now briefly describe. The simplest method is to place the paper upon the same level as the stage upon which the object is situated. If we now look steadily at the object with one eye, while the other is employed to govern the movements of the pencil, the object will appear to be thrown as it were upon the paper, and its outline may be very readily traced. By a little practice, the relative size of objects may be insured in this manner, but it is troublesome and difficult to keep both the object and paper perfectly still. The principle of the camera lucida has been applied to taking microscopical drawings, and has been found to succeed admirably. The object appears to be thrown down upon the paper, and with a little practice the observer may trace the lines with great accuracy. If a little *steel disc* be placed at an angle of 45° with the eye-glass, it will receive the magnified image of the object and reflect it upwards upon the retina of the observer.—H. to W., § 43. The simplest and cheapest reflector for microscopical drawing, consists of a small piece of plate-glass slightly coloured, in order to improve its reflecting power, but still not so dark as to prevent an object being seen through it perfectly.—H. to W., § 44, plate xvii.

77. Of Drawing with these Instruments.—In order to use these

instruments, the microscope is arranged horizontally, and the paper placed on the table. It is important to arrange the light very carefully. The image should not be illuminated too intensely, and the paper upon which the drawing is made should not be too much in the shade, or the point of the pencil will not be seen distinctly. Experiment can alone decide the relative intensity of the light upon the object and upon the paper, but with a little practice the proper amount of illumination will be discovered. The distance between the reflector and the paper should be precisely the same as from the object to the eye-piece, for otherwise the size of the object delineated will be altered.

The object appears to be thrown upon the paper, and its outline is very readily traced. If it is to be drawn smaller, it is only necessary to place the paper upon a stand closer to the reflector. If, on the other hand, a large *diagram* is required, the distance must be increased. By placing the diagram paper upon the floor, the object can be readily traced with a long pencil. In this manner many of my diagrams have been made. They must of course be accurate copies of the objects themselves, and are therefore far more truthful than diagrams, copied from drawings representing microscopical structure, can be. If the distance of the diagram paper be always the same, the drawings so obtained may be compared with each other, and scales of measurement may be appended to them.—H. to. W., § 62.

78. Of making Drawings which it is intended should be Engraved.—With a little practice, the observer may acquire the power of drawing on wood, and the engraver will often be able to produce a more faithful representation of the object than he could by copying the *drawings* on paper of the microscopical observer. It is, however, necessary to practise the plan of producing varieties of tints, by straight lines, whenever this can be done, as the labour of engraving is thus much economised. The drawing should first be made roughly on paper, in order to obtain the size and general characters of the object. A piece of retransfer paper is then placed between the prepared block and the paper sketch, and the prominent lines of the drawing retraced with some blunt-pointed instrument (a needle, the point of which has been made blunt by filing it, answers very well). By using a slight pressure, the colour of the retransfer paper is transferred to the wood block in the lines corresponding to those of the drawing. These lines are afterwards traced with lead pencil, corrected, if necessary, and the delicate parts of the drawing filled in by carefully copying from the object.

If the engraving is to be a facsimile of the drawing with the

different parts on corresponding sides, it is necessary, in the first place, to copy the picture with ordinary tracing paper, and *invert* the tracing upon the retransfer paper on the wood block, as the impressions are of course always reversed; or a reverse may be obtained by copying the image of the drawing reflected from a looking-glass.

Tracing Paper, Retransfer Paper and Wood blocks can be obtained all ready for use at the artists' colourmen. See list of addresses at end of the volume.

79. Of obtaining Lithographs of Microscopical Drawings.—I have given directions for drawing on stone in H. to W., § 50, *et seq.*

If the drawing does not contain much very minute work, it may be drawn on good lithographic *transfer paper* with lead pencil, direct from the microscope. Afterwards, the lines are to be traced with a pen with lithographic ink; the shading may be effected by delicate lines made with the pen, or with lithographic chalk. There are two plans for drawing on the stone itself, which produce better results than the preceding method, but they require more practice for their performance.—See H. to W., § 53. If the work is very delicate, as is the case with most subjects the microscopical observer wishes to obtain representations of, engraving on stone will give the most satisfactory results. The process is very simple, but requires considerable practice in executing it.—H. to W., § 54. It will, I know, be said that these processes take much time, and are of a nature which an intelligent draughtsman can perform, and are hardly worth the labour which a microscopical observer who wishes to carry them out must be content to bestow. Objections of other kinds may be urged, but I cannot but feel that if I had been prevented from having the drawings made at home, not one of the pages illustrating many of my works would have been published. I believe it to be quite as impossible to obtain a good representation of any microscopic object without long and careful study, as it is to produce a copy of any other object in nature; and surely it is hard to expect a draughtsman who is engaged in copying various subjects to spend hours in looking at specimens in a microscope, observing things which he neither knows, nor perhaps desires to know, anything about.

Whatever is observed is worth copying, provided it has not been correctly copied before. Very much yet remains to be done in representing microscopic texture faithfully. Photography has done much, and will doubless assist more; but there are many structures, the colour of which alone renders it quite impossible to obtain photographs of them. It can only be by patient study that any one can hope to be able to copy accurately by hand the beautiful and

delicate lines and tints in many microscopic objects; but it is so important that this should be done well, that I cannot too strongly urge on all those who wish to work at the microscope, earnestly to practise drawing as much as possible on micro-photography.—See H. to W., chapter ix., p. 149 to 189.

It is beyond the power of language to describe the characters of many structures in such a way that their appearance could be reproduced in the mind of another; and even if this could be done, so wonderfully delicate and minute are the observed differences in many cases, that any attempt to classify and arrange our observations seems at present hopeless, and becomes more hopeless in proportion as observations multiply, while the different meanings which different persons attach to words and phrases, give rise to another difficulty in our attempt to collate and deduce inferences from the observations which have been made. It therefore seems to me that all advance in our knowledge of structure, as well as of the minute changes incessantly going on in living organisms, really depends upon accurate copies of the objects being made, for in this way alone can the work of the present generation be useful to that which succeeds it.

80. On Measuring the Diameter of Objects.*—Instead of alluding to the dimensions of an object in the text, it is better to refer the reader to properly arranged scales appended to every drawing. If these scales are magnified in the same degree as the objects delineated, the diameter of every object depicted may be at once read off. For all ordinary purposes, it is only necessary to compare roughly the size of the drawing with the scale, which is magnified in the same degree as the specimen itself, but in those instances where great accuracy is important, a pair of compasses may be used. In my memoirs and books, I have not stated the dimensions of any of the objects, because any one can readily ascertain these for himself, by reference to the scales appended.

I cannot therefore too strongly recommend all microscopic observers to ascertain for themselves *the magnifying power of every object-glass*, and to prepare, in the manner described in H. to W., § 62, *a scale of measurement by which the dimensions of every object can be at once ascertained.*

81. Mode of ascertaining the Magnifying Power of the Object-glass.—A glass micrometer divided into 100ths of an inch is placed in the focus of the object-glass of the microscope, which is arranged horizontally. The neutral tint glass-reflector is fitted to the extremity

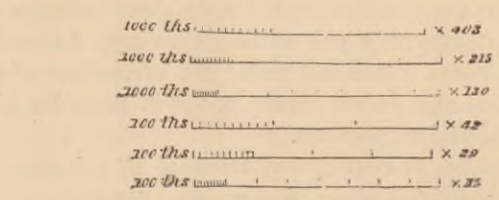
* See also "How to Work with the Microscope," and a paper in the "Archives of Medicine," No. 1.

of the eye-piece, and the light carefully adjusted so as to render the micrometer lines distinctly visible. Care must, however, be taken that the distance from the object-glass to the reflector is the same as from the latter to the paper beneath it, upon which the magnified micrometer lines may now be traced. A four or six-inch scale, accurately divided into 10ths of an inch, is now applied to the magnified 100ths of an inch, which have been traced on paper, and the magnifying power of the glass is at once ascertained. Suppose each magnified 100th of an inch covers one inch, the magnifying power will be 100 diameters; if an inch and three-tenths, 130 diameters; if four-tenths of an inch, 40 diameters; and so on, each tenth of an inch corresponding to a magnifying power of ten times.

If we wish to ascertain the magnifying power of one of the higher object-glasses, a micrometer divided into 1000ths of an inch should be employed instead of the one just alluded to. In this last case, each tenth of an inch upon the scale, corresponds to a magnifying power of one hundred, instead of ten diameters. Any fractional parts can be readily estimated if we have a very accurately divided scale. This process must be repeated for every object-glass, as well as for each different eye-piece employed with the several objectives.

82. To ascertain the Diameter of an Object.—If an object be substituted for the micrometer, and its outline carefully traced upon paper, its dimensions may of course be easily ascertained by comparison with the micrometer lines. The magnifying power used being the same in both cases.—H. to W., § 64.

The following are examples of some of the scales referred to:—



1000ths and 100ths of an English inch magnified in various degrees. The smallest divisions indicate 10,000ths and 1000ths of an inch.

83. Standards of Measurement.—In this country we usually employ the English inch, but on the continent the Paris line=·0888, or about 1-11th of an English inch, is very generally used. The sign ''' is used to signify "of a line," and has been employed by Professor Kölliker in his works, while '' signifies "of an inch." In order to compare the researches of different authors, it is often necessary to convert one expression of measurement into another.—See H. to W., § 66.

CHAPTER II.

Methods of Examining Tissues.—Preliminary Operations.—Of Hardening Tissues.—Of Colouring and Staining the Living Matter and Formed Matter of Tissues.—Of Cutting Thin Sections of Soft Tissues.—Of Cutting thin sections of Hard Tissues: new Process.—Instruments.—Of Making Minute Dissections, and of Dissecting under Water.—Of Injecting.—New Method of Preparing Tissues for Microscopical Examination under the highest Magnifying Powers.—Of Examining Living Bodies under the Microscope, and of Arrangements for Preserving their Vitality.—Examination of Deposits from Fluids, and of their Preservation.—Of Preserving Specimens Permanently.—Of the Binocular Microscope. —Of Finders.

84. Methods of Examination.—In order to examine the structure of many tissues, it is necessary to obtain a section evenly cut, and sufficiently thin to permit the transmission of the light readily. The difficulty of making thin sections of many textures is often very great, and the section cannot be made with an ordinary scalpel. Sometimes we require to cut a thin section of a soft texture, which can scarcely be touched without injuring its delicate structure and altering the position of its constituents; while, in other instances, we must obtain a very thin transparent section of a substance so hard, that steel tools will scarcely scratch it, as the enamel of teeth, fossil teeth, &c.

Before the operation of cutting a thin section can be performed, it is sometimes necessary to soften the tissue by soaking it in some chemical solution. In other instances, the texture requires hardening, in consequence of being too pulpy and soft to be cut with a knife. A tissue may be hardened in some cases by drying it, but various chemical substances are highly valuable for this purpose.

Preliminary Operations in Examining Tissues.

85. Of Hardening Tissues by Boiling.—This operation is often of great service in enabling us to demonstrate the structure of a tissue. For instance, the fibres of which the crystalline lens is composed, are best shown after boiling the lens in water. The branched

muscular fibres in the tongue of the frog, and in other situations, may be made out very readily by boiling the tissue in water for a few moments, and then tearing up small portions with fine needles. Beautiful sections of muscular fibre can often be obtained after the texture has been boiled in water. Various glands and other tissues often require to be boiled for some time in water, in order to harden them. In all cases the microscopical characters of the recent texture should be ascertained, as well as those of the tissue which has been hardened by boiling. Small portions of tissue can be readily boiled in a test-tube over the spirit-lamp.

86. Of Washing, Soaking, or Pressing Tissues.—Not unfrequently it is necessary to get rid of the soft and more pulpy part of a tissue, in order to subject the more dense and fibrous portion to examination. This object is usually effected by soaking the tissue in water for some little time, and then placing it under a running stream of water, by which means the softer portions are gradually washed away. Soaking in water frequently enables us to tear up a tissue very readily with the aid of needles, and thus to demonstrate its structure. Occasionally it is found necessary to press the tissue, and rub parts of it together, before the soft pulpy portions can be got rid of. In this way we may demonstrate the supporting or trabecular tissue of the spleen, and the areolar and vascular tissue of many organs. Thin sections of kidney, liver, and other glandular organs, may be thus treated when we wish to wash away the epithelium and blood, in order to study the characters of the tissues which remain. In these operations the wash-bottle, fig. 28, will be found useful. Generally it will be better to make a thin section of the tissue first, and then soak and wash carefully, when the parts may be seen *in situ*. The process of rendering delicate tissues extremely thin by pressure is greatly facilitated if the tissue be immersed in a viscid medium such as strong glycerine or syrup instead of water. In this way the tissue may be frayed out without being destroyed or crushed, and thus its structure may be most clearly demonstrated.

87. Drying the Tissue previous to Examination.—Thin sections of certain tissues can be obtained only by drying the substance thoroughly in the first place; and then cutting off a thin shaving with a sharp knife. In this way specimens of skin, mucous membrane, and many other tissues, are often most advantageously prepared. The tissue is stretched on a board with pins, and then allowed to dry, when a very thin section can be cut off and examined in Canada balsam; or it may be soaked in water for a short time, and when subjected to examination, will have regained its fresh appearance. Portions of muscular fibre, pieces of the tongue, skin, the sclerotic,

choroid, and retina, and many other tissues, may be allowed to dry in this manner, and with a sharp knife exceedingly thin sections may be easily obtained, which could not be procured in any other way. The drying may be effected in a warm room, or in a current of air. A high degree of artificial heat should be avoided, and in many cases the best plan of drying a tissue is to place it in a basin under a bell jar, supported on a piece of coarse wire gauze, over sulphuric acid. The process is expedited by exhausting the air, which may be readily effected under the receiver of a small hand air pump.

88. Igniting the Substance in order to remove Organic Matter. —When the inorganic part of a tissue which is not altered by exposure to a red-heat is to be examined, recourse may be had to ignition, in order to get rid of the animal matter. In this way, crystals of carbonate and phosphate of lime, and granules of siliceous matter may be separated from the organic material with which they were combined. The beautiful siliceous shells of the diatomaceæ may be thus obtained. The ignition should be performed in a small platinum capsule, supported on a tripod (pl. III, fig. 13), or upon a small piece of platinum foil. The carbonaceous residue must be exposed to the dull red-heat of a spirit-lamp for some time, until only a pure white ash remains, which will be found to contain the objects of our search in a very perfect state. If the siliceous matter only is wanted, the ash should be treated with strong nitric acid, which will dissolve any carbonate or phosphate. The insoluble residue may then be washed and dried, and subjected to microscopical examination immersed in water, glycerine, turpentine, or Canada balsam. In many cases, this method is superior to that of boiling in nitric acid, in order to remove the organic matter. Both processes may, however, be employed where only the siliceous residue is wanted; but if we require the calcareous salts, ignition at a dull red-heat is alone applicable.

89. Of rendering Transparent Tissues more Opaque, and of making Opaque Tissues more Transparent by chemical reagents. —Many tissues which are perfectly transparent, and apparently structureless when subjected to ordinary examination, can be shown to possess a peculiar structure if treated with some chemical reagent which has the property of rendering them more or less opaque. In many cases the granular appearance produced by certain reagents, depends upon the precipitation of albuminous matter.—Thus a weak solution of alcohol often enables us to cause coagulation of the surface of a mass of germinal matter, and many have been led to infer from the appearances produced, the presence of an external membrane or cell wall where no such structure really existed. Some-

times coagulation is effected in certain lines only, and in some instances, important deductions may be arrived at, concerning the structure of the texture, as well as the manner in which the new matter was deposited. Chromic acid renders some perfectly transparent structures composed of albuminous matter more or less granular, and by the action of this substance, peculiarities of the tissue which were before invisible, are often developed. The transparent vitreous humor of the eye, was shown by Mr. Bowman to possess a curiously lamellated arrangement, by the action of acetate of lead. Acids and many salts, such as alum, acetate of lead, acetate of alumina, solution of perchloride of iron, nitrate of silver (§ 91) &c., effect a very important alteration in many perfectly transparent tissues.

Contrary to general opinion, many of the softest textures may however be investigated with the greatest facility after having been soaked in strong glycerine, and much concerning their structure may be learnt by this process. The glycerine used at first must be weak, and its strength must be very slowly and gradually increased. The reagents above referred to may be dissolved in the glycerine, and usually the prolonged action of weak solutions afford more satisfactory results than the quick action of strong ones. I have beautiful preparations of the most delicate embryonic tissues, preserved in the strongest glycerine. It is often advantageous to harden the tissues slightly by the addition of a little of the chromic acid glycerine solution. (H. to W., § 299). When once the tissues have been fully permeated by glycerine, they may be dissected and manipulated in a manner which before was impossible.

Sometimes the mere addition of a coloured solution is sufficient to render a tissue perfectly distinct, which before was too transparent to be visible. A little Prussian blue, diluted with much water, or a solution of carmine in ammonia, used in a very dilute state, will in some instances enable the observer to demonstrate the presence of basement membrane, which could not be seen before. The process of '*staining*' is very valuable for demonstrating delicate structural peculiarities in many transparent tissues. (See § 91.)

The most important *chemical* agents for rendering tissues *more transparent*, are acids and alkalies. Many structures, however, are made perfectly clear by being immersed in certain solutions of high specific gravity, which exert no *chemical* alteration on the texture. Syrup or glycerine may be used for this purpose, but I much prefer the latter, as it is not so liable to be invaded by fungi, while it forms a most excellent preservative solution. The solution of glycerine or sugar first added should be dilute, and its strength gradually increased.

This may be effected either by adding small quantities of strong glycerine or sugar at intervals of a few hours, or by concentrating the original solution by evaporation at a gentle heat or in vacuo over sulphuric acid. White fibrous tissue, which even in a very thin layer appears opaque when examined in most fluids, becomes perfectly clear and transparent after being soaked for a short time in glycerine.

Acetic Acid renders some tissues transparent by virtue of its property of dissolving earthy salts, such as phosphate and carbonate of lime, and in other instances certain forms of albuminous matters, especially the granular matter which exists in the cell wall is made perfectly clear. Acetic acid also causes white fibrous tissue to swell up and become perfectly clear, while all traces of its fibrous appearance is lost. On all varieties of yellow elastic tissue, however, it exerts no action, so that by its use the fibres of yellow elastic tissue can always be demonstrated, although embedded in the white fibrous connective tissue. Various other acids are employed in microscopical enquiries, but these will be considered in Chapter III.

Alkalies dissolve a great number of coagulated albuminous principles, and many opaque tissues are rendered perfectly transparent if acted upon by an alkali. The principal alkaline solutions used by the microscopist are *carbonate of potash*, *liquor potassæ*, and *liquor sodæ* (solutions of hydrate of potash and soda in water). These are employed of different strengths. They dissolve many opaque albuminous substances, if used very strong, and if diluted, render them clear and transparent. Sometimes it is desirable to render fibrous tissue transparent, in order to observe the character of certain earthy phosphates, or other substances embedded in it, which are known to be soluble in acetic acid. In such case an alkali must be employed. Instances of the application of acids or alkalies to the same end might be alluded to, but the particular advantages of one or other class of reagents will be brought forward in other parts of the work.

In some cases a texture may be dissolved, and thus other textures which were embedded in it become visible. The soft pulpy portion of an organ may often be got rid of by allowing a stream of water to play upon it for some time. The spleen pulp may thus be separated from the trabecular tissue of the spleen. Cells may be washed away from thin sections of liver or kidney leaving the vessels, nerves, and connective tissue of these organs. Sometimes the addition of a little hydrochloric acid is advantageous in breaking up the cellular part of a tissue. The cellular tissue may be thus removed from the vascular and fibrous texture of leaves.

Schultze has recommended the use of chlorate of potash and nitric acid for destroying connective tissue, and Kühne has particularly advocated the plan very strongly for the purpose of demonstrating the arrangement of the nerve fibres distributed to voluntary muscle, and he maintains that by this plan the nerve fibres may be shown to perforate the sarcolemma of the elementary fibres which are isolated from one another by the destruction of the intervening connective tissue. The solution may be made of various strengths. One or two small crystals of chlorate of potash may be placed in a test tube, and about half a teaspoonful of distilled water, and from ten to twenty drops of nitric acid, added.

The reaction with strong nitric acid sp. gr. 1·5 is of course much more decided, but if the solution is dilute, although the action will be slower, the results obtained will be more satisfactory. The mixture may be gently warmed and freely shaken. The muscular fibres may be seen to separate from one another. The action of the reagents, especially if strong solutions be used, corrugates the nerve fibres and alters the muscles. Indeed, as far as I am able to judge, after having examined some specimens prepared by Kühne, and others made by myself according to his directions, the results are by no means satisfactory. The appearances which I have myself seen would not lead me to accept the conclusions arrived at, but it is possible that Kühne has succeeded in making specimens more distinct and definite than any I have actually seen. I think, however, that this process, as well as many other plans of preparation strongly recommended in Germany, is wrong in principle. I have proved experimentally that many of the very fine nerve fibres which I have succeeded in demonstrating by a totally different procedure, are completely destroyed or rendered invisible in tissues subjected to strong chemical actions.

90. Of rendering Soft Tissues Hard and Transparent.—There are very many solutions which have the property of hardening soft tissues, but as their action depends principally upon the formation of insoluble albuminous compounds which are opaque and granular, but few are applicable for microscopical purposes. Various saline solutions as alum, bichloride of mercury, arsenious acid, &c., render most tissues too granular and opaque for observation. A very dilute solution of chromic acid of a pale straw colour, is useful for hardening many textures, but in most instances a compound fluid, consisting of a mixture of two solutions—of which, one has the property of precipitating albuminous substances in an insoluble state, while the other tends to dissolve them—is to be preferred. Such a solution hardens a tissue effectually, but at the same time renders it transparent. If

desirable, the refractive power of such a fluid may be increased by the addition of glycerine, and with a little trouble, fluids suitable for the examination of almost every structure may be made. The solutions which I have used, are the following: alcohol, glycerine, acetic, nitric, chromic, and hydrochloric acids, potash, and soda. Now alcohol, hydrochloric and nitric acids render many transparent albuminous textures, granular and opaque, and as is well known, produce precipitates in albuminous solutions. Alcohol will, however, dissolve fat granules. Acetic acid, potash and soda, cause many albuminous tissues, which are more or less opaque or granular, to become clear and transparent, and dissolve insoluble precipitates of certain albuminous compounds. Glycerine, in consequence of its high refractive power, renders many tissues, which in their natural state are opaque, perfectly clear. Glycerine may be made the basis of all test solutions and preserving media. The various chemical tests may be added to it, and if the textures to be tested are well saturated with the same substance, most excellent results are obtained.

By mixing together certain solutions, having opposite properties, compound fluids may be obtained, which will exert different effects upon tissues according to the proportion of the different constituents present. A mixture of alcohol and acetic acid, renders sections of the spinal cord and nerves so beautifully transparent, that many new points in their minute structure have been demonstrated, which, as far as is known, can be distinguished by no other process. This solution was employed by Mr. Lockhart Clarke in his investigations on the spinal cord. It was only after a very laborious course of investigation and repeated trials of every kind of admixture which he thought likely to produce the desired end, that Mr. Clarke hit upon this most useful fluid. In his very first paper, before he had carried his observations upon the anatomy of the cord to any very great extent, he described minutely the manner in which his specimens had been prepared, and thus liberally gave his fellow-labourers the advantage of carrying on investigations in this wide field of enquiry, although he himself had only commenced his researches. Dr. Lenhossek, of Vienna, has adopted Mr. Lockhart Clarke's plan, and has made some beautiful specimens, which he exhibited in London some time since, and which may now be seen in the Museum of the Royal College of Surgeons.

No better example than this can be adduced of the great value of studying the chemical and physical characters of the tissues, and endeavouring to overcome, by particular methods of investigation, the impediments which exist to the successful demonstration of the

anatomy of many structures. The solution employed by Mr. Clarke, is composed of three parts of alcohol and one part of acetic acid. The proportions may be varied according to the properties which the new fluid is required to have. For some time past Mr. Clarke has adopted a modification of his original plan. He has been kind enough to send me the following directions, which I print in his own words :—

Mr. Lockhart Clarke's Method of preparing the Brain and Cord for Microscopical Examination.—The spinal cord and medulla oblongata of man, and the higher mammalia are to be cut into pieces of half or three-quarters of an inch long, and steeped in a solution of one part of chromic acid in 200 parts of water, for three weeks or a month. It is then preserved for use in a solution of about one part of *bichromate of potash* in 200 parts of water. For hardening the convolutions of the cerebrum and cerebellum, the solution of chromic acid must be weaker than for the spinal cord or medulla oblongata, that is the proportion of one part of the acid to four, or even five hundred parts of water; but the portions of brain must be small, not more than half an inch thick, otherwise they become rotten before the acid has reached their centres. A little spirit added to the solution for two or three days, after the first day, will prevent this. The pure solution can then be renewed.

Spirit of wine is used to wet the knife or razor in making sections, which should be washed in water before they are placed in the solution of carmine. When sufficiently coloured, the sections are again washed in water, and placed for ten minutes or a quarter of an hour in strong spirit; after which, if they be thin, they are floated on the surface of spirit of turpentine, where they remain until they are quite, or nearly transparent, when they are removed to glass slides, on which a little Canada balsam has been previously dropped. If now examined under the microscope, they frequently show but little traces of either cells or fibres—a circumstance which seems to have caused Schroeder Van der Kolk, and some others, to abandon the method *at first*,—but if the sections be set aside for a little while, and treated occasionally with a little turpentine, the cells and fibres reappear, and present a beautiful appearance. Before they are finally covered with thin glass, they should be examined at intervals under the microscope, to see whether all the details of structure have come out *clearly;* and if so, as much Canada balsam must be used as suffices for mounting. If the sections be of considerable *thickness*, it will be found best to place them in a shallow vessel, the bottom of which is kept simply wet with turpentine, which can therefore ascend through them from below, while the spirit evaporates from their *upper*

surfaces, for the *principle* of the method is this :—to replace the spirit by turpentine, and this by Canada balsam, *without drying* the sections. The method at first is attended with some difficulty, and practice is necessary to ensure complete success. Experience, also, may suggest, according to circumstances, certain modifications of the *exact* process here given, which, to a certain extent, must be considered as general.

This method is now generally adopted in Germany, and other parts of the continent, in investigating the structure of the brain and spinal cord.

Alcohol, Acetic Acid, and Nitric Acid.—By the addition of a little nitric acid, a fluid may be obtained which has been found very useful in investigations on the different forms of epithelial cells. One of these fluids was composed of the following ingredients ; but of course useful modifications will be made by every practical observer, according to the properties which he desires the fluid should possess, and it is therefore only necessary to give the composition of one or two :—

Water	... 1 ounce.
Glycerine	... 1 „
Spirit	... 2 ounces.
Acetic acid	... 2 drachms.
Hydrochloric acid... ...	... ½ drachm.

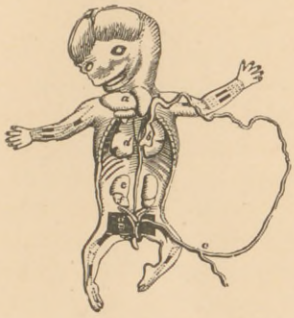
Alcohol and Soda.—In many investigations I have obtained excellent results from the use of a fluid composed of alcohol and solution of caustic soda, in the proportion of eight or ten drops to each ounce of alcohol. Many tissues are, at the same time, rendered very hard and transparent in such a mixture, and it is particularly adapted for investigations upon the character of calcareous matter deposited in tissues in various morbid processes. It is especially useful in tracing the stages of ossification in the early embryo. It renders all the soft tissues perfectly transparent, but exerts no action on the earthy matter of the developing bone. The most minute ossific points can therefore be very readily discovered. A fœtus, prepared by being soaked for a few days in this fluid, and preserved in weak spirit, forms a very beautiful preparation. A drawing of one, about the end of the second month, is given in pl. II, fig. 10, and in fig. 11, one about the end of the third month is represented. The first was prepared thirteen years ago (1853—4), and still preserves its transparency. The practical advantages of such a plan over the usual very laborious process of dissection, in investigating the periods of ossification in various bones, are obvious. This fluid will be found very useful in investigations upon soft granular organs. I found it of special service when working at the anatomy of the liver.

On mounting Moist Tissues in Canada Balsam.—Moist tissues may be mounted in Canada balsam without being previously dried, by the use of these alcoholic solutions. As is well known, Canada balsam will not permeate a tissue moistened with water; but the water may be removed by soaking in an alcoholic solution of acetic acid or soda, which does not alter the albuminous materials. When well saturated, the alcoholic solution, which now contains a little water derived from the specimen, may be changed for a little fresh fluid, and after the specimen has been allowed to soak for some time in this, it may be removed to a solution of Canada balsam in ether. The ethereal solution drives out the alcohol, and after the preparation has been placed once or twice in fresh portions of solution, it may be placed on a glass slide. The ether gradually evaporates, but the tissue remains thoroughly impregnated with Canada balsam. A little fresh balsam may be added, and the specimen mounted permanently. Thus, although Canada balsam does not possess the property of wetting a tissue containing an aqueous fluid, it and similar media may be made to permeate it. In carrying out investigations of this kind, the following circumstances must be borne in mind. Alcohol mixes with water, ether with alcohol, Canada balsam with ether. The first removes the water, the second replaces the alcohol, and the last being readily soluble in ether, may be thus introduced into the interstices of the tissue. The ether is allowed to evaporate, and the specimen preserved in Canada balsam in the usual manner. By pursuing a similar plan, other tissues may be thoroughly impregnated with fluids, which do not possess the property of wetting them in their ordinary state.

In some cases thin sections of tissues may be moistened with turpentine by allowing them to lie for some time upon the surface of the fluid in a shallow dish. Another dish containing a little strong sulphuric acid or some chloride of calcium may be placed near and the whole covered with a bell jar. The sulphuric acid or chloride of calcium gradually absorbs the water which is thus removed from the thin section, and the turpentine gradually permeates the tissue and takes its place, but it is seldom this plan succeeds perfectly.

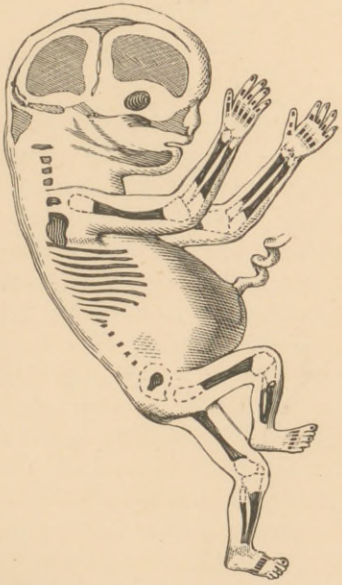
91. Of Colouring and Staining the Germinal Matter and Formed Material of Different Tissues.—Of the many artificial processes proposed for the purpose of rendering a transparent and perhaps invisible substance more or less distinct, the process of staining is the most efficient. It is surprising how many important facts relating not only to the build or structure of the tissue, but concerning the mode of its formation, have been ascertained by adopting this process. And it is quite certain that that which has been already discovered bears a very

Fig. 10.



Human Fœtus, about the eighth or ninth week of intrauterine life, soaked in alcohol and soda, and preserved in glycerine. *a*, heart. *b*, stomach. *c*, intestine, not yet much longer than the body. The branch below the letter is the remains of the omphalo-mesenteric duct. *d*, lungs. *e*, supra-renal capsules. *f*, kidneys. *g*, remains of Wolffian bodies, with ovaries and genital ducts. Points of ossification are observed in the humerus, radius, ulna, last phalanges of the fingers, femur, tibia, and ribs. The ossification of the clavicle is advanced, but no ossific points are yet to be detected in the feet. Natural size. § 90.

Fig. 11.



Human Fœtus, about the eleventh or twelfth week. Ossific points are observed of considerable size. But one point exists in the os innominatum and two are seen in the scapula. The shading in the head and face indicates the formation of bone. The ossification of the first and third phalanges of the fingers and metacarpal bones has advanced, but at present there is only one point of ossific deposit in the tip of the great toe and one for the middle toe. In both drawings the development of the anterior extremities is much more advanced than that of the legs. Soaked in soda and alcohol for a few days, and preserved in spirit. Not changed since 1853—4. Natural size. § 90.

[To face page 24.

small proportion to what yet remains to be ascertained. Not only may points of the greatest interest be made out in the structural arrangement of tissues, but the germinal or living matter which is alone concerned in tissue-production can be accurately demonstrated. In the early stages of disease, changes which would be inappreciable to the eye if the specimen were prepared by the ordinary methods are rendered obvious enough if the process of staining is resorted to. The number of masses of germinal or living matter seen in all tissues is enormously greater when the texture has been subjected to the particular plan of staining about to be described, than when examined in the ordinary manner. In truth only comparatively few of the masses of germinal matter (nuclei), are seen by those observers who simply examine textures in water, serum, vitreous humour and the like. We therefore employ the processes of staining for two very different objects.

1. For colouring the *living or germinal matter* of the cell or texture.
2. For demonstrating peculiarities in the build of the *formed material, cell wall, intercellular substance* or *tissue*, and for ascertaining the order in which the several parts of which it is composed have been laid down.

Method of Colouring the Germinal or Living Matter.—This living matter is in all cases perfectly clear and transparent. It never exhibits structure, and is invariably colourless. It possesses an acid reaction, or, to speak more correctly,—an acid reaction is always developed immediately after the death of living matter. Hence if any alkaline solution of colouring matter in which the colour is precipitated or fixed by an acid, be caused to pass into the living matter of a cell, the alkali is neutralised by the acid there developed, and the colour is retained. It may be precipitated in a state of very minute subdivision, or may combine with some of the constituents of the germinal matter and form a compound insoluble in weak acids. The tissue itself or formed material being ordinarily bathed with an alkaline fluid does not take the colour, and hence by carrying out the process with due care the germinal or living matter may be coloured while the formed material or tissue remains perfectly colourless. Any one can satisfy himself of this fact by placing upon a glass slide a few liver cells from any animal immediately after its death. If a drop or two of the solution of carmine in ammonia (§ 101) be allowed to flow over the cells, the nucleus or mass of germinal matter of each cell will be tinted in the course of a few seconds, while the outer part of the cell will not be affected.

It has been objected that the formed material can be coloured by carmine as well as the germinal matter. This is true in a sense, for it need scarcely be said that dead and dry paper, cotton, hair, wool, and other things may be stained with carmine. White fibrous tissue may be deeply dyed if a strong solution of carmine be employed, or the texture be left to soak for a considerable time. In like manner the axis cylinders of the nerves (which I believe to be formed material only), and yellow elastic tissue, nay, even bone and teeth, can be deeply stained. But on the other hand, the nuclei or masses of germinal matter taking part in the formation of every one of these tissues may be deeply and permanently coloured, although the tissue itself which is bathed on all sides by the fluid, remains perfectly free from all colour. If, however, the formed material be first impregnated with a little weak acid and then placed in the carmine fluid, the carmine is retained as in the case of germinal matter. While if the germinal matter be rendered *alkaline*, it will not take the colour without long soaking. The fact of real interest and importance is that the germinal matter of every living thing, when fresh and without previous preparation, is invariably coloured deeply, and in a short time, while *under the same circumstances*, its formed material, although in contact with the carmine fluid, is not coloured at all, notwithstanding all the fluid that reaches the germinal matter has traversed this formed material in the first instance.

The germinal matter will take the colour long after the death of the animal, if decomposition, in which case an *alkaline* reaction would be developed, is prevented, as by alcohol and some other preservative fluids. So that specimens which have *been preserved for some time*, may be tinted with the carmine solution, provided they were immersed in the preservative medium very soon after death, but the results are, of course, not so satisfactory as if the tissue had been plunged into the carmine fluid when perfectly fresh. However, new appearances are often caused by the action of preservative media. By some the germinal matter is in part, or entirely, coagulated, and thus modifications are brought about which may lead the observer to draw very erroneous inferences. In practice, therefore, it is always desirable to immerse the texture when it is perfectly fresh, in fact, as soon as possible after it has been removed from the animal.

Plants and the lower animals may be killed by immersion in the carmine fluid.

The Rev. Lord Osborne, in June, 1856, showed that the nuclei of plants which were allowed to *grow* in a carmine solution, were more deeply tinged by carmine than other parts of the cell. ("*Vegetable cell structure and its formation, as seen in the early stages of the*

growth of the wheat plant. '*Trans. Mic. Soc.*,' vol. v, plate iv, 1856.") Welcker and Gerlach subsequently employed the ammoniacal carmine solution for colouring nuclei.

Gerlach first used a concentrated solution of carmine in ammonia, in which he placed specimens, for instance, sections of brain or cord previously hardened by chromic acid, for from ten to fifteen minutes. They were then well washed in water for some hours, and treated with acetic acid. The water and acid were removed by immersion in alcohol, and the sections afterwards mounted in Canada balsam. Gerlach afterwards found that dilute solutions (two or three drops of the ammoniacal solution of carmine to an ounce of water), and maceration for two or three days, afforded better results.

Thiersch uses the following carmine fluid:—Carmine, 1 part, caustic ammonia, 1 part, distilled water, 3 parts. Filter. One part of this solution is to be mixed with 8 parts of a solution of oxalic acid (1 part of the acid to 22 of water), and 12 parts of absolute alcohol. If the solution is orange coloured, instead of dark red, more ammonia is to be added, and the orange becomes red. The orange colour may also be used for staining. If crystals of oxalate of ammonia become formed, they must be separated by filtration.

The composition of the carmine fluid I have found most useful for staining the germinal matter of tissues (nuclei, protoplasm), and which I now employ for all specimens, is given on page 53.

Germinal matter may be coloured with Prussian blue fluid (p. 52), if it be rendered alkaline in the first instance by soaking the texture in a weak solution of ammonia. I have prepared some beautiful specimens as follows:—An alkaline solution was injected into the vessels, and after allowing twelve hours or more for the tissues to become thoroughly permeated, the finest Prussian blue fluid (p. 52) was introduced. The latter passed into the very substance of the germinal matter, which was tinged much more deeply than the surrounding substance. The liver cell may be thus impregnated with the blue in every part. It seems probable that by prosecuting more detailed enquiries in this direction, we might learn something concerning the physical arrangement of the matter constituting the formed material. Specimens prepared in this way enable us to prove the unsoundness of the old notion concerning the supposed cell wall and cell contents, but in endeavouring to draw correct inferences regarding the natural arrangement of the parts prepared in this way, it must not be forgotten that the alkaline ammonia may have effected alterations in the formed material, and modified its structure in an important manner.

In 1858—59 I studied carefully the changes occurring in the

same texture at different periods of its growth, with the aid of an alkaline carmine fluid of uniform strength, and repeated my observations upon many different tissues of man, the higher and lower animals, as well as upon the simplest and most complex vegetable organisms, and was led to the general conclusions published in my paper "On the structure of tissues, with some observations on their growth, nutrition, and decay." (Archives of Medicine, 1860). Since that time I have continued to employ the same plan of observation, improving it from time to time, as new suggestions occurred. More careful and prolonged observations upon the part of many other observers have strongly supported the general view I ventured to advance with regard to the structure and formation of all tissues,—namely, that every anatomical element or "cell" consists of matter in two distinct states or conditions of existence, *a*, *living*, that is capable of growth and of changing the matter it takes up, and *b*, *formed*, perhaps exhibiting structure, but passive, lifeless, incapable of growth, or of forming new structures or compounds.

In all cases, by taking certain precautions, we can distinguish in any given tissue what part is living and growing, and what part has already been formed and has ceased to undergo *vital* changes. In considering the *structure* of any texture or in describing the alterations occurring in the course of disease, we shall find it most advantageous to regard it as made up of *germinal matter* and *formed material*.

The *formed material* differs much in consistence and properties in different cases, but it never manifests the properties or powers characteristic of the germinal matter. It is often so very transparent that it appears, even to the highest powers, as if it was perfectly structureless, but in many cases indications of structure, and in some, peculiar and remarkable structural arrangements may be discerned by the aid of tinting processes. Every observer is familiar with the assistance derived from allowing very transparent textures to become partly covered with insoluble particles suspended in the fluid in which they are immersed. Any insoluble powder in a state of very minute division will often enable us to demonstrate an outline in the case of a tissue which cannot ordinarily be distinguished from the fluid which bathes it.

For the purpose of *tinting* a transparent texture almost any soluble colouring matter, which does not produce any chemical change upon the tissue, may be employed.

Some solutions, however, give much more satisfactory results than others. A dilute solution of the carmine fluid answers very well for many purposes, but I append several solutions which have been employed by different observers.

Coloured fluids have also been recommended for demonstrating cavities, spaces, or minute tubules existing in some textures. Not unfrequently a coloured fluid may be made to pass in the slight intervals existing between the epithelial cells of many textures, and the appearance is such as to have led many observers to entertain the opinion that there existed a system of very fine capillary tubes, much narrower than the finest capillaries, in epithelial and other textures. From the fact that the appearance in question is seen very commonly in injected specimens, it has been, I think, too hastily inferred that such apparent channels are real tubes connected with the vascular or lymphatic systems, and form a connecting network of tubes, and thus establish free communications between the interior of the blood vessels and lymphatics.

The beautiful reds and blues which have been lately so largely used as dyes, popularly known in this country as mauve, magenta, solferino, have been much employed by microscopists. The colour is not very soluble in water, but is readily dissolved by alcohol. A grain of the colour, ten or fifteen drops of alcohol, and an ounce of distilled water, make a dark red solution ; or the colour may be boiled in water, allowed to cool, and then filtered. This fluid colours *tissues* very readily.

Magenta has been recommended by Dr. Roberts for showing a minute spot connected with the red blood corpuscles of man. ("On peculiar appearances exhibited by blood corpuscles under the influence of solutions of magenta and tannin"—"*Proceedings of the Royal Society*," vol. xii, p. 481, No. 55, April, 1863). The peculiar action exerted by magenta and tannin upon the red blood corpuscles (see below), has not yet been satisfactorily explained, but my friend, Dr. Hughes Bennett, of Edinburgh, tells me that, with the aid of very high powers, he has been able to demonstrate that the minute spot appearing after the blood corpuscles have been soaked in magenta exhibits angles, and he considers that it is in fact a minute crystal which has formed upon the corpuscle.

Every kind of cell wall and delicate membrane may be coloured.

The cilia of ciliated epithelium may be tinted while they continue to vibrate. As the substance of the cell becomes coloured, however, the action of the cilia ceases.

Thiersch recommends the following blue fluid, the composition of which I take from Frey:—Oxalic acid, 1 part; distilled water, 22 parts; indigo carmine, as much as the solution will take up.

Another solution of oxalic acid and water in the same proportion is required. One volume of the first solution is mixed with two

volumes of the last and nine of absolute alcohol. The mixture is then filtered, and is ready for use.

An anilin blue fluid may be thus made:—Soluble anilin blue, ½ grain; distilled water, 1 ounce; alcohol, 25 drops. This fluid is not acted upon by acids or alkalies.

Thiersch gives the following fluid for colouring textures of a lilac tint:—Borax, 4 parts, distilled water, 56 parts—the borax is to be dissolved in the water, and 1 part of carmine added. The red solution is to be mixed with twice its volume of absolute alcohol and filtered. The precipitate of carmine and borax is redissolved in distilled water, and is ready for use.

Although *tannin* does not colour animal membrane, it alters its character to such an extent as to enable us to see many peculiar points of structure or arrangement not visible before, or it produces a chemical change upon the substance, from which we gain important information. The action of tannin upon the red blood corpuscle is very peculiar; it has been specially studied by Dr. Roberts of Manchester. The solution is made by dissolving 3 grains of tannin in an ounce of distilled water. One drop of blood may be mixed with four or five drops of the tannin solution and a portion of the mixture examined under the microscope.

Solutions of Nitrate of Silver.—Of late years nitrate of silver has been used for demonstrating minute and delicate pores, and for staining tissues. Recklinghausen and His, have employed this plan with great success. A weak solution may be imbibed by delicate tubes, and part being precipitated in the tube, perhaps as a chloride or in combination with some albuminous material, subsequently becomes decomposed by the action of light, and a very dark line results. In this way the position of a previously perfectly invisible channel may be clearly demonstrated. Transparent connective tissue and the outer part of cells can thus be coloured, the nuclei remaining perfectly colourless and transparent. The nuclei by longer immersion will also be coloured. The appearances may be made to vary very much by modifying the mode of procedure and the time which the preparation is allowed to remain in the solution. After soaking in the nitrate of silver solution for some time the specimen may be placed in distilled water, or in a weak solution of common salt, in order to wash away the nitrate which adheres to the surface or occupies the intervals between the cells. When this has been effected the specimen is exposed to daylight or sunlight until the requisite degree of blackening has been obtained. The strength of the solution employed may be varied according to circumstances. Recklinghausen uses a very dilute solution, consisting of 1 part of nitrate of silver to

400—800 of distilled water. I have used the nitrate of silver in solution in glycerine with advantage.

The structure of the cornea has been recently investigated by His, after the tissue was prepared with nitrate of silver solution. The so-called "intercellular substance" (formed material) only may be coloured, or, after the whole structure has been thoroughly impregnated with the solution, it may be soaked out of the formed material, while that taken up by the nuclei (masses of germinal matter) is retained, and may be decomposed by being exposed to light. In this case the nuclei appear very dark and surrounded by a pale brown formed material. His thinks that when the nuclei are coloured, the precipitate of chloride of silver in the formed material is re-dissolved and absorbed by the nuclei, in which it is afterwards reduced by the action of the light.

Osmic Acid—(Os. O_2) has been strongly recommended for demonstrating delicate nerve structures by M. Schultze and Roudneff. Fat cells, oil globules, and white substance of Schwann and Myelin entering into the formation of various kinds of nerve fibres, become of a very dark colour or almost black. Other textures are neither coloured so quickly nor so intensely, and often exhibit only a brownish tint. So that by this substance nerve fibres ramifying in various textures may be stained and thus distinguished from other elements of the tissue. Solutions of various strengths may be employed, but one part of osmic acid in 100 of water is stated to be strong enough to produce the desired effect. These processes are capable of almost endless modification.

I shall describe in detail the course of investigation I myself follow for demonstrating the germinal matter and formed material of all textures after the method of injection has been alluded to, because this forms an essential part of my process (see page 50) as applied to the investigation of the tissues of man and the higher animals.

Of Cutting Thin Sections.

92. Of Cutting Thin Sections of Soft Tissues.—There is no more important operation in microscopical investigation than this. The student often requires thin sections of different textures, and whether he pursues the study of vegetable or animal physiology, or morbid anatomy, it is necessary to make a very thin section of the tissue which is to be examined; and upon the amount of skill he displays in cutting these sections, will mainly depend the success which attends his investigation. The more deeply tinted, and the more complicated in its structural arrangement the tissue may be, the more important is it to obtain a section of extreme tenuity, for other-

wise sufficient light cannot be transmitted through the section to enable us to see its structure; moreover, in a thick section, the objects occupying different planes so much interfere with one another, as to prevent the possibility of any one being defined clearly, although the tissue is tolerably transparent.

Sections of the large glands, and other soft tissues may be made with an ordinary knife, which should be very sharp. A clean surface is first cut, and then a thin slice is removed with a slow sawing movement of the knife, which is much facilitated by the application of a drop of water; indeed, whenever we require a very thin section of a soft tissue, the blade of the knife should always be well wetted with water or with the fluid in which the preparation is immersed.

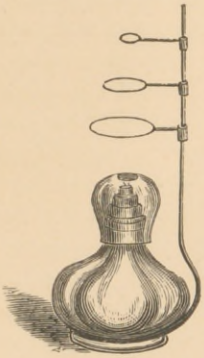
The knife may be rendered very sharp just before cutting a thin section, by drawing the edge forwards first on one side and then on the other, upon a very smooth plate glass slide, or upon a smooth strop, or even upon a smooth piece of wood. In practice, however, I prefer the plate glass slide.

The most important instruments for making thin sections of soft tissues are the following: scissars of different sizes, pl. III, figs. 15, 16, 17, Valentin's knife, pl. IV, figs. 21, 22, doubled-edged scalpels, pl. IV, fig. 20, or lancets mounted in handles, and a few other instruments, such as forceps, pl. III, fig. 18, and needles of different sizes, pl. III, fig. 14, mounted in handles, are often required in demonstrating minute structure. Tissues which have been hardened can be often cut into thin sections more readily by a sharp razor than by any other instrument. The observer should be provided with several razors, so that he may always have one or two sharp ones by him. Razors can now be purchased for 1*s.* each.

93. Instruments for Cutting Thin Sections of soft Tissues.—*Double-edged Scalpel.*—For cutting thin sections, a knife of the form represented in fig. 20, pl. IV, is very useful, and, where only sections of small dimensions are required, this will answer all the purposes of Valentin's knife. In cases, however, where a section is wanted of considerable extent, the latter instrument must be used. The double-edged scalpel is made after the fashion of a common lancet; it is not so wide, but should be quite as thin. When employed for making a section (after cutting a clean surface), the point is made to perforate the surface, and carried along at a proper depth, so as to cut its way out. The width of the section may then be increased by carrying the knife first to the right, and then to the left, until the desired width is obtained. Messrs. Weiss & Son, of the Strand, have made for me excellent knives of this kind.

Common Lancets mounted in handles will be convenient for cutting

Fig. 12.

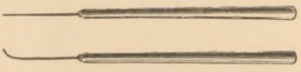


Spirit lamp, to which a wire stand is attached for supporting watch glasses, &c. § 14.

Fig. 13.

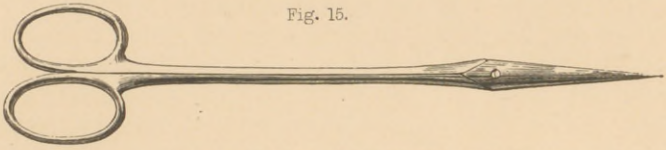
Porcelain basins, on tripod wire stand. § 13.

Fig. 14.



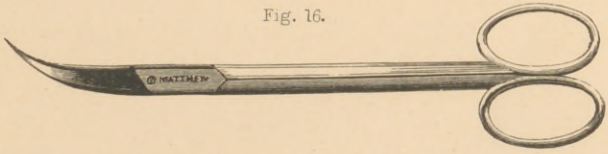
Needles, fixed in handles for dissecting. § 22.

Fig. 15.



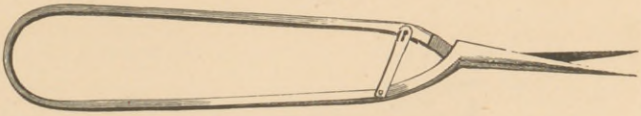
Fine straight scissors, for dissecting. § 93.

Fig. 16.



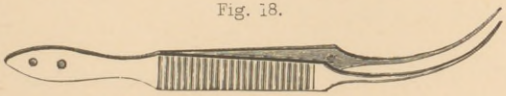
Curved scissors, for cutting thin sections of tissues. § 93.

Fig. 17.



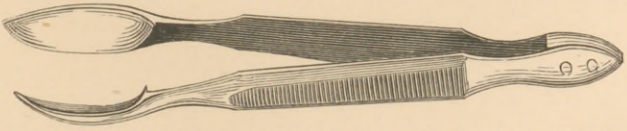
Small spring scissors, for making minute dissections. § 96.

Fig. 18.



Curved forceps, for making minute dissections. § 23.

Fig. 19.



Forceps, for removal of small portions of viscid Sputum, for microscopical examination. §§ 23 & 207.

[To face page 32.

thin sections, but each side of the blade should be sharpened down to the point of insertion into the handle.

Scissars are also very useful instruments for cutting small thin sections of different tissues. The most convenient forms for this purpose are those represented in pl. III, figs. 15, 16, 17. When only very thin sections of a tissue of no very great extent are required for examination, they will be removed with scissars more easily than with any other instrument.

Valentin's Knife has two blades, both perfectly flat on the opposed surfaces, very thin, and made perfectly sharp. By a mechanical arrangement, the blades may easily be separated from each other, or approximated to any required degree, according to the thickness of the section desired. The thin section is received between the blades, and is removed by separating them and agitation in water. This instrument is of the greatest value in making thin sections of soft tissues, but it requires care to keep it in good order. It is very easily made blunt if used for cutting fibrous or cartilaginous textures. By its aid, most beautiful sections of the kidney, liver, and other soft glandular organs may be obtained with the greatest facility. The blades should always be dipped in water just before use, for, if wet, the operation of cutting is much facilitated, and the section is more easily removed from between the blades. Immediately after use, the blades should be washed in water, and dried with a soft cloth or a piece of wash-leather. If a drop of water gets into the upper part of the knife where the blades meet, the screw must be taken out, and each blade cleaned separately. With care the knife may be kept in use for a long time.

Two forms of Valentin's knife are in common use; in one of these the blades are sharp on both edges, and of a lancet-shape, and in the other, which I much prefer, of the form represented in fig. 21, pl. IV. The best form of Valentin's knife that I have made use of, is that represented in fig. 22, pl. IV, which was made by Mr. Matthews. The blades of this knife can be completely separated from each other and easily cleaned. Moreover, the distance between the blades is regulated by a little screw, *a*, which is a most convenient arrangement. Mr. Matthews has lately much simplified the plan of making this instrument, thereby rendering it much cheaper, without in any way impairing its usefulness. By adapting *two* screws to the blades he has made Valentin's knife much more perfect; not only can the blades be separated or approximated more readily, but greater firmness is obtained, and the perfect parallelism of the two blades is ensured. The knife may now be purchased for much less than formerly—10*s.* 6*d.* to 15*s.*

94. Of the Use of the Compressorium.—Not unfrequently is it required to tear up delicate portions of tissue upon the field of the microscope, or to float them out, as it were, from the general substance under examination. In examining minute living animals we often wish to fix them in a position for careful observation. These objects are effected by an instrument termed a compressorium, pl. IV, fig. 26, which consists simply of a mechanical arrangement, by which we are enabled to apply a certain amount of pressure upon the thin glass covering an object, which can be increased or diminished at pleasure, and regulated at will. The compressorium consists of a flat piece of brass, with a small ledge on one side, and a large hole in the centre. To one end is attached a lever, bearing a flat brass ring, the rim of which is about a quarter of an inch in width. This ring is free to move, and is capable of being gradually raised up and down upon the object, by moving a screw, having a fine thread, which passes through the other extremity of the lever. The compressorium I have just described is one of the simplest forms I have seen, and presents this great advantage, that the ordinary glass slide, with a preparation upon it, may be subjected to pressure without the latter being removed, and placed upon the glass, which, in most compressoriums is fixed in the hole cut out of the brass plate. Professor Quatrefages has introduced an improvement by which either side of the object can be subjected to examination.

95. Of Cutting Thin Sections of Hard Tissues.—Bone and teeth, the hard calcareous plates in the walls of arteries and in cysts, and morbid growths of firm consistence, are, in the first place, cut into thin slices with a fine saw, fig. 24, pl. IV. These are reduced in thickness with a file, or by rubbing on a stone until the sections are transparent, when the scratches may be rubbed out by grinding on a smooth hone with a little water, and subsequent polishing on a dry hone or piece of plate glass, or on a leather on which putty powder has been placed.—See also H. to W., § 146 to 152.

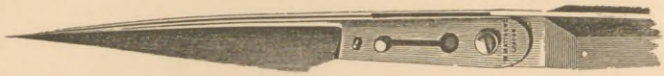
New Method of preparing Specimens of Bone and Teeth and other Hard Tissues.—By the methods generally employed for demonstrating the structure of bone, teeth, and other hard tissues, we are enabled to form a notion of the dead and dry tissue only. The soft material is dried up before the section is made.

And yet this very soft material, which is not represented in the drawings published in many standard works, is that which makes the only difference between the dried bone or tooth in our cabinets and that which still remains an integral part of the living body. So far from this soft matter being unimportant, it is the most important of all the structures of the hard texture. It is by this alone that all

Fig. 20.

Double-edged scalpel, for cutting thin sections of soft tissues. § 93.

Fig. 21.

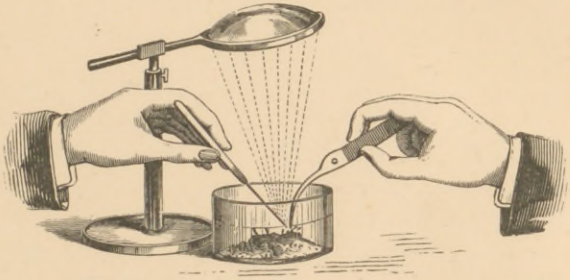


Valentin's knife, for cutting thin sections. § 93.

Fig. 22.

Another form of Valentin's knife. § 93.

Fig. 23.



Arrangement for dissecting objects under water. The bull's-eye condenser is much larger than those usually employed. § 95.

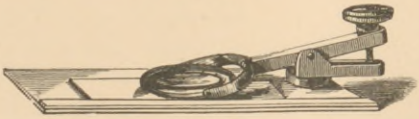
Fig. 24.

Fine saw, for cutting thin sections of bone and teeth, which are afterwards to be ground thinner on the hone and polished as described in § 95.

Fig. 25.

Loaded cork, for pinning objects upon, for the purpose of dissection. § 96.

Fig. 26.



Compressorium, for pressing out flat thin sections of tissues before mounting. § 94.

[To face page 34.

osseous and dental tissues are formed and nourished, and from the arrangement of this soft matter not having been recognized, the most erroneous ideas have prevailed, and still prevail, upon the formation and nutrition of the osseous and dental tissues.

Even now it is generally believed that the dentinal tubes are real tubular passages for conveying *fluids* to all parts of the dentine, and are thus subservient to its "nutrition," and yet it is more than eight years since Mr. Tomes proved most conclusively that these so-called "tubes" were occupied in the recent state by a moist but tolerably firm material ("Phil. Trans.," Feb., 1856). I have verified Mr. Tomes' description, and am quite certain that the so-called dentinal tubes are not channels for the mere flowing up and down of nutrient fluid.*

Suppose a tooth is to be prepared for minute microscopical investigation, we may proceed as follows. The same plan is applicable to bone and shell.

1. As soon as possible after extraction, the tooth may be broken by a hammer into fragments, so as to expose clean surfaces of the tissues. Pieces of dentine with portions of pulp still adhering to them may then be selected and immersed in the carmine fluid (p. 53), and placed in a vessel lightly covered with paper, so as to exclude the dust. The whole may be left in a warm room for from twenty-four to forty-eight hours.

2. The carmine solution may then be poured off, and a little plain dilute glycerine added, as described in the case of soft tissues.—§ 101.

3. After the fragments of teeth have remained in this fluid for five or six hours, the excess, now coloured with the carmine, may be poured off, and replaced by a little strong glycerine and acetic acid.

4. After having remained in this fluid for three or four days, it will be found that the portions of soft pulp have regained the volume they occupied when fresh. They have swollen out again even in the strongest glycerine.

5. I have found that in many cases, when it is desired to study the arrangement of the nerves, it is necessary to harden the pulp by immersion in a solution, made by adding to an ounce of the mixture of glycerine and of acetic acid, two or three drops of a strong solution of chromic acid. The fragments may remain in this solution for three or four days, and then be transferred to the acetic acid solution, in which they may be preserved for years with all the soft parts perfect.

* On the structure of recent bone and teeth, see my lectures on "The structure and growth of the tissues." Delivered at the Royal College of Physicians, 1860.

6. The specimens are now ready for examination. Thin sections are *cut* with a knife from the fractured surfaces of the dentine, including a portion of the soft pulp. The knife should be strong, but sharp. In practice I have found the double-edged scalpels made for me by Messrs. Weiss and Son, of the Strand, answer exceedingly well for this purpose, nor will the edge of the knife be destroyed so soon as would be supposed.

7. The minute fragments of sections thus obtained are placed upon a slide and immersed in a drop of pure strong glycerine, in which they may be allowed to soak for an hour or more, and then examined by a low power (an inch). The best pieces are then to be selected by the aid of a fine needle, and removed to a drop of glycerine containing two drops of acetic acid to the ounce, and placed upon a clean slide. Lastly the thin glass cover is carefully applied, and the specimen may be examined with higher powers.

8. If it is desired to retain the specimen, the excess of glycerine fluid is absorbed by small pieces of blotting-paper, and the glass cover cemented to the slide by carefully painting a narrow ring of Bell's cement round it. When this first thin layer is dry, the brush may be carried round a second time, and after the lapse of a few days, more may be applied. Mounted in this way the specimen will retain its character for years.

Hard tissues, like bone, dentine, and enamel, become somewhat softened by prolonged maceration in glycerine, and if a few drops of acetic acid are added, the softening process may be carried to a greater extent, and yet without the calcareous matter being entirely dissolved out. If desired, of course the calcareous matter may be in part or entirely removed by increasing the strength of the acid fluid in which the preparation is immersed. But, far short of this, the hard, brittle texture is so altered that thin sections may be *cut* without any difficulty. Specimens prepared in this way may be examined by the highest magnifying powers yet made,—by which statement I mean, of course, to imply that more may be learned by the use of such high powers (1,000 to 3,000 linear) than by employing ordinary object glasses.

Of Making Dissections.

96. Of making Minute Dissections and of Dissecting under Water.—Many very ingenious stands, tables, or stages, have been devised for the purpose of facilitating the operation of dissecting. The dissecting microscope of Professor Quekett is one of the most useful,

and this has been improved upon by Mr. Highley and others. The instrument recently proposed by Mr. James Smith is extremely useful and compact, but the binocular dissecting microscope arranged by Professor Lawson, is the most perfect instrument of the kind yet introduced.

The observer may make a very efficient dissecting microscope by removing the body of the ordinary microscope and replacing it with a bar carrying a simple lens. In practice, however, I have found that more is gained by condensing a very strong light upon the dissection than by magnifying the object itself. If the object to be dissected be transparent, the light may be transmitted through it from the mirror beneath the stage of the microscope. If opaque, the light is to be condensed upon it by the aid of an ordinary bull's eye. Two slanting rests for the arms are easily made of a convenient height with a little thin deal board or mill-board.—See also H. to W., §§ 20, 22.

Minute dissections of many tissues are carried on most advantageously under the surface of fluid with the aid of small scissars, needles, or small knives and forceps. If the preparation has been preserved in spirit or other solution, it must be dissected in the same fluid, but in ordinary cases clear water may be used. The microscopist should be provided with a few small dishes, varying in size, and about an inch or more in depth. The large built cells make very good troughs for dissecting in, and circular vessels are made for the purpose, but a common flat pomade pot answers as well as anything, and the cover protects the specimen from injury by dust.

Loaded Corks.—The object to be dissected is attached to a loaded cork by small pins. We may take a piece of flat cork rather smaller than the cell, and cut out a piece of sheet lead somewhat larger than the cork. The edges of the lead are then folded over the cork and beaten down slightly with a hammer, and may afterwards be filed smooth with a coarse file, pl. IV, fig. 25.

The object being fixed upon the cork and placed in the cell, fluid is poured in until it just covers the surface of the specimen. A strong light is then condensed upon it by means of a large bull's eye condenser, or by a large globe full of water. With a strong light, magnifying glasses are not required; and I have always found that delicate dissections could be made with the greatest facility without the aid of a dissecting microscope, provided a strong light was condensed upon the object. Occasional examination of the dissection with a lens of low power is advantageous; but if a lens be employed during the dissection, there is great danger of accidentally injuring the specimen, as it is impossible to judge of the distance which the needle point may be beneath the surface of the fluid. Minute branches of nerves

or vessels, may in this way be followed out, and small pieces of the different tissues into which they can be traced may be removed for microscopical examination with a pair of fine spring scissars. I had scissars of a particular form made some years since for very delicate dissections, and I have found them of great use in dissecting thin membranes from delicate structures beneath, pl. III, fig. 17. With the aid of these scissars, the coats of an artery may be dissected off, and mucous membrane may be readily stripped from subjacent tissues. By a similar plan the nervous system of the smallest insects can be very readily dissected. The arrangement for carrying on minute dissections is shown in pl. IV, fig. 23.

Tablets upon which Dissections may be Pinned out.—Many preparations require to be arranged in a particular position, before being mounted as permanent objects. *Slabs of wax* are usually employed by anatomists for this purpose, but if transparency is required, the dissections may be attached by threads to thin plates of *mica*.

I have found that the best slabs are made of a mixture of *wax* and *gutta percha*, in the proportion of one part of the former to from two to four of the latter, according to the degree of hardness required. The ingredients are to be melted in an iron pot, over a clear fire, and well stirred. When quite fluid, the mass may be poured upon a flat slab and allowed to cool. Thin cakes of about the eighth of an inch in thickness are thus obtained, and they can be easily cut with a knife to fit the cells intended for the preparation. Pins, or small pieces of silver wire, may be inserted into these slabs, and will adhere firmly, although the material is very thin.

Of Injecting Tissues for Microscopical Examination.

In the investigation of healthy and morbid structures, many points of great importance can only be made out by examining injected preparations. From their extreme tenuity and perfect transparency, the capillary vessels are scarcely distinguishable. By looking at uninjected preparations only, we may sometimes be led to conclude that a tissue is only slightly vascular, when it is abundantly supplied with vessels ; and in other cases we may describe as a fibrous matrix or supporting frame-work, a tissue which is composed almost entirely of a dense net-work of capillaries. Capillary vessels when uninjected usually collapse, and in the manipulation necessary for preparing a microscopical specimen, are inevitably pressed and somewhat stretched and torn. In such a specimen the vessels are liable to be mistaken for nerve fibres, or for fibrous or connective tissue, and in not a few instances have been so described.

In investigating the anatomy of morbid growths, still greater confusion has arisen from the vessels of the specimen not having been properly injected, and it is hardly to be expected that we shall be able to ascertain the nature of the texture, or the history of the various stages through which a particular structure passes in the course of growth, until the arrangement of the vessels has been accurately made out, and the precise relation which they bear to the most important anatomical elements of the tissue, demonstrated. It is obviously impossible to determine these points, unless the vessels are filled with some coloured material, which renders them less transparent than in the natural state; and it is at the same time quite clear that they must not be filled with any opaque, granular matter, for this would prevent the possibility of the surrounding structures being seen at the same time. For investigations, therefore, of this class, the materials formerly employed for injecting the capillary vessels, such as vermilion, chromate of lead, and other opaque colouring matters, are inadmissible. Neither can the tissues be dried and mounted in Canada balsam in the manner in which vascular preparations are usually preserved, because delicate, but most important structures are invariably altered and destroyed by this process, or rendered invisible. In such dried preparations, vessels occupying very different positions all appear on the same plane, and it is impossible to distinguish if one particular branch of tube or fibre is really continuous with another, or if the apparent continuity results merely from one lying exactly over or under the other. Many erroneous statements have arisen from trusting implicitly to such specimens.

It is somewhat strange that some minute anatomists of high authority have expressed themselves against this process of injection for the investigation of the anatomy of tissues. It is true that for the most part these objections refer to preparations made with opaque materials, the disadvantages of which I feel strongly, and have alluded to above. But so far from the process of injection not being of advantage, I am quite satisfied that we shall learn more from its use than from any other known method of investigating the anatomy of the tissues of animals. The importance of different media for examining tissues is admitted by all, and how, it may be asked, can these be so successfully introduced, as by injecting them into channels from which their absorption is immediate? By this plan all parts of the tissue will be acted upon by a solution of uniform strength. I cannot help fearing that many fanciful objections raised to this mode of investigation have been made by those who cannot, or will not inject, and who therefore are not in a position to form an opinion at all. I am certain that those who do not inject will add little indeed to our

knowledge of the structure and mode of formation of the tissues of man and the higher animals, and by their opposition they will not only retard true progress, but they may actually lead to the revival and acceptance of erroneous views which have even been abandoned by our predecessors.

In order to inject satisfactorily the most minute vessels of a tissue, and at the same time to demonstrate their relation to adjacent structures, we must be provided with an injecting medium which possesses the following properties :—The fluid should be of such a consistence that it will run readily through the smallest vessels. It must contain a certain amount of colouring matter to render the arrangement of the vessels distinct, but must be sufficiently transparent to admit of the examination of the specimen by transmitted light. The colouring matter must not be soluble, for in this case it would permeate the tissues indiscriminately, and would thus prevent the vessels from being distinguished from other textures. Though insoluble, the particles of which the colouring matter is composed should be so minute as not to exhibit distinct granules when examined with the highest powers, for if this were so, the specimen would have a confused appearance. The fluid in which the colouring matter is suspended, must be capable of permeating the walls of the vessels with tolerable facility. It must possess a certain refractive power, and a density approaching to that of the fluid which surrounds the tissues in the natural condition. It must be of such composition that it may be employed without the application of heat.

The injecting fluid must not escape too readily from the numerous open vessels necessarily exposed in cutting a thin section of the tissue for examination, and particles accidentally escaping ought not to adhere intimately to the surface of the section, for this would render the specimen confused and indistinct, when subjected to examination, especially if high magnifying powers are required. The fluid employed must not interfere with the preservation of the specimen, and it ought not to undergo any alteration by being kept some time. It should be cheap and capable of being readily prepared.

The injected specimens must permit of being examined with the highest powers yet made.—See also § 101.

97. Transparent Injecting Fluids.—*Prussian Blue Injecting Fluids.*—In searching for a fluid possessing all these different properties, many experiments have been made. The fluid which I employed in my investigations upon the anatomy of the liver (1854), possesses the various qualities required, and is applicable for making minute injections of the capillaries as well as the ducts of glands. This fluid consists of Prussian blue in a state of very minute division, suspended

in a solution which also acts the part of a preservative fluid. The particles of blue are quite insoluble, so that they will not pass through basement membrane, but at the same time they are so minute that when examined by a very high power, the precipitate appears uniform and homogeneous. It is not easy to wash this fluid out of the vessels when a section of the injected tissue is prepared, because it becomes incorporated with the fluid remaining in the vessels without being precipitated. It runs very freely, and a perfect injection can be made with it in the course of a few minutes. It is well adapted for injecting morbid growths, and possesses many advantages over other injecting fluids, of great importance to practitioners who have little time at their disposal for such work. It can be kept for a length of time without being impaired, and can be used at once. Before injecting the tissue no warming is necessary, as in the use of size injections, and the preparation may be examined immediately after the injection has been completed. The fluid is inexpensive, so that small portions of an organ may be efficiently injected, in which case a considerable quantity of the injecting material must necessarily escape from the divided vessels, and be wasted. It tends to harden the coats of the vessels as it passes through their channels, while at the same time it increases the transparency of the specimen. The colour is not affected by acids, and after having been removed by alkalies, is immediately restored upon the addition of an acid. Capillaries thus injected, may be examined by the twelfth of an inch object-glass.

In using this fluid, it is not even necessary that the pipe should be tied in the vessel, for when this cannot be effected readily, the injection may be driven as the pipe lies loosely in the channel. Although a good deal escapes, much will run in, and the capillaries may often be well injected in this manner. Good injections may be made of small pieces of liver and kidney, although much cut in various directions.

The ordinary Prussian Blue Fluid:—

Glycerine (common)	1 ounce.
Spirits of wine	1 ,,
Ferrocyanide of potassium ...	... 12 grains.
Tincture of perchloride of iron...	... 1 drachm.
Hydrochloric acid	5 drops.
Water	4 ounces.

Specimens injected with this preparation may be preserved in any of the ordinary preservative solutions, but I give the preference to acid glycerine or glycerine jelly. They may also be dried and mounted in Canada balsam if desired.

The ferrocyanide of potassium is to be dissolved in one ounce of the water, and the tincture of perchloride of iron added to another ounce. These solutions should be mixed together very gradually, and well shaken in a bottle. *The iron being added to the solution of the ferrocyanide of potassium.* When thoroughly mixed, these solutions should produce a dark blue mixture, in which no precipitate or flocculi are observable. Next, the naphtha is to be mixed with the spirit, and the glycerine and the remaining two ounces of the water added. This colourless fluid is, lastly, to be slowly mixed with the Prussian blue, the whole being well shaken in a large bottle during the admixture. The tincture of perchloride of iron is recommended because it can always be obtained of uniform strength. It is generally called the *muriated tincture of iron*, and may be purchased of chemists and druggists. The composition of the Prussian blue fluid which I use for very fine injections which are to be examined under $\frac{1}{25}$ and $\frac{1}{50}$ of an inch object-glass is given in page 53.

Turnbull's Blue.—My friend, Mr. B. Wills Richardson, of Dublin, has introduced Turnbull's blue in preference to ordinary Prussian blue. Ten grains of pure sulphate of iron are to be dissolved in an ounce of glycerine, or better, in a little distilled water and then mixed with glycerine, and thirty-two grains of ferridcyanide of potassium in another small proportion of water, and the solution mixed with glycerine. These two solutions are then gradually mixed together in a bottle, the iron solution being added to that of the ferridcyanide, and mixture ensured by frequent agitation. The other ingredients are added as in the Prussian blue fluid. This modification may be adopted in all cases in which I have recommended the ordinary Prussian blue. The proportions given in the text are unnecessarily large, and I find that the following makes a good fine injecting fluid.

Ferridcyanide of potassium ...	... 10 grains.
Sulphate of iron	... 5 „
Water	... 1 ounce.
Glycerine (Price's)	... 2 ounces.
Alcohol	... 1 drachm.

The iron, dissolved in a little water and mixed with glycerine, is to be added to the solution of the ferridcyanide, as in the preparation of the other fluid.

Carmine Injecting Fluid.—In the hands of Mr. Smee, Professor Gerlach, and others, carmine has long been employed for making minute injections with the most satisfactory results. The solution is made by adding a few drops of *liquor ammonia* to a little carmine, when a beautiful violet coloured *solution* is produced. This may be

diluted to the required tint, and injected. It is most applicable to injecting very delicate vessels, as those of the brain ; indeed, if much force be employed, the fluid transudes through the walls of the vessels, and tinges all the neighbouring tissues indiscriminately. The fluid is much improved, and its tendency to transude diminished, by the addition of glycerine and a little alcohol. I had long wanted a transparent injection which could be used for injecting some vessels, while others in the same preparation, were injected with Prussian blue. Professor Gerlach has made some beautiful double injections of the portal and hepatic capillaries, by injecting one set of vessels with carmine, and the other with Prussian blue. One of these he kindly sent me by my friend, Dr. Harley, but as Professor Gerlach's preparations were dried and mounted in Canada balsam, there are many important points in the structure which cannot be made out. If it is attempted to preserve such a preparation in the moist state, it soon becomes destroyed. The alkali of the carmine injection always destroys the blue colour of the Prussian blue, while if acid be added to the carmine previously, a precipitate unfavourable for injecting the capillaries is produced. After trying a great many different combinations to effect this object, I arrived at the following, which answers the purpose exceedingly well :—

Carmine	5 grains.
Glycerine, with about eight or ten drops of hydrochloric acid	½ ounce.
Glycerine	1 „
Alcohol	1 drachm.
Water	6 „
Ammonia, a few drops.	

Mix the carmine with a few drops of water, and when well incorporated, add about five drops of *liquor ammonia*. To this dark red solution, about half an ounce of the glycerine is to be added, and the whole well shaken in a bottle. Next, very gradually, pour in the acid glycerine, frequently shaking the bottle during admixture. Test the mixture with blue litmus paper, and if not of a very decidedly acid reaction, a few drops more acid may be added to the remainder of the glycerine, and mixed as before. Lastly, mix the alcohol and water very gradually, shaking the bottle thoroughly after adding each successive portion, till the whole is mixed. This fluid, like the Prussian blue, may be kept ready prepared, and injections may be made with it very rapidly.

Dr. Carter's Carmine Injecting Fluid.—For a carmine injecting fluid which will run perfectly freely through the most minute

capillaries, and one that will not tint the tissues beyond the vessels themselves, Dr. Carter has found the following formula to answer satisfactorily :—

Pure carmine	60 grains.
Liq. ammon. fort. (P.L.)	120 „
Glacial acetic acid	86 minims.
Solution of gelatin (1 to 6 water) ...	2 ounces.
Water	1½ „

The carmine is to be dissolved in the solution of ammonia and filtered, if necessary. With this mix thoroughly an ounce and a half of the hot solution of gelatin. The remaining half ounce of gelatin is to be mixed with the acetic acid, and dropped, little by little, into the solution of carmine, stirring briskly during the whole time. ("Archives of Medicine," vol. iii., p. 287).

This fluid is admirably adapted for specimens which are to be mounted in Canada balsam, but not for those to be preserved in glycerine. The vessels are well displayed, but all the delicate nerve fibres are invisible.

Transparent injecting fluids of several different colours are very much to be desired, but although many experiments have been made in the hope of obtaining such, we are, as yet, restricted to two, the blue and the red. Thiersch has succeeded in making others, the composition of one of which, yellow, is given below. I have not myself met with much success hitherto in the use of these fluids, for if I employ them according to the directions given, I am unable to demonstrate the masses of germinal matter (nuclei), and various points of importance, and when made according to the principles followed in the case of the Prussian blue fluid, the results are by no means satisfactory, and as the colour is, in many cases, affected by acids, the subsequent steps of my process are interfered with. (See p. 57).

An injecting fluid of a greenish tint may be made, according to the directions given in page 42, for Turnbull's blue, by employing different proportions of the ingredients,—1 grain or less of the sulphate of iron to 10 grains of the ferridcyanide of potassium.

Thiersch ("Das Mikroskop, 1865," von Dr. H. Frey) prepares a transparent yellow injecting fluid as follows :—

A.—A solution of bichromate of potash is made, in the proportion of 1 part of the salt to 11 of water.

B.—A solution of nitrate of lead of the same strength.

One part of solution A is placed in a small basin and mixed with 4 parts of a concentrated solution of gelatine. Two parts of solution B are placed in another basin and mixed with 4 parts of jelly.

These are to be slowly and thoroughly mixed together at a temperature of from 75° to 90°, and then heated in a water-bath at a temperature of about 212° for half an hour or more. The mixture is then to be carefully filtered through flannel.

98. Of the Pressure required for Successful Injection.—The requisite amount of pressure for forcing the injection into the finest capillaries may be obtained in several different ways. 1. By employing a long tube, to one end of which is attached a small piece of India-rubber tube furnished with a stop-cock which fits into the injecting pipe. 2. By placing the injecting fluid in a vessel three or four feet above the table and immersing a syphon tube which may be entirely composed of India-rubber or partly of glass. 3. By arranging a glass vessel upon the principle of the wash-bottle § 107, or the dropping-tube pl. X, fig. 70, pressure upon the surface of the liquid being produced *a*, by the aid of an India-rubber bottle compressed by a weight or spring, or *b* by pouring mercury into the tube which reaches nearly to the bottom of the flask. The other tube must of course also dip below the surface of the injecting fluid while to its upper free end a piece of India-rubber tubing provided with a stop-cock at its extremity, must be adapted. Other arrangements have also been proposed, but after having tried many different plans, I find that upon the whole, the ordinary injecting syringe is the most successful as well as the cheapest, the most convenient, and the most simple instrument, and it is most easily kept in perfect order. It need scarcely be said that by no mechanical means can such varieties of pressure be obtained as by the aid of the muscles of the hand and arm, and the pressure can be modified instantly, according to the judgment of the operator.

99. Of the Operation of Injecting.—The student will find that the process of injecting will be learnt after a few trials, and although he may quite fail in the first attempts he makes, I earnestly recommend him not to give up, for this mode of investigation is of the greatest advantage, and by it we learn facts of great anatomical importance. Every one engaged in the investigation of the anatomy of tissues in health and disease, should be able to inject well, and by employing the fluids recommended, it will be found that injections can be made without much sacrifice of time.

The manner in which the operation is performed will now be briefly described. In the first place, the following instruments must be conveniently arranged :—

The syringe thoroughly cleansed with distilled water; with pipes,

stop-cock, and corks, all of which must be washed in distilled water just before use, pl. V, figs. 32, 33, 34, 35.

One or two scalpels, pl. IV, fig. 20.

Two or three pair of sharp scissars, pl. III, figs. 15, 16, 17.

Dissecting forceps, pl. III, fig. 18.

Bull's-nose forceps, pl. V, fig. 36.

Curved needle, threaded with silk or thread, the thickness of the latter depending upon the size of the vessel to be tied, pl. V, fig. 37.

Wash-bottle, pl. V, fig. 28.

Injecting fluid, a small quantity of which is to be poured out into a small cup or glass beaker which is a little wider than the syringe in its widest part.

An incision is made through the vessel to be injected, with a pair of strong, sharp scissars; the two sides may easily be separated with the aid of a blunt-pointed needle. Into the opening a pipe is inserted and directed towards the point of distribution of the artery. Before the pipe is inserted, however, a little of the injecting fluid is drawn up so as to fill it, in order to prevent the air contained in the pipe from being forced into the vessels, which would cause the injection to fail.

The point of the pipe having been introduced into the artery, the needle with the thread is next carried round the vessel close to its outer surface, and the thread seized with the forceps, the needle unthreaded and withdrawn, or one end of the thread may be held firmly, while the needle is withdrawn over it in the opposite direction. The thread is now tied over the vessel, so as to include the tip of the pipe only, for if the pipe be tied too far up, there is great danger of its point passing through the delicate coats of the vessel.

The nozzle of the syringe is now plunged beneath the surface of the fluid, the piston moved up and down two or three times, so as to force out the air completely, and the syringe filled with injecting fluid. It is then connected with the pipe, which is firmly held by the finger and thumb of the left hand, with a screwing movement; a little of the injection having been already forced into the wide part of the pipe so as to prevent the possibility of any air being included.

The pipe and syringe being still held with the left hand, the piston is slowly and gently forced down with the right, with a slightly screwing movement, care being taken not to distend the vessel so as to endanger rupture of its coats. The handle of the syringe is to be kept uppermost, and the syringe should never be completely emptied, in case of a little air remaining in it, which would thus be forced into the

vessels. The injection will soon be observed running into the smaller vessels in different parts of the structure.

The student is recommended to practise the process by injecting the organs, and animals, in the order in which they are enumerated, and not to attempt the second until he has succeeded with the first. In all cases the operation is to be conducted patiently, and very slight pressure on the piston is to be exerted.

1. Kidneys of man, sheep, or pig.—*Artery.*
2. Eye of ox.—*Artery.*
3. Rat, mouse, frog.—*Injected from the aorta.*
4. Portion of intestine.—*Branch of artery.* All divided vessels being tied before commencing to inject.
5. Liver. In one part, a *branch of duct;* in a second, a *branch of artery;* in a third, *portal vein;* and in a fourth, *hepatic vein.* The portal and hepatic vein, the artery and portal or hepatic vein, or the duct and portal vein may be injected with injections of different colours in one part.

The branch into which the pipe is to be inserted, must be carefully dissected out in the first instance. When the trunk is small, some difficulty will be experienced in attempting this. The small vessel should be seized in forceps and drawn over the tip of the finger with as little stretching as possible. Next, with a pair of sharp scissars, a slit is to be made quite through the walls of the vessel and slightly extended in a longitudinal direction. If any trouble is felt in endeavouring to insert the pipe into the slit, a little water may be projected upon it from the wash-bottle, when the coats of the vessel become slightly raised, and the pipe can easily be passed into the tube.

Where a pipe is required to be inserted into a duct of a gland, which is even found with difficulty in the natural state of the parts, I have resorted to the following expedient with advantage. Tepid water is gradually injected into the artery or vein which supplies the part. The whole organ swells up considerably, water soon transudes into the follicles of the gland, and passes along the ducts, which, in consequence, become so much distended that they can be easily found; while at the same time, they are completely washed out, and any epithelium or secretion which would interfere with the passage of the injection, removed. An opening can readily be made in the wall, a pipe inserted, and the tube tied over it. When this is done, the water can be removed by wrapping the organ up in cloths and placing the whole under pressure for twenty-four hours, when nearly all the water will have been absorbed, and the duct and vessels will be in the most favourable state for receiving injection. A pipe may often be inserted

into a small lymphatic trunk by pursuing the same course, although it would be quite impossible to introduce it under ordinary circumstances.

100. On Injecting Morbid Growths.—Morbid growths may be injected in the same manner as healthy tissues, but it is almost impossible to obtain very satisfactory results with opaque injections. The walls of the vessels are so thin that they often give way, while the canals themselves are frequently so large and numerous, that when filled with injection other parts of the structure are invisible. In many cases, a very slight warmth destroys the mass, and reduces it to a mere pulp, so that all injecting fluids which contain size or gelatin are inadmissible. If the capillaries are filled with opaque injections, in many cases the whole looks of a uniform colour, and the specimen could not be be distinguished from a mass of extravasation.

With the *fine Prussian blue fluid*, p. 52, however, I have succeeded in obtaining very good injections of some tumours, and have satisfactory specimens of very soft cancerous growths in which the vessels have been filled without rupture, while the cells are well displayed in the same specimens. From the rapidity with which decomposition takes place, especially in the case of soft tumours, the injection should be commenced as soon as possible after the removal of the tumour. The free passage of the fluid along the vessels is not prevented to the same extent, as in healthy tissues, by the contraction of their coats. Many morbid growths are principally supplied by large veins, which are very readily injected, if only slight force be employed.

The process of injection may be employed for other purposes besides demonstrating the arrangement of the vessels of a tissue. The importance of examining objects in different media, has been fully discussed in "How to Work with the Microscope." The value of various chemical reagents, in hardening textures, and in rendering certain structures transparent, or increasing the opacity of others, has also been alluded to (§§89, 90). It is obviously desirable that tissues to be examined in any of these fluids, should be thoroughly saturated in every part, and no portion should long remain out of contact with the fluid in which it is to be examined or preserved. In the ordinary manner in which tissues are prepared, especially if they be very thick, it is a long time before the fluid in which they are placed penetrates into the interior, and when it reaches this part, in consequence of having been filtered through a considerable thickness of structure, its action will be weakened. Indeed, in many instances, decomposition has commenced before the preservative solution has

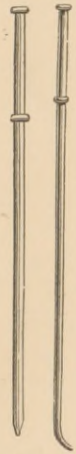
Fig. 27.

Conical glass for allowing deposits from fluids to subside.

Fig. 28.

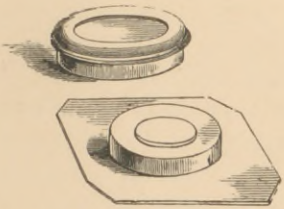
Wash bottle, for washing preparations. A stream of water is projected from the orifice of the pipe, when air is blown into the upper tube. § 107.

Fig. 29.



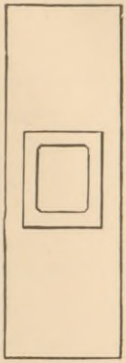
Pipettes. § 105.

Fig. 30.



Animalcule cage for examining deposits from fluids. § 109.

Fig. 31.

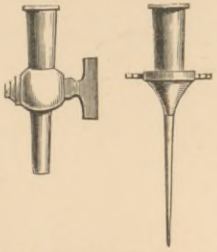


Thin glass cell for examining deposits from fluids, mounting preparation in fluids, &c. § 109

Fig. 32.

Small syringe used for injecting. § 90.

Fig. 33.



Stopcock and injecting pipe, which fit on to the syringe. § 99.

Fig. 34.

Corks for stopping pipes. § 99

Fig. 35.

Performing the operation of injecting. § 99.

Fig. 36.

Bull's-nose forceps, for stopping vessels from which injection is escaping. § 99

Fig. 37.

Needle for passing thread round a vessel which s to be tied upon the pipe. § 99

[To face page 48

thoroughly permeated every part of the structure. Now all these objections may be avoided if the vessels of the part be injected with some of the same solution as that in which the preparation is to be preserved. By such a plan, it is clear that every portion of the tissue will be bathed with the solution, which permeates the delicate walls of the capillaries just as it is bathed by fluid which transudes through the vessels during life. Latterly I have injected various tissues with different preservative fluids and chemical reagents, and have obtained most satisfactory results. The Prussian blue fluid serves the double purpose, not only of rendering the arrangement of the vessels distinct, but of making the tissues transparent, and at the same time it acts the part of a preservative solution.

By acting as above recommended, many fallacies are guarded against. Uninjected and contracted capillaries have often been mistaken for a form of fibrous tissue, and the loop-like arrangement of vessels in some textures has produced an appearance which has been mistaken for epithelial cells. Indeed in the uninjected state, especially when a few blood corpuscles remain in the vessels, the resemblance to an epithelial layer is very striking. Such an appearance is seen both in the lungs and in the kidney. If, however, the vessels are injected with the Prussian blue fluid, or with a colourless solution, the blood corpuscles are washed out, the vascular loops are distended, and the walls of the capillaries are seen in profile, as sharp, well-defined, clear and unbroken, outlines. I have injected fluids which have the property of rendering cells, where they exist, exceedingly distinct, and in no single instance have I ever been able to demonstrate in either of the above situations in the adult, an epithelial layer such, for instance, as that figured by Kölliker, in his drawing of the air cells of the lung, or in the drawing of the capillaries of the Malpighian body by Dr. Isaacs.* It has been urged, by those who have described this epithelium, that in the process of injection, it is forced off from the vessels, but even if this occurred to some extent, we should certainly, here and there, find a few cells still adherent; and it is easy to show that epithelial cells, where they exist, are not so easily removed by injecting the vessels. One of the strongest advocates for the existence of this epithelium in the kidney, Dr. Isaacs, gives diagrams of it still adhering to partially injected vessels. The delicate epithelium in the minute gall ducts, is not unfrequently found still adhering to the basement membrane, not only after the ducts have been thoroughly washed out with water forced through them in one direction, but injected with fluid in an opposite one.

* "On the Anatomy and Physiology of the Kidney." Transactions of the New York Academy of Medicine, 1857.

NEW METHOD FOR PREPARING ALL HEALTHY AND MORBID TISSUES, TUMOURS, &C., FOR MICROSCOPICAL EXAMINATION UNDER THE HIGHEST MAGNIFYING POWERS.

101. Of Injecting the Vessels and Staining the Masses of Germinal Matter.*—It is necessary to consider in the first place what circumstances interfere with the perfect demonstration of structure under the highest powers of the microscope, and how the operation of these may be prevented.

1. Of many tissues, sections sufficiently thin for high powers cannot be obtained by the process usually adopted. In order to make the specimen thin enough, *pressure* must be employed, and in many instances very strong pressure is required. Even by moderate pressure under glass, tissues immersed in water are destroyed completely. Experience has proved that unless the tissues be immersed in, and thoroughly impregnated with, a viscid medium, it cannot be pressed thin enough. Not only should this medium be readily miscible with water in all proportions, but with such chemical reagents as may be required to act upon one or more constituents of the tissues for the purposes of demonstration.

2. As many structures are exceedingly delicate, and undergo change very soon after death, it is necessary that the medium in which they are examined should have the property of preventing softening and disintegration, and should act the part of a preservative fluid.

3. In order that tissues may be uniformly permeated by a fluid within a very short time after the death of the animal, it is necessary that the fluid should come quickly in contact with every part of the texture. This may be effected in two ways :—

a. By soaking very thin pieces in the fluid, or

b. By injecting the fluid into the vessels of the animal.

4. As different structures require fluids of different refractive power for their demonstration, the medium employed must be such that its refractive power can be increased or diminished, or that, for the medium fulfilling the former condition, another can be readily substituted which fulfils the latter requirements.

5. In investigations upon the changes which structure undergoes in the organism, we want to distinguish between that part of the texture which is the oldest, and that which has been recently produced—between matter in which active changes are going on, and matter

* The process of investigation described in this section was first published in the third edition of "How to Work with the Microscope," August, 1864, but the author had adopted it for years previously.

which is in a passive state. The process of staining enables us to demonstrate the direction in which growth takes place, and the point where new matter is added.

6. It is necessary, in many investigations, that the vessels should be positively distinguished from the other constituents of the tissue, and it is important that the process by which this is effected, should not interfere with the demonstration of nerves or any other tissues in the immediate vicinity of the vessels.

7. It is of the utmost importance the medium employed for demonstration should have the property of preserving the specimens, so that observers should be able to exhibit their preparations to others.

Glycerine and *syrup*, with certain colouring matters fulfil the requirements mentioned in the foregoing paragraphs. Strong syrup may be made by dissolving, with the aid of heat, lump sugar in distilled water, in the proportion of about three pounds to a pint. It is necessary in many cases to employ the strongest glycerine. In this country we have had the advantage of the beautiful preparation called Price's glycerine, which is made of specific gravity 1240. It has been said that glycerine and strong syrup are not adapted for preserving soft tissues, because the tissues shrink and soft cells collapse in consequence of osmose of their fluid contents. But I have many hundred specimens preserved in the strongest glycerine I could procure, and I should obtain advantages if glycerine could be made of still greater density. There would be no difficulty in impregnating even very soft tissues with it.

Tissues possess a highly elastic property, and although they shrink when immersed in a medium of great density, they gradually regain their original volume if *left in it for some time.* In practice, the specimen is first immersed in *weak* glycerine or syrup, and the density of the fluid is gradually increased. In this way, in the course of two or three days, the softest and most delicate tissues may be made to swell out almost to their original volume. They become more transparent, but no chemical alteration is produced, and the addition of water will at any time cause the specimen to assume its ordinary characters.

The hardest textures, like bone and teeth, may be thoroughly impregnated and preserved in strong glycerine, and the softest, like cerebral tissue, delicate nervous textures like the retina, or the nerve textures of the internal ear, may be permeated by the strongest glycerine, and when fully saturated with it, dissection may be carried to a degree of minuteness which I have found impossible when using any other medium. Nor is the use of glycerine and syrup confined to the tissues of man and the higher animals. I have preparations from creatures of every class. The smallest animalcules, tissues of entozoa,

polyps, star fishes, mollusks, insects, crustacea, various vegetable tissues, microscopic fungi, and algæ of the most minute and delicate structure, as well as the most delicate parts of higher vegetable tissues, may all be preserved in these viscid media; so also may be preserved the slowest and most rapidly growing, the hardest and softest morbid growths, as well as embryonic structures at every period of development, even when in the softest state. I am, indeed, not acquainted with any animal or vegetable tissue, which cannot with the greatest advantage be mounted thus. All that is required is, that the strength of the fluid should be increased very gradually until the whole tissue is thoroughly penetrated by the strongest that can be obtained. Glycerine has long been in use among microscopists, but it is universally applicable, and it or syrup may be made the basis of all solutions employed by the microscopical observer with the greatest advantage. Many points are to be demonstrated by the use of these solutions, which have hitherto escaped observation, and there are reasons for believing that very much may yet be discovered by the use of these substances.

From these general remarks, I pass on to describe, more in detail, the particular method I have adopted during the last four years for minute investigations upon structures magnified by the highest powers yet employed. It will be necessary, in the first place, to give the composition of the different solutions which I find useful for general purposes.

1. *Weak common glycerine* of about the specific gravity 1050.
2. *The strongest Price's glycerine* that can be obtained, or,
3. *Syrup* made by dissolving, by the application of a gentle heat in a water-bath, 3lbs. of sugar in a pint of distilled water. A weaker solution can be prepared, as required, by mixing equal parts of syrup and water.

The two following solutions should be kept ready prepared. They will keep for a length of time. The first is required for rendering the vessels distinct. The last enables us to distinguish with certainty the *germinal* or *living* matter of every tissue from the formed material.

The Injecting Fluid.—The following mixture has succeeded admirably in my hands, and I therefore recommend it strongly. It penetrates to the finest vessels. The specimens injected with it retain their colour perfectly, and the injected tissues can also be stained with carmine.

Price's glycerine, 2 oz. by measure.
Tincture of perchloride of iron, 10 drops.
Ferrocyanide of potassium, 3 grains.
Strong hydrochloric acid, 3 drops.
Water, 1 oz.

Mix the tincture of iron with one ounce of the glycerine ; and the ferrocyanide of potassium, first dissolved in a little water, with the other ounce. These solutions are to be mixed together very gradually in a bottle, and are to be well shaken during admixture. The iron solution must be added *to* the ferrocyanide of potassium. Lastly, the water and hydrochloric acid are to be added. Sometimes I add a little alcohol (one or two drachms) to the above mixture. For the perchloride of iron, 5 grains of *sulphate of iron*, and for the ferrocyanide of potassium, 10 grains of the *ferridcyanide* may be substituted.—See p. 42.

This fluid does not deposit any sediment, even if kept for some time, and it appears like a blue solution when examined under high magnifying powers, in consequence of the insoluble particles of Prussian blue being so very minute.

The Carmine Fluid.—The following is the composition of the carmine fluid :—

Carmine, 10 grains.
Strong liquor ammoniæ, ½ drachm.
Price's glycerine, 2 ounces.
Distilled water, 2 ounces.
Alcohol, ½ ounce.

The carmine in small fragments is to be placed in a test tube, and the ammonia added to it. By agitation, and with the aid of the heat of a spirit-lamp, the carmine is soon dissolved. The ammoniacal solution is to be boiled for a few seconds and then allowed to cool. After the lapse of an hour, much of the excess of ammonia will have escaped. The glycerine and water may then be added and the whole passed through a filter or allowed to stand for some time, and the perfectly clear supernatant fluid poured off and kept for use. This solution will keep for months, but sometimes a little carmine is deposited, owing to the escape of ammonia, in which case one or two drops of liquor ammoniæ may be added to the four ounces of carmine solution.

The rapidity with which the colouring of a tissue immersed in this fluid takes place, depends partly upon the character of the tissue and partly upon the excess of ammonia present in the solution. If the solution be very alkaline the colouring is too intense, and much of the soft *tissue* or imperfectly developed formed material around the germinal matter, is destroyed by the action of the alkali. If, on the other hand, the reaction of the solution be neutral, the uniform staining of tissue and germinal matter may result, and the appearances from which so much may be learnt are not always produced. When

the vessels are injected with the Prussian blue fluid the carmine fluid requires to be sufficiently alkaline to neutralise the free acid present. The permeating power of the solution is easily increased by the addition of a little more water and alcohol.

Some tissues absorb the colour very slowly. Fibrous tissue, bone and cartilage, even in very thin sections, will require twelve hours or even more, but perfectly fresh, soft, embryonic tissues, very thin sections of the liver and kidney, and thin sections of mordid growths rich in cells, may be coloured in half an hour, while the cells of the above structures, placed on a glass slide, may be coloured in less than a minute. I have often coloured the germinal matter of the fresh liver cell *in a few seconds*, by simply allowing the carmine fluid to flow once over the specimen.

After the specimen has been properly stained, it is to be washed in a solution consisting of—

Strong glycerine, 2 parts.
Water, 1 part.

It is then transferred to the following acid fluid :—

Strong glycerine, 1 ounce.
Strong acetic acid, 5 drops.

After having remained in this acid fluid for three or four days, it will be found that the portions of even soft pulpy textures have regained the volume they occupied when fresh, and that they have regained their original size even in the strongest glycerine.

It being established as a principle that, for minute investigation, tissues must be immersed and thoroughly saturated with viscid media miscible in all proportions with water, it almost follows that re-agents applied to such tissues should be dissolved in media of the same physical properties. For a long time past I have been in the habit of employing solution of potash, acetic acid, and other reagents, dissolved in glycerine instead of in water. In some cases I have found the addition of very strong solutions of certain reagents necessary. For example, the greatest advantage sometimes results from the application to a tissue of very strong acetic acid. If the acid be added to glycerine in quantity, the solution will no longer be viscid, so that another plan must be resorted to. I thicken the strongest acetic acid with sugar, a gentle heat being applied to dissolve the sugar. Thus a very strong acetic acid solution of the consistence of syrup can be most readily prepared. Strong solutions of potash, soda, and other reagents, are to be made in the same way. Thus a complete chemical examination may be conducted upon tissues, solutions, or deposits preserved in *viscid* media. The reactions are most conclusive,

but of course take a much longer time for completion than when carried out in the ordinary manner. Ten or twelve hours must be allowed to elapse before the change is complete, the process being expedited if the slide be placed in a warm place (about 100°).

Chromic Acid Fluid.—A fluid most valuable to the microscopist, is a solution of chromic acid in glycerine, and another solution of bichromate of potash in the same fluid. A few drops of a strong solution of chromic acid may be added, so as to give to the glycerine a pale straw colour. The bichromate of potash solution is prepared by adding from twelve to twenty drops of a strong saturated solution of bichromate of potash to an ounce of the strong glycerine. By this plan, the hardening effects of these reagents upon the finest nerve tissues are improved, while the granular appearance which is caused by aqueous solutions of these substances is much diminished. Sometimes advantage seems to result from mixing a little of the chromic acid with the acetic acid solution of glycerine.

If desired, sugar may be substituted for glycerine in all the fluids employed, including the carmine and injecting fluids; but glycerine, although more expensive, possesses many advantages, and, as far as I am able to judge, is the best viscid medium to employ for general purposes.

One great inconvenience of syrup arises from the growth of fungi, especially in warm weather. Camphor, creosote, carbolic acid, naphtha, prevent this to some extent; but it is a disadvantage from which strong glycerine is perfectly free. Sometimes, too, crystallisation occurs, and destroys the specimen. In using first a syrupy fluid, and then glycerine, to the same specimen, it must be remembered that the two fluids mix but slowly, so that plenty of time must be allowed for the thorough penetration of the medium used last.

I keep various tests, such as alcohol, ether, the various acids, and alkalies, and other tests in the form of viscid solutions made with glycerine or sugar. The reaction of the iodine tests (§ 136) for amyloid matter, starch and cellulose, is much more distinct when employed in this manner. The plan is, to allow the texture to be tested to be thoroughly saturated with the strong glycerine solutions, and then to add water. In the course of a few hours the reaction takes place very strongly.

The plan pursued for preparing Tissues generally.—The general plan I follow, is the same for all tissues of all vertebrate animals and morbid growths; but I will describe the several steps of the process as they were conducted in the demonstration of the minute structure of ganglion

cells, and of the structure of the papillæ of the frog's tongue.* The description given also applies to the mode of preparing specimens of muscular fibre to demonstrate the mode of distribution of the finest branches of nerve fibre, and specimens of the minute structure of the brain, spinal cord, and ganglia of man and the higher animals.

Perhaps it will be most useful to describe the mode of proceeding when a frog is to be prepared for minute injection. My researches upon the tissues of the frog have been principally conducted upon the little green tree frog (Hyla arborea), for experience has proved to me that the tissues of this little animal are so much more favourable for investigation than those of the common frog, that it is well worth while to obtain specimens, even at the cost of *2s.* or *2s. 6d.* each. The student may, however, obtain very beautiful specimens from the common frog. The animal is killed by being dashed suddenly upon the floor, but it must first be carefully folded up in the centre of a large cloth, so that the tissues may not be bruised in the least degree. Next an opening is made in the sternum, the heart exposed, and a fine injecting pipe, after being filled with a little injection, is tied in the artery. The injection ought to be completed in from twenty minutes to half an hour, and sometimes in less time than this. The injection, being pale, cannot be very distinctly seen by the unaided eye, but if the operation has been conducted successfully, the tissues will be found swollen and the areolar tissue about the neck will be fully distended.

The injection being complete, the abdominal cavity of the frog is opened, and the viscera washed with strong glycerine. The legs may be removed, the mouth slit open upon one side, and the pharynx well washed with glycerine. If it is desired to prepare one organ only, this may, of course, be removed and operated upon separately; but I generally subject the entire trunk, with all the viscera, to the action of the carmine fluid. If the brain and spinal cord are special objects of inquiry, the cranium and the spinal canal must be opened so as to expose the organs completely, before the staining process is commenced. Enough of the carmine solution is then placed in a little porcelain basin or gallipot, just sufficient to cover the entire trunk and viscera. The specimen is then moved about in the carmine fluid, so that every part that is exposed may be thoroughly wetted by it; sometimes slight pressure with the finger is required. It is left in the carmine fluid from a period varying from four to six or eight

* "On the structure and formation of the so-called apolar, unipolar, and bipolar nerve cells of the frog."—Phil. Trans. May, 1863. "New Observations upon the minute anatomy of the papillæ of the frog's tongue."—Phil. Trans. June, 1864.

hours, being occasionally pressed and moved about during this time, so as to ensure the carmine fluid coming into contact with every part. By this time the blue colour of the vessels of the lungs, viscera, &c., will have almost entirely disappeared, and all the tissues will appear uniformly red. The staining is now complete. The carmine fluid is poured off and thrown away, and the preparation washed quickly with the glycerine solution. The specimen is now placed in another little basin, and some strong glycerine poured over it; it is then left for two or three hours, and a little more strong glycerine added; when, from six to twelve hours since the specimen was removed from the carmine solution have elapsed, the preparation is ready for the last preliminary operation. The glycerine used for washing it is poured off, and sufficient strong Price's glycerine added just to cover it. To this, three or four drops of strong acetic acid are added, and well mixed with the glycerine. In this acid fluid the preparation may be left for several days, when a small piece of some vascular part may be cut off, placed in a drop of glycerine, and subjected to microscopical examination. If the injected vessels are of a bright blue colour, and the nuclei of the tissues of a bright red, the specimen is ready for minute examination; but if the blue colour is not distinct, three or four more drops of acetic acid must be added to the glycerine, and the preparation soaked for a few days longer.

If the nuclei are of a dark red colour, and appear smooth and homogeneous, more especially if the tissue intervening between them is coloured red, the specimen has been soaked too long in the carmine fluid; but in this case, although parts upon the surface may be useless for further investigation, the tissues below may have received the proper amount of colour.

Another plan which I have adopted, and which, although more difficult in practice, if carried out with due care, possesses some great advantages, is the following: The vessels are in the first instance thoroughly injected with the carmine fluid, and the preparation allowed to soak for four-and-twenty hours, when a little glycerine is injected, and then the Prussian blue injecting fluid introduced until the capillary vessels are completely filled with it. The fluid must be injected very slowly, and but slight pressure employed, or the vessels will certainly be ruptured. When the second injection is complete, the textures required for investigation may be removed, washed in glycerine, and after soaking for a day or two in acetic acid glycerine, will be ready for microscopic investigation. Beautiful and most perfect specimens of solid internal organs, like the brain and spinal cord, may be obtained by this process; and it is the most perfect plan I have adopted, although it presents many practical difficulties,

and will probably fail in the hands of the student unless he has the patience to make the attempt many times; when, however, success is obtained, he is well rewarded for the trouble he has taken, and the many failures he may have experienced.

The tissues or organs to be subjected to special investigation may now be removed, and transferred to fresh glycerine; they may be kept in little corked glass tubes, and properly labelled. Generally, the tissue will contain sufficient acetic acid, but if this is not the case, one drop more may be added.

Suppose, now, the nerves with the small vessels and areolar tissue at the posterior and lower part of the abdominal cavity, have been placed in one tube, and the prepared tongue of the Hyla in another. The former specimen may be taken out of the glycerine, and spread out upon a glass slide. If it be examined with an inch power, numerous microscopic ganglia may be seen. Several of these, perhaps, are close to small arteries. Those which are most free from pigment cells are selected, and removed carefully by the aid of a sharp knife, fine scissars, forceps, and a needle point. This operation may be effected while the slide is placed upon the stage of the microscope. The *transmitted light* enables the observer to see the minute pieces very distinctly, but if necessary, a watchmaker's lens may be used. The pieces selected are transferred to a few drops of the strongest glycerine placed in a watch glass or small basin, or in one of the little china colour moulds, and left to soak for several hours.

The microscopical examination of the specimen may now be carried out. One of the small pieces is placed upon a glass slide, in a drop of fresh glycerine, and covered with thin glass. The glass slide may be gently warmed over the lamp, and the thin glass pressed down upon the preparation by slight taps with a needle point. The specimen may now be examined with a quarter, and afterwards with the twelfth of an inch object glass. A good deal of granular matter will possibly obscure the delicate points in the structure. The slide is again gently warmed, and, with the aid of a needle, the thin glass is made to slide over the surface of the specimen, without the position of the latter being altered, and then removed and cleaned. The specimen is then washed by the addition of drop after drop of strong glycerine containing five drops of acetic acid to the ounce. The slide can be slightly inclined while it is warmed gently over the lamp, in such a manner that the drops of glycerine slowly pass over the specimen and wash away the debris from its surface. The most convenient instrument for dropping the glycerine on the specimen is a little bottle, of two ounces capacity, with a syphon tube drawn to a point, and a straight tube, with an expanded upper part, over which

is tied a piece of stout sheet vulcanized India-rubber. Upon compressing the air, by pressing down the India-rubber, the glycerine is forced drop by drop through the syphon tube and allowed to fall upon the specimen.* See pl. X, fig. 70.

When several drops of pure glycerine have been allowed to flow over the specimen, the thin glass cover, after having been cleaned, is re-applied and pressed upon the specimen very gradually, but more firmly than before. If the preparation looks pretty clear when examined with the twelfth, the glass cover may be cemented down with Bell's cement, and the specimen left for many days in a quiet place. It may then be re-examined, the process of washing with glycerine repeated, and further pressure applied until it is rendered as thin as is desired. When this point had been reached, more glycerine with acetic acid is to be added, and a plate of mica or the *thinnest glass cover* applied, when it may be examined with the twenty-fifth. The process of flattening may be pushed still further if desirable,—and if only carried out very slowly by gentle taps or careful pressure with the finger and thumb *from day to day*, the elements of the tissues are gradually separated without being destroyed. If there be much connective tissue, which interferes with a clear view of the finest nerve or muscular fibres, it may be necessary to immerse the specimen for some days in the acetic acid syrup, and then transfer it to fresh glycerine. The success of this process depends upon the care and patience with which it is carried out. The most perfect results are obtained in cases where the washing, pressure, and warming have been very slowly conducted, and it is most interesting to notice the minute points of structure which are gradually rendered clearer by the application of a gentle heat, subjecting the specimen to a little firmer pressure or by soaking it in a little fresh glycerine placed in a watch-glass.

Specimens of tissue prepared in this way can be transferred from slide to slide, and no matter how thin they may be, after having been allowed to soak in fresh glycerine they may always be laid out again perfectly flat upon another slide, by the aid of needles.† The action of these viscid fluids is most valuable, and I feel sure that by the process here given, retaining the principle, but modifying the details

* These little bottles, as well as any other instruments or apparatus required, can be obtained of Mr. Matthews, Carey-street, Lincoln's Inn-fields ; Mr. G. King, 190, Great Portland-street ; or Mr. Highley, Green-street, Leicester-square.

† I often mount these specimens upon a circle of thin glass about ¾ of an inch in diameter, instead of upon a glass slide. The circle is then placed in a wooden slide in the centre of which a hole has been drilled of the proper dimensions to receive it. It is fixed in its place by a ring of gummed paper.

in special cases, many new and important anatomical facts will be discovered. Until this process is carried out successfully by other observers, I have little hope of my own observations being confirmed.

Of the very many new methods of preparation recently introduced, only a few of those which I have found most useful have been published in this work. Had I included many, I fear I should have confused rather than assisted the student, while I have been so disappointed with the practical results of some plans, although most strongly recommended by their inventors, that no good purpose would have been served by their introduction. I am satisfied that many of these new methods rest upon unsound principles altogether, and that by drawing conclusions from what is very imperfectly demonstrated in the specimens prepared, observers have been and are being led away from the truth, and encouraged to accept views, some of which have been actually proved to be erroneous by preceding observers.

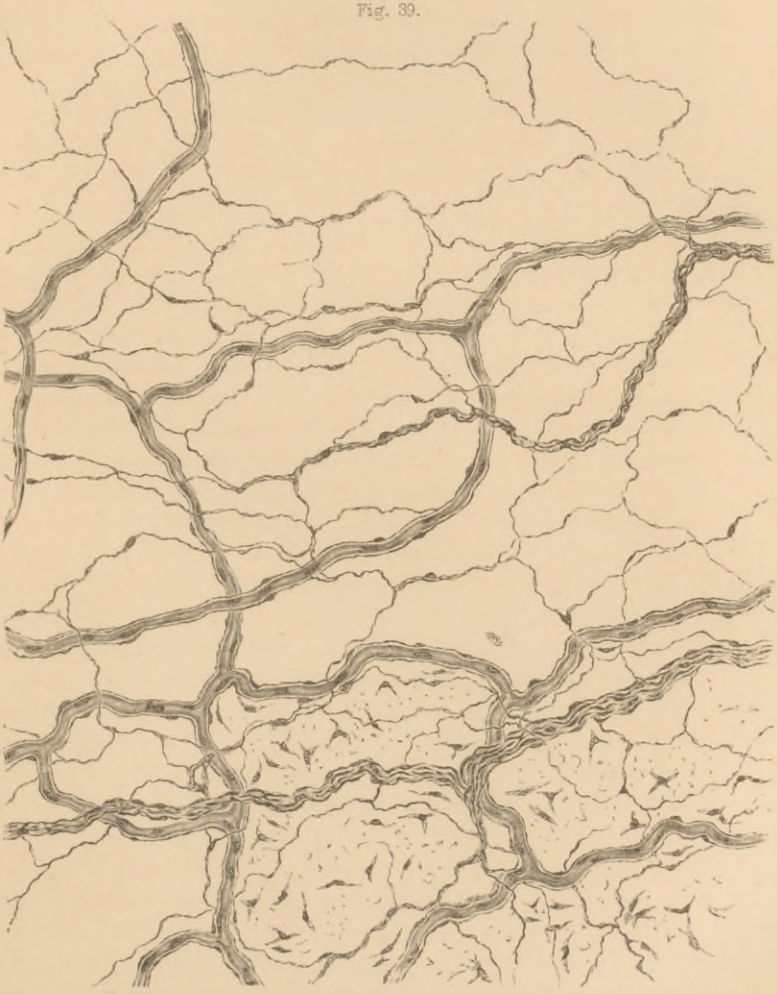
As regards the value of certain methods recently recommended for investigating the distribution of the finest nerve fibres, I can speak confidently. If the processes adopted by some who have recently investigated the subject be adopted, it will be found that the very part of the nerve fibre which is required to be followed is actually destroyed, and thus the observer has been led to conclude that the nerve *ended* very near to the dark-bordered fibre, the truth being, as proved by altogether different methods of enquiry, that the nerve cannot be seen to end at all, and can be traced a very long distance beyond the point where it is believed to terminate, as a bundle of extremely fine fibres, which are arranged in networks.

Such points as those, clearly delineated in figs. 38, 39, pl. VI., would not have been visible in specimens, had the processes of investigation usually adopted been followed. The delicate nerve fibres ramifying in every part of the connective tissue in fig. 39, would not have been seen, had the specimen not been prepared according to the principles laid down in p. 50. I have never been able to demonstrate the fine nerve fibres distributed to the capillary vessels, except by the method of investigation I have recommended. In my specimens they can be traced in every part of their course from the nerve trunks to their ultimate distribution, quite close to, and sometimes in actual contact with the vascular walls; and it is possible to distinguish the nuclei or masses of germinal matter connected with these nerve fibres from those of the capillaries themselves. Many other exceedingly delicate points may be demonstrated most conclusively in these specimens.

Fig. 38.

Portion of a muscular fibre from the diaphragm of a mouse, showing nerve fibres and capillary vessels. p. 60.

Fig. 39.



Connective tissue covering mylo-hyoid muscle of the hyla, or green tree-frog. *a*, capillary vessels, with their nerve fibres. *b*, bundles of fine dark bordered nerve fibres, from which fine nerve fibres may be traced to the capillaries and to their distribution in the connective tissue, where they form networks of exceedingly fine compound fibres. The engraving represents the specimen as magnified only 110 diameters, but the original drawing was taken from it when magnified by a much higher power. × 110. p. 60 1864.

(To face page 60.

Those who condemn the plan I have recommended, without being practically acquainted with it, and those who seek to excite prejudice against it by denying the conclusions I have arrived at, and the truthfulness of my drawings, without having seen the specimens, are taking a course which may not be fair, but which at any rate, I shall not object to. As my specimens are preserved, and can be examined by any one who cares to do so, it is scarcely necessary to say more. The actual specimen from which fig. 39 was copied, has been put up for upwards of two years, and is still in a good state of preservation; but it is, of course, vain to hope that many observers can come here to minutely examine specimens. Various circumstances render this impossible. Time, however, will determine which, of several conflicting observations, is correct, permitting that which is false to evaporate quietly—fixing and perfecting all that is worth preserving permanently.

The Microscopical Examination of Living Things.

102. Of Examining Living Bodies under the Microscope, and of Arrangements for keeping them alive while under Observation.—Some of the most remarkable phenomena which distinguish *living* from *non-living* matter may now be observed under the microscope with the aid of the highest powers. There is no department of natural knowledge in which a greater advance is to be noticed than this, and the facts which have been recently discovered enable us to draw a sharp and well-defined line between living things and the various forms of inorganic matter, be it of simple or of complex composition. If as investigation still further advances the facts already known are confirmed, and the conclusions arrived at from recent researches, supported by new observations and experiments—the operation of some agency, force, or power in living matter, distinct from every kind of physical force operating in non-living matter must be admitted, and the views at this time most popular, will have to be modified in most important particulars.

Hitherto many of the movements occurring in living things have been referred to the property of *contractility*, and strange to say, the very authorities who never lose an opportunity of condemning those who attribute any changes in things living to the influence of a peculiar force or power—*vitality*, consider that movements are sufficiently explained and accounted for if they are attributed to this so-called property of *contractility*. They do not attempt to define what they mean by the word, nor do they show in what this supposed property resembles or differs from other properties of matter.

If the student studies the question carefully, he will, I think, find that great confusion has arisen from the circumstance that several essentially different kinds of movements have been attributed to this one property of contractility. Thus any tissue which ultimately becomes shortened or lengthened, gaining in one diameter what it loses in another, is said to be contractile, while on the other hand, that which moves in every conceivable direction is said to do so by virtue of this same property. It is not, however, very easy to see how two such different movements, as repeated acts of contraction and relaxation within a definite space, and the actual movement of a mass from place to place, can depend upon one and the same property. In fact, it has yet to be shown that the many different movements commonly known to occur in living things are really all of the same nature. I think that a very little attention to the actual phenomena will convince the observer that there are really many different kinds of movements essentially distinct from one another, and due to very different causes. It is desirable to refer particularly to the change taking place in the single elementary part or cell. The movements occurring in living beings may be arranged as follows:—

1. Primary or Vital Movements—affecting matter in the *living* state only, and occurring in every direction, as seen in the amæba, white blood corpuscle, and in germinal or living matter generally.

2. Secondary Movements—the consequence of vital movements, or of other phenomena, affecting matter which is not in a living state:—

   a. **Ciliary Movements.**—Probably due to alterations in the quantity of fluid within the cell, the changes in the proportion of fluid being brought about by the action of the living or germinal matter of the cell.

   b. **Muscular Movements.**—Due to a disturbance (electrical or otherwise) in the neighbourhood of a contractile tissue—that is, a structure so disposed that its constituent particles are susceptible of certain temporary alterations in position, which alterations take place in certain definite directions only.

   c. **Molecular Movements.**—Which affect all insoluble particles, *non-living* as well as *living*, in a very minute state when suspended in a fluid not viscid.

   d. **Movements of Solid Particles suspended in Fluid in Cells, caused by Currents in the Fluid,** as the pigmentary matter in the pigment cells of the frog.—Due to the motion of the fluid as it passes into, or out of, the cell, through its permeable wall; this movement being dependent upon changes taking place external to the cell.

Vital Movements are peculiar to matter in the living state, and

are not known to occur in any matter which has not been derived from matter in a living state. Such movements cannot be imitated. They cease when death occurs, and having once ceased, they cannot be caused to reappear in the same particles of matter. Excellent examples of vital movements are presented in the Common *amœbæ*, in the *white blood corpuscles, in mucus and pus corpuscles.*

a. *Amœbæ* can always be obtained by placing a small fragment of animal matter in a wine-glass full of water and leaving it in a light part of the room for a few days. I have found it convenient to introduce a few filaments of the best cotton wool into the water. The amœbæ collect amongst the fibres which protect them from being crushed by the pressure of the thin glass when removed to the glass slide. An imperfect idea may be formed of the changes taking place in the form of the most minute amœbæ by reference to fig. 40, pl. VII.

b. *Mucus Corpuscles* are embedded in the mucus which is found upon the surface of the mucous membrane of the nares, fauces, and air tubes. By coughing sharply or by making a violent effort, something between coughing and sneezing, small portions of transparent mucus may often be detached. The transparent viscid mass is placed upon a glass slide, and covered very carefully with a piece of the thinnest glass, which is to be very gradually and not very firmly pressed down, so as to cause the mucus to spread out, and form a very thin layer. The movements occurring in a mucus corpuscle are represented in pl. VII, fig. 41.

c. *Pus Corpuscles* should be obtained from a mucous or other surface at the time that they are *growing and multiplying.* Pus, which is usually examined, consists of *dead*, not of *living corpuscles.* These are *spherical*, as generally represented in books, and many have a sharp, well-defined outline, owing to coagulation having occurred upon the surface. Thus the so-called membrane or cell wall of the pus corpuscle has resulted. A cell membrane may always be formed artificially, by exposing the surface of a mass of albuminous material to the influence of a re-agent, or to conditions which are known to effect the coagulation of albumen.

The best specimens of pus for studying vital movements may be obtained from the urine in some cases of *chronic inflammation of the bladder.* Not uncommonly in this affection the urine contains very little solid matter, and the pus corpuscles retain their vitality, although immersed in it for many hours after the urine has been removed from

the bladder. So far from the corpuscles being spherical, as usually figured and described, in many specimens not a single corpuscle of this form is to be detected. Every corpuscle exhibits little "buds," "offsets," or "protrusions" at every part of its circumference, as is well seen in pl. VII, fig. 44, and attentive examination, even under moderate magnifying powers, will convince the observer that the corpuscles are slowly undergoing alterations in form. The movements are very remarkable. Many of the altered appearances seen in a single specimen of pus are represented in fig. 44, but it would occupy too much space to describe the changes. Movements also occur in the most minute of these buds or offsets, which have been detached as represented in pl. VII, fig. 42. In fig. 43 a drawing of some of the particles from vaccine lymph has been introduced. One of the smallest of the particles detached from a pus corpuscle is capable of absorbing nutrient material and growing into a corpuscle, having all the properties and powers of that from which it was derived. If the student will only examine into these things, he will soon be able to picture to himself the wonderful changes which occur in inflammation, and in the multiplication of the living virus of contagious fevers, and perhaps form a correct notion of the nature of the changes.

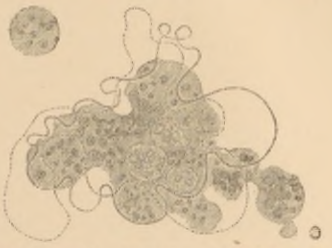
In order to watch the vital movements above referred to, it is only necessary to place a very small portion of the pus on a glass slide, and cover it very carefully with a piece of the thinnest glass, pressure upon the corpuscles being prevented by the introduction of a portion of hair, or a small piece of tissue paper or thin writing paper. In very cold weather it is desirable to warm the slide slightly, or to use one of the arrangements referred to in section 122.

The movements in germinal matter can be distinctly seen with a twelfth of an inch object glass, but it is often necessary to examine one particular corpuscle very attentively for half a minute or more. In some cases the changes in form are so slow that the observer who looks at the object for the first time cannot satisfy himself of the actual occurrence of movement at all. It is absolutely useless to attempt observations of this kind in an off-hand, slap-dash, self-asserting manner. Those who desire to have the delight of pondering over such changes will gladly find the leisure to observe the facts. This is just one of those phenomena which, having been well seen once can generally be detected afterwards without difficulty. Under the sixteenth, twenty-fifth, or fiftieth, the alteration in form can be seen very distinctly, and there are few things more wonderful, or which will furnish more interesting matter for careful thought and for valuable and useful speculation.

Fig. 40.

Very minute amœbæ, from water containing a little dead animal matter. The smallest free particles exhibiting very active movements were less than the ten-thousandth of an inch in diameter. × 5000. pp. 64 & 204.

Fig. 41.



Mucus-corpuscle. From the mucus of the throat of man in health; showing the different forms assumed by the living mass within a minute. pp. 64, 1 9, & 204. 1863. × 2800

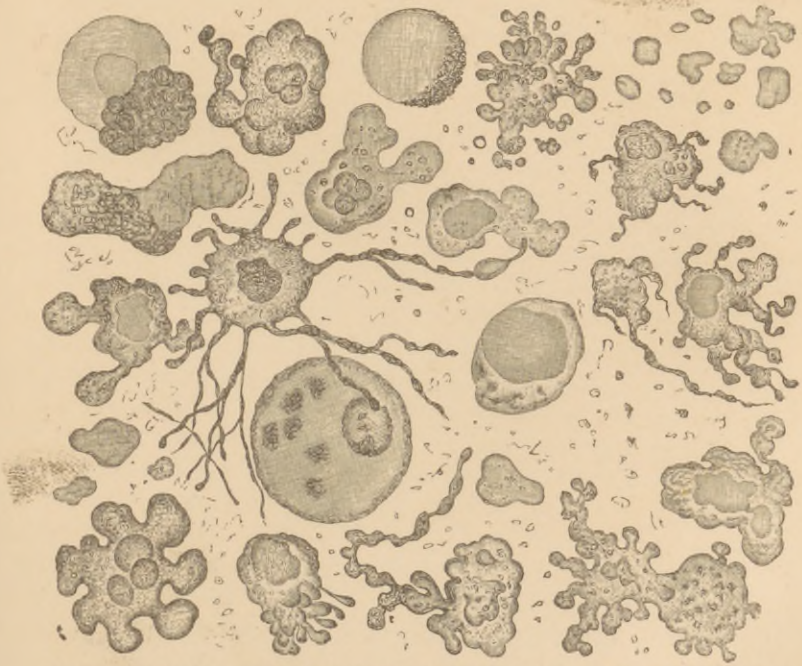
Fig. 42.

Different forms assumed by the same minute mass of germinal matter of pus from the bladder during five seconds. × 2800. p. 204.

Fig. 43.

Particles from vaccine lymph, exhibiting very active movement. × 5000. p. 204.

Fig. 44.



Pus corpuscles, exhibiting very active movements, from the bladder of a case of chronic inflammation. Man. Showing alterations in form due to (vital?) movements. × 1300. pp. 64 & 204.

d. Chyle and Lymph Corpuscles, cells from the aqueous humor of the frog's eye, the white blood corpuscles, certain corpuscles in the connective tissue and young epithelial cells from the mucous surfaces generally, exhibit movements of the same kind. Masses of germinal matter in the frog's cornea, especially when under the influence of a current of electricity, exhibit active movements. (Kühne). The white corpuscles in the circulating fluid of many mollusks and other animals, also exhibit vital movements, and it is probable that they occur in every kind of germinal matter, but in consequence of some forms being very easily and quickly killed, we are not able to demonstrate the movement in all cases.

e. Ova.—Vital movements are manifested by the germinal matter entering into the formation of ova. Much may be learnt by patiently studying the changes taking place from day to day in the ova of the common water snail (Limnæus Stagnalis) and other mollusks. As is well known the fertilised ovum of many amphibious reptiles, fishes, and mammalia, is the seat of wonderful changes in form. The movements of the mass in some cases commence before, and always continue for a long time after, impregnation has been effected. The result of the movements is the concentration of the germ yolk at one part of the surface, and the division of the entire ovum into this and the food yolk. It is probable that the layer of germinal matter around the food yolk is the seat of the active movements and not the yolk itself. That part which is known as the germ yolk is alone the seat of all those wonderful phenomena which result in the formation of the embryo. The phenomena may be well observed, and with great facility, in the ova of frogs, newts, and many osseous fishes.

Dr. Ransom, of Nottingham, who has for some years paid the greatest attention to the examination of the ova of fishes, recommends those of the *Stickleback* and the *Pike* as well adapted for observation. It is not necessary that the ova of the latter fish should be fertilised even. No form of active living matter is better adapted to the purposes of the physiologist than that of the egg of the pike.

In making experiments upon either of these fishes, Dr. Ransom divides the spinal cord just behind the edge of the gill covers, and then the fish is amenable to manipulation, and yet lives and breathes well. In order to impregnate the ova of the stickleback, the same observer recommends that the ripe male should be cut open and his

testes used in fragments, as the semen cannot be well *squeezed* out. The application of heat and cold in investigations of this kind is referred to in § 122.

f. Cyclosis or Rotation of the contents of cells.—The circulation in the cells of *vallisneria*, *anacharis*, *chara* and *nitella*, may be observed without any difficulty. In all these the movement is due to the *vital* properties or powers of the germinal matter which moves round and round the cell; the hard cell wall preventing its escape, and rendering movements in a right line impossible. If subjected to examination under the highest powers, however, certain precautions are necessary. The thinnest possible layer should be removed with a thin but very sharp knife, pl. IV, fig. 20, from the surface of a young leaf of *vallisneria* or *anacharis*, and the two thin pieces thus obtained must be carefully placed on the slide with a drop of water and covered with the thinnest possible glass, care being taken to prevent it from pressing firmly upon the freshly cut surface.

It not unfrequently happens that cyclosis has entirely stopped in the cells when submitted to examination, but after the fragments of the leaf have remained still for a short time the movement recommences, especially if slight warmth be applied; and it is a good plan, especially in winter, to place the sections which have been made in water, in a small corked glass tube, which may be carried in the pocket for a quarter of an hour or more before they are to be subjected to examination.

Facts of the utmost general interest and importance may be demonstrated in vallisneria by the aid of the highest powers. The stream which moves round and round the cell, and looks like pure water under a twelfth, is found to be composed of extremely minute and apparently spherical particles endowed with active motor power, if examined by a $\frac{1}{25}$ or $\frac{1}{50}$. The green chlorophyll masses are urged on by the actively moving germinal particles. One portion of the active, colourless, moving mass is seen to outstrip another portion, amongst which it gradually blends and incorporates itself, to be, in its turn, outstripped by other portions.

Solid particles are often suspended in moving germinal matter, and appear to move of themselves, although, really, they are perfectly passive and are but carried in the moving stream. Sometimes these are formed from the germinal matter itself, sometimes they are foreign particles entering from without. The latter may be seen commonly enough in the amœba. Pus and mucus corpuscles and many other forms of germinal matter, contain extremely

minute particles, the nature of which has not been positively determined.

The hairs from the flower of the Virginian spider-wort (*Tradescantia Virginica*) are beautiful objects for studying the movements of the living germinal matter in the cell. The transparent matter in active movement contains many minute highly refractive particles, which enable one to detect the slightest variation of the direction in which the stream sets. The young hairs of the nettle, the cuticular cells of this and many other plants, exhibit rotation. The movement can often be seen in the young, although it may not be visible in the fully-formed cells.

The movements described in this section as *vital movements* I regard as *primary*, and think that the power of movement exists in connection with the matter of which each small portion of the moving mass is composed. It may be to some minds unsatisfactory to attribute the phenomenon to the influence of a power of the nature of which nothing is known, but it is surely better to do this for the present, than to assert that these movements are due to physical force, when they cannot be explained by known laws. Any unprejudiced person who thoroughly studies the movements and carefully thinks over the facts of the case, will, I think, find himself compelled to admit that they cannot be accounted for in the present state of our knowledge, without assuming the existence of *vital power*. No one will be more ready to acknowledge that these movements and other phenomena characteristic of living matter are due to ordinary force than myself, so soon as the correctness of such a doctrine shall have been proved, or when any advance towards this end shall have been made; but as a working physiologist desiring to promote to the utmost, real advance in this department of science, I consider it a duty to oppose as strongly as I can the practice pursued by some scientific authorities in the present day, and especially in this country, of reiterating the assertion that *all*, or *nearly all* the phenomena of living beings are to be accounted for by the action of ordinary force. Instead of my objections to the assertions being answered, or the challenge to consider the matter in detail being accepted, we are told that the "tendency of modern science is towards this" apparently much-desired "end, and that although living matter cannot yet be prepared by man, the day is not far distant when its artificial production will be rendered possible," and so forth!

The student should endeavour to detect the fallacies which underlie many of the modern doctrines, and which are very often so cleverly concealed by the ingenious choice of words, that they are not easily discovered, except by one who has accustomed himself to

analyse modern scientific writing. It has been stated, with what appears to be learned precision, that force is "conditioned" by the "*molecular machinery*" existing in the cell, and no doubt it has been concluded by those who made the assertion, that no one would be likely to inquire what the molecular machinery was, and how the "conditioning" took place. But it so happens that the changes in question occur without the existence of anything to which the term *machinery* can be properly applied. Instead of the living cell being like a machine, it is perhaps less like a machine than anything else that we have any knowledge of. This "living machine"! is just a very minute mass of soft, colourless, transparent, semifluid matter, endowed with very wonderful properties or powers,—in which matter is decomposed and its elements rearranged, while its forces are conditioned in a manner that cannot be effected by man with the aid of the most perfect machinery and elaborate apparatus his ingenuity has devised. Living matter is not a machine, nor does it act upon the principles of a machine, nor is force conditioned in it as it is in a machine, nor have the movements occurring in it been explained by physics, or the changes which take place in its composition by chemistry. The phenomena occurring in living matter are peculiar, differing from any other known phenomena; and therefore, until we can explain them, they may be well distinguished by the term *vital*. Not the slightest step has yet been made towards the production of matter possessing the properties which distinguish living matter from matter in every other known state. As investigation advances the movements of living or germinal matter will acquire a still higher importance, for there can be no doubt that the alteration in the position of cells with respect to one another during the formation of tissues is due to vital movements. It is therefore unnecessary for me to make any apology for having considered the question at some length, or for having urged my readers to observe the phenomena.

The white blood corpuscles have been termed *contractile cells* and *amœbiform corpuscles*, as if everything which exhibited this peculiar property of movement were of an *amœbiform* type. I have shown that the lymph and chyle corpuscles, the white blood corpuscles, the so-called mucus and pus-corpuscles, young epithelial cells, &c., are but free masses of living germinal matter, which, being destitute of any firm cell-wall, and embedded in a more or less fluid medium, are free to move in every direction. In short, the movement characterises not only the amœba and the so-called amœbiform cells, but every kind of living matter, although it cannot be seen in every instance, in consequence of the slow rate at which the changes in form occur. At the present time we are acquainted with so many

cases in which active movements may be actually seen, and every year new examples are discovered—that we are justified in concluding that all germinal matter possesses the same property. The changes in relative position and alterations in form which take place in the case of the germinal matter of the firmest tissues during development, prove that this form of germinal matter is no exception. The movements of the amœba must therefore be regarded as *vital movements*, not peculiar to it and a few other things. The terms *amœbiform* movements and *amœbiform* bodies should no longer be employed, since it can be demonstrated that spontaneous movement, growth, multiplication, and formation are attributes of every kind of living matter, while they are not known to be manifested by any kind of non-living matter whatever. No satisfactory explanation of the movements has yet been offered, and though I know many scientific men will attribute them to antecedent changes in the moving matter, and rest content, refusing to discuss the nature of the antecedent changes they imagine, it seems to me that by doing so they fall into the fatal mistake of really checking the progress of scientific enquiry, which they profess to promote. It looks as if they feared that enquiry should extend beyond the point at which the narrow physico-chemical doctrines to which they have most prematurely committed themselves, in direct opposition to all the teachings of true science would limit it.

Ciliary Movements.—Ciliary action is, I think, due to changes going on within the cell, but probably very intimately connected with the currents which flow to and from the germinal or living matter, and the altered tension thus caused in the cell. Ciliary motion is not dependent upon nervous action, nor is it due to any disturbance in the surrounding medium. Ciliary motion cannot be regarded as a *vital* movement, although it is probably due to changes which are consequent upon vital phenomena. Cilia consist of "formed material." In the immediate vicinity of ciliated cells are sometimes observed cells with open mouths, out of which mucus and various substances, formed or secreted in the interior of the cell, pass. In the formation of these products, nutrient matter from the blood, after passing through the attached extremity of the cell, is probably absorbed by the living matter. At the same time the outermost portion of the latter becomes converted into the peculiar contents of the cell, and thus the formed matter which has been already produced becomes pushed towards the orifice. I think that the movements of cilia are brought about by a somewhat similar series of changes, in

which the germinal or living matter, usually termed "nucleus," plays the active and most important part.

Different forms of ciliary action may be observed among the different species of infusoria. It is, however, doubtful if many of the very fine spine-like bodies, the movements of which seem under voluntary control, should be regarded as cilia. The simple organisms of this class seem to possess the power of permitting or stopping the vibrations, although there can be no doubt that in vertebrate animals, generally, ciliary action is quite independent of volition. There is certainly no connection between the cells of ciliated epithelium and the nerves.

Cells of ciliated epithelium in active vibration can always be obtained by scraping the back of the frog's tongue. Mucus is removed in which numerous cells are found. The thin glass cover must be prevented from pressing too firmly by inserting a small piece of thin paper beneath it. The student may also obtain very beautiful ciliated epithelium in active vibration from the branchiæ (gills) of the oyster or mussel. Some of the cilia from the latter situation are of considerable length, and occasionally the vibration of a single cilium may be watched, in which case the observer may demonstrate the interesting fact that movement occurs not only at the base of the cilium, but in every part of the vibratile filament.

Of all the ciliated structures, the newt's kidney is perhaps the most beautiful and the most remarkable. The tortuous uriniferous tubes in the upper thin portion of the kidney are lined in their whole length with ciliated epithelium, which continues in active motion for some time after the removal of the organ from the body of the animal. In order to display this wonderful object, we must proceed as follows:—After destroying the newt by cutting off the head, the abdominal cavity is laid open, and by turning the viscera to one or other side, the kidneys may be exposed. Towards the pelvis of the animal, the kidney presents much the same appearance as in the frog: but, upon tracing it upwards, it will be found to become gradually thinner, and to extend quite into the thoracic portion of the animal. It is this upper thin part of the kidney which shows the ciliary motion to the greatest advantage. See pl. VIII, fig. 45. A probe, *a*, is represented in the drawing underneath that portion of the kidney which should be examined in the microscope. The secreting tubes lie upon one plane, so that a tube throughout the entire length of which active ciliary motion is constantly taking place, may often be seen in the field of the microscope at one time. A more beautiful object under a half inch object-glass, can scarcely be conceived. The thin portion of the kidney,

above referred to, is to be very carefully removed from the body by delicate munipulation with fine forceps and a pair of scissars, moistened with a little water, or, what is still better, with some of the serum of the animal, placed in a large thin glass cell, and carefully covered with thin glass. The cell should be sufficiently thick to prevent any pressure upon the preparation. After ciliary action has stopped, the cilia are with great difficulty distinguished. Many of the tubes in the lower thick part of the kidney do not exhibit ciliary action perhaps because they are undergoing degeneration. I have been able to find in some newts tubes in every stage of wasting.

Ciliated epithelium may also frequently be obtained from the larynx and trachea of man by coughing violently. The vibration will continue for some time after the specimen has been transferred to the glass slide. The observer will be surprised at the enormous number of cilia projecting from a single cell; indeed it often happens that a mass is expelled which seems to consist of hundreds of long filaments all in active vibration, radiating from a common point.

Contractility of Muscle.—Contractile tissues exhibit a repetition of movements. Contractility is essentially different from any form of vital movement. The first affects various kinds of formed material only; the last is peculiar to germinal matter. Vital movement is continuous. Contractility is essentially interrupted. By vital movements a weight may be raised higher and higher. Contraction involves yielding or relaxation. It is, as it were, a vibration to and fro—the alternate shortening and lengthening of a fibre. Vital movement may occur in a mass of living matter in any direction. Contraction takes place in one definite direction only, and never alters.

Contractile movements may be watched in many of the lower animals. The alternate contraction and relaxation of the spiral stem of a vorticella is a good example. Muscular contraction may be studied in any of the small insects or crustacea. Mr. Bowman strongly recommends muscular fibres from a young crab (Phil. Trans. 1841). Many small transparent aquatic larvæ are very favourable for this purpose.

The phenomena of muscular contractility may, however, be studied more satisfactorily in the broad muscles just beneath the skin of the common maggot or larva of the blow-fly, than in those of any other animal I am acquainted with, and as these can be always readily obtained, I recommend them for observation. The movements, which are very beautiful, continue for ten minutes or a quarter of an hour after the muscles have been removed from the body of the recently killed animal, so that a specimen may be prepared and

passed round the lecture room in one of the portable microscopes. In the winter I have seen the contractions continue for upwards of half an hour. But the most instructive method of examination is under the influence of polarised light, with a plate of selenite. When the ground is green, the waves of contraction which pass along each muscular fibre in various directions, are of a bright purple. In other parts of the field the complementary colours are reversed. There are few microscopic objects, that I am acquainted with, so beautiful as this. With the aid of very high powers, the actual change occurring in the contractile tissue as it passes from a state of relaxation to contraction, and from this to relaxation again, may be studied, and for many minutes at a time.

In order to obtain the muscles, it is only necessary to slit up the larva, and after removing the viscera, to separate some of the muscles from the outer skin to which they are attached. They may be moistened with some white of egg, saliva, or better than all, a little of the colourless fluid from the animal.

Of Molecular Movements.—When any solid matter in an exceedingly minute state of division is suspended in a limpid fluid, every one of the minute particles is seen to be in a state of active motion or vibration in the neighbourhood of other particles. The cause of these molecular movements has not yet been satisfactorily explained, and they have often been mistaken for *vital movements*. If some *bacteria* developed in any decomposing water be exposed to a temperature of 200° they are destroyed, but although quite dead, *molecular movements* still occur. If, however, the movements of the dead particles be compared with those of living bacteria, a great difference will be discerned.

Movements of Granules within Cells.—The movement of insoluble particles from one part of a cell to another, as occurs in the radiating pigment-cells of batrachia, is probably due to alteration in the direction of the flow of fluid in the cells, *from* the cavity of the cell *towards* the tissues, or *from* the surrounding tissue *into* the cell. If the capillaries were fully distended, fluid would permeate their walls and would pass into the cavity of the cells, in which case the insoluble particles would gradually become diffused and would pass into all parts of the cell ; while, on the other hand, if the capillaries were reduced in diameter, and the lateral pressure upon their walls reduced, there would be, as is well known, a tendency for the fluid in the surrounding tissue to flow towards the vessels and pass

into their interior (pl. VIII, fig. 47). In this case the quantity of fluid in the cells would be gradually reduced, and the insoluble particles would become aggregated together, and would collect in those situations where there was most space, as in the central part of the cell around the nucleus. Moreover, in the last case, the flow of fluid, which constantly sets towards the nucleus, would be instrumental in drawing the particles in this same direction, while if the cell contained a considerable proportion of fluid, the currents would pass between the articles without moving them. Evaporation, as it occurs after death, causes concentration of the insoluble particles towards the centre of the cells.

On the other hand, the changes in the pigment-cells of the frog have been considered by Professor Lister to be due to *vital actions*, and he agrees with Wittich and others who maintain they are under the immediate control of the nervous system. Indirectly they are, but I do not think that any experiments have proved satisfactorily that the nerves exert any *direct* influence upon the movements of the particles in these cells. It is well known that the nerves govern the calibre of the vessels, and thus influence the amount of fluid in the surrounding tissues, and in this indirect manner nerves may be said to affect the movements of the particles in the cells. The reader will find a full account of Prof. Lister's experiments, and the arguments deduced from them, in his paper "On the Cutaneous Pigmentary System of the Frog," published in the Philosophical Transactions for 1858.

Movement of Blood: of the Heart's action: of Growth and Multiplication.—*Movement of the Blood.*—For examining the circulation in the web of the frog's foot, a young frog with a thin web should be selected. The body and one hind leg are loosely bound up in wet rags, the other leg being allowed to protrude. The body is then tied to the frog plate, and a piece of thread having been carefully tied to two of the toes, the webs may be stretched over the glass at the end of the plate, and fixed in the proper position for observation. A drop of water may then be added, and the web covered with thin glass.

By careful observation of the circulation, first of all under a low power, and then under a quarter of an inch object glass, most important and highly interesting facts will be learnt, and if some irritant be applied to one part of the web, the early changes occurring in inflammation may be demonstrated. A little mustard, a fragment of Cayenne pepper, a little strong acid, or a hot wire may be used to excite inflammation. But a minute piece of the paper now used as

a substitute for a mustard poultice, is most convenient. In cases in which it is necessary to conduct observations on the circulation with the aid of very high powers, it will be found desirable in practice to increase the length of the tube instead of employing object glasses of very high magnifying power. A quarter of an inch object glass may thus be made to magnify as highly as a twelfth, and as the distance between the object glass and the thin glass covering the web is very considerable, there is not the same danger of serious derangement every time the animal moves slightly. Several different lengths of tube may be adapted to the microscope body, which may be thus increased to the length of two feet or more, if desired.

If a small artery be brought into focus and the tip of one of the toes be very lightly touched, the artery is seen to contract immediately, and somewhat irregularly in different parts of its course. Sometimes a few blood corpuscles are firmly compressed, and for several seconds the vessel remains so strongly contracted that not a corpuscle passes along it. By performing this instructive experiment, the observer may form a notion of the wonderful contractile power of the coats of the smaller arteries, and demonstrate conclusively that the afferent nerve fibres distributed to the skin of the foot generally, influence the nerve centres from which the nerves ramifying amongst the muscular fibres of the arterial coats take their rise. This is a beautiful instance of reflex nervous action affecting the vessels.

The *lungs* of the frog and newt have been submitted to microscopical examination. The circulation may also be studied during life in the capillaries of the tail of a small fish, minnow, stickleback, carp, &c. The fish should be wrapped up in wet lint and loosely tied at one end of a glass slide, the tail being placed about the centre, and covered with a piece of very thin glass.

Heart.—A more correct idea of the action of the heart may be formed by watching the contractions in a small living animal under the microscope than in any other way with which I am acquainted. A young fish, or newt, or frog tadpole may be taken for the purpose, but I have found that a young snake removed from the egg exhibits the phenomena most beautifully. The blood may be distinctly seen as it eddies through the various apertures in passing to or from the different vessels and cavities of the heart. The undulating contractions of the auricles and ventricle of the heart are very wonderful. Under a two-inch power adapted to a binocular microscope, a good idea of the heart's action is obtained.

The branchiæ of the frog tadpole or young newt may be examined in a flat glass cell specially prepared for the purpose, and by an

arrangement of tubes the animal may be supplied with fresh water while it remains under observation. In pl. VIII, fig. 46, is represented a form of cell which I made some years ago for a proteus, but a cell for a newt or other animal may be made upon the same plan. —H. to W., § 131. The circulation of the blood in the capillary vessels of a mammalian animal may be studied in the thin membrane forming the 'wing' of a young bat.

Chyle. — For studying the movements of the chyle in the lacteals, a mouse, rat, or young rabbit may be taken. The animal should be fed with a little lard beaten up with a piece of pancreas and a small quantity of bile, so as to form a soft pultaceous mass which may be strained through muslin. About half an ounce, or less, of the cream-like fluid may be injected by the aid of a small syringe into a flexible catheter which has been passed down the gullet into the animal's stomach. After a couple of hours, the creature should be pithed, stunned, or destroyed very suddenly, and a small portion of the mesentery with the intestine attached withdrawn through an aperture in the abdominal walls and submitted to microscopical examination with a low power.

The examination of all the moving objects alluded to in this section, should be conducted with the aid of the binocular. The circulation in the cells of vallisneria, and the movements of the cilia of small animalcules or ciliated cells under a high power with the new binocular of Messrs. Powell and Leeland, once seen can never be forgotten, for the mind seems to realise the actual state of things occurring during life, in a manner which before was not possible.— See § 114.

Of Growth and Multiplication.—The observer who aims at studying the remarkable and highly interesting phenomena of germination, growth, and multiplication of cells or elementary parts, in the tissues and organs of man in health and disease, will find it absolutely necessary to investigate these processes in the simplest living beings where they occur under less complex conditions. He must exercise the utmost caution in drawing inferences from what he sees, or rather thinks he sees, and he must always bear in mind that great and irreconcileable differences of opinion exist among even distinguished observers with regard to the general nature of the changes which take place when, for example, a spore of common mildew germinates, or an insignificant bacterium gives rise to new bacteria. How then is it likely that the mode of growth, origin, and mul-

tiplication of some of the highly complex structures formed in man, especially in the course of disease can be described with correctness or fully explained to the student?

It has been stated over and over again that bacteria originate in decomposing matters, and one who has recently written on the subject thinks that he has seen the fibrillæ of muscle resolve themselves into these living bodies! It is always necessary to be on our guard against fallacious observations of this kind. Those who have had much experience in the manufacture of pseudo-bacteria could produce a number of objects and advance facts and arguments which would probably fully convince any inexperienced person that there was abundant evidence to prove that bacteria were but the modified particles of certain tissues, although the evidence really points entirely the other way. Perfect looking bacteria may be produced readily enough by gently warming over a spirit-lamp a little blood placed on a glass slide and covered with thin glass. From the red blood corpuscles under these circumstances numerous very narrow-jointed filamentous processes are seen to project, and from their constant vibration and molecular movements these might be easily mistaken for living bodies (pl. VIII, figs. 53 and 53*). Sometimes they become detached and move about in a manner much resembling certain forms of bacteria. At the same time any one familiar with investigations of this kind would be deceived neither by the general appearance nor by the movements of these bodies. True bacteria are represented in pl. VIII, figs. 48 to 52.

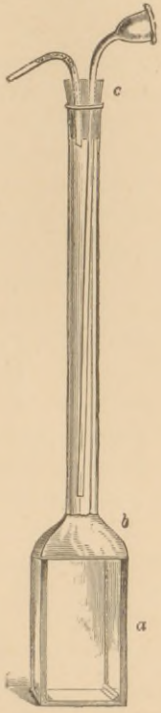
The student will learn many most important facts by watching the germination of the common mildew, and studying the different appearances of the plant when developed under different circumstances. It is exceedingly instructive to watch the growth of the spongioles of a young plant (mustard, wheat, mignonette, or better, any very small seed), as they grow under the thin glass. Fluid may be constantly supplied according to the plan described in page 77.

The mode of origin and multiplication of a bacterium and the growth of a spongiole of a plant, may appear to be questions far indeed removed from the province of medical enquiry, and yet we shall find that by such investigations alone can we hope to determine the nature of some of the phenomena, the true explanation of which lies at the very root of a knowledge of the real nature of disease. To gain any real advance, either in physiology or in medicine, we must establish certain fundamental truths; and unless we are content to examine and revise again and again the first principles of our science, we cannot hope to progress. Let not the student of medicine, therefore, conclude that the multiplication and growth of the lower forms

Fig. 45.

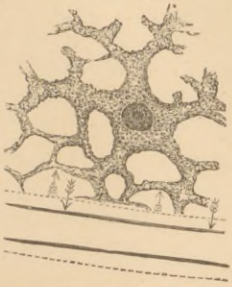
Newt dissected to display the thin part of the kidneys. p. 70.

Fig. 46.



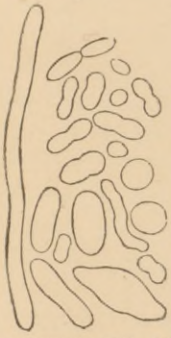
Apparatus made for examining the circulation in the branchiæ of a proteus. The smaller tubes were for the purpose of supplying the animal with fresh water. p. 75.

Fig. 47.



Pigment cell of the frog and its relation to a capillary; showing direction of flow of fluid in different states of contraction of the vessel. p. 73

Fig. 48.



Most minute bacteria. × 2800. p. 76.

Fig. 49.

Bacteria undergoing germination. × 1800.

Fig. 50.

Vibriones in old epithelial cells of the mouth × 3000 p. 76.

Fig. 51.

Fungi in old epithelial cells. Mouth. × 3000.

Fig. 52.

Bacterian vibriones from the mouth. × 1800.

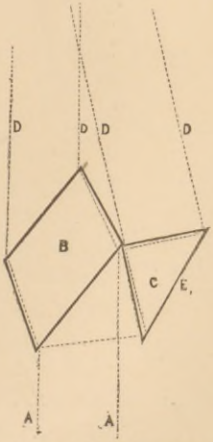
Fig. 53.

Vibratile filaments and minute particles, consisting of viscid coloured matter. Blood corpuscles, human subject, after being subjected to heat. × 1800.

Fig. 53 A.

Curious spontaneous changes in form of red blood corpuscles of the frog. × 700. p. 76.

Fig. 54.



AA, rays of light proceeding from object glass. B, parallel piece of glass. C, triangular prism. DDDD, emergent rays. p. 86.

[To face page 76.

of animal and vegetable life are not in his province. There is, indeed, scarcely a department of natural knowledge which does not bear more or less directly upon medicine, and those who discourage careful research, or speak disparagingly of its results, are doing their utmost, unconsciously it may be, and perhaps unintentionally, but nevertheless most effectively, to retard real progress.

Some of our leading practitioners are still so prejudiced as to discourage minute investigation among their pupils. Ignorant of what has been done for the advance of medicine by scientific research, and determined to continue so, they laugh at that true work which can alone teach them what they ought to know.

Since the greatest physician cannot yet give a satisfactory account of what is going on in an ordinary cold, or the greatest surgeon explain to us the phenomena which are connected with the formation of a common boil, it is surely time that those inclined to study these things should be permitted to do so without having their hard true life ruffled by the scoffs of people who are over-proud of having found a short cut to fame, but which earnest, thoughtful, students do not care to tread.

103. Arrangements for keeping Living Bodies alive while under Observation. — In order to study the changes occurring in the growth and multiplication of some of the simplest organisms which live in water, it is necessary to adopt some plan for preventing, or compensating for, the evaporation which takes place. This may be effected, as recommended by Recklinghausen, by adapting a piece of sheet India-rubber tubing to the glass ring fixed on an ordinary glass slide, the diameter of the ring being sufficient to allow a piece of thin glass to be placed within its circumference. The upper end of the tube is tied round the object glass of the microscope. Thus a "*moist chamber*" is made, and if one of Hartnack's "immersion lenses" be employed, observations may be continued upon a given object for some time. The moist chamber is, however, better adapted for use with low than with very high magnifying powers. I have found that a similar object is gained if the loss of fluid by evaporation is compensated for by a little reservoir of water, fixed at one end of the slide, from which a small piece of blotting paper or silk thread conducts the fluid to the object as fast as evaporation takes place. By placing a little cement round two-thirds of the thin glass cover, sufficient space is allowed for the requisite access of oxygen, while at the same time loss by evaporation is reduced to the smallest amount. By this arrangement the growth of the spongioles of plants can be studied very successfully. In some cases living bodies can only be kept alive if exposed in a temperature of 100, and it is therefore

necessary to have some arrangement by which the object may be kept warm during examination. § 122.

A small quantity of pus, mucus, and fluids or semi-solid matters containing various kinds of living matter, may be preserved for some days without the death of the living matter they contain taking place, by the following arrangement. A small glass tube about half an inch in diameter and an inch and a half in length is prepared, the edge of one extremity being turned outwards in the blow-pipe flame, so that very thin membrane may be tied over it. The tube is so arranged that the membrane just touches the surface of some distilled water in a small dish or capsule; the whole being placed in a hot-air oven maintained at a temperature of 100° F. In this way I was enabled to keep secretions freely exposed to the air, whilst evaporation was compensated for by the gradual imbibition of fluid from below through the pores of the membrane. I have succeeded in preserving mucus corpuscles and masses of germinal matters from the higher organisms alive for a considerable time longer than they would have lived at the ordinary temperature of the air. I am still engaged in various experiments conducted according to this plan, by which one is enabled to imitate very closely the conditions under which changes go on in the body of the living animal. The plan is well adapted for a variety of observations upon the changes occurring in living things.

On Examining Deposits from Fluids.

The most important pieces of apparatus required in the examination of deposits which subside from fluids, are the following:—Test tubes, pl. X, figs. 67, 68, pipettes of different sizes, pl. V, fig. 29, conical glasses, pls. V, IX, figs. 27, 57, wash-bottle, pl. V, fig. 28; watch-glasses, funnels for filtering, pl. X, fig. 72; and cells in which the deposit may be subjected to microscopical examination, pl. V, figs. 30, 31.

104. Test Tubes.—The observer should be provided with several test tubes, varying in length from five or six inches to an inch and a half, or even less. The smaller tubes are very convenient for preserving small quantities of deposits immersed in a preservative solution, for examination on a subsequent occasion. In boiling a specimen of urine in a test tube over a lamp, it may be held by twisting a piece of paper three or four times folded round the neck, so as to serve for a sort of handle; or a little support made of wire, and mounted in a wooden handle may be used; or the tube may be placed through the smallest ring of the stand represented in pl. III, fig. 12, and in this manner exposed to the action of the lamp.

105. Pipettes.—The pipettes required in microscopical examina-

tion should be of various sizes, according to the depth of the vessel which contains the deposit, and the diameter of its orifice. When it is required to remove some of the deposit from the bottom of a bottle with a narrow neck, we shall want a pipette of very small calibre. If the deposit be very thick and viscid, the pipette must have a wide orifice, or it will not enter it. The orifice of the pipette should be from the tenth to the eighth of an inch in diameter. Pipettes are made of common glass tube of various sizes; the opening at the bottom being drawn out slightly in the blowpipe, in order to make it a little narrower than the tube itself.* The top of the pipette should be slightly bent over in the form of a lip, and perfectly smooth, so that it may be completely covered with the forefinger, while the middle finger and thumb are placed on either side of the tube immediately below the ring.

It is convenient to have a sort of collar to the pipette, about two inches from the top. This will prevent the finger and thumb from slipping when the instrument is used, pl. V, fig. 27. Occasionally a pipette, the end of which is slightly bent round, will be found useful; and sometimes when we wish to decant a considerable quantity of fluid from a watch-glass, &c., a pipette, upon the stem of which a bulb has been blown, will be of service.

Various other forms of pipettes have been employed, but the above will be found most useful to the microscopical observer. A small pipette with a narrow opening is convenient for removing any superfluous fluid which may escape outside the thin glass cover when preparations are being mounted in fluids and preserved in cells.

106. Conical Glasses.—Glasses of the shape figured in pls. V, IX, figs. 27, 57, are the most convenient vessels in which to allow deposits to subside. After the fluid has stood for some time, the deposit will have collected in the narrow portion of the glass, and however small in quantity, it may be very easily removed with the pipette. These glasses can be obtained of various sizes. In choosing them, it is better to select those in which the narrow part terminates in a rounded extremity, for many will be found to have a little prominence in the bottom around which the deposit collects, and in this case it is with difficulty removed by the pipette. Others terminate in a sharp point, too narrow to force even a wire into it for the purpose of removing the deposit which collects there. If the deposit is allowed to dry in such a glass, it is hardly possible to clean it. The very useful glass for allowing deposits to collect in, represented in fig. 57, was designed by Dr. Budd, and is of great use

* Glass tubing adapted for making pipettes, may be purchased at the operative chemists', or of Messrs. Powell, Whitefriars.

in examining urine and other fluids, as the specific gravity may be taken, and the specimen allowed to stand in the same glass without the trouble of transferring it to another vessel. This must be done, if the ordinary upright jar be employed for taking the specific gravity.

107. Wash-Bottle.—This simple piece of apparatus, which is ordinarily used by chemists, is of great use to the microscopical observer. He will find it most convenient for washing away the parenchymatous part of tissues in order to leave the most fibrous portions, removing epithelium from the surface of membranes, &c. It is employed by the chemist chiefly for washing precipitates on filters, &c. The wash-bottle is made with an ordinary bottle or glass flask, having a moderately wide mouth. Two tubes bent, as shown in pl. V, fig. 28, are accurately fitted into a cork adapted to the neck of the bottle. Upon nearly filling the bottle with water, and blowing through the shorter tube, the fluid will be projected from the capillary orifice of the longer one in the form of a fine jet, which may be directed upon any desired point.

108. Funnels; Filtering.—The funnels required in microscopical examination are very small. Those of about two or three inches in diameter are large enough for most purposes. Glass funnels are the cheapest and the best. The funnel is supported in the small retort stand, pl. X, fig. 72, or upon a tripod. The filtering paper may be obtained already cut in packets of circular pieces of any size required. One of these is folded in the manner shown in fig. 71, when used. Before filtering, the filter should always be moistened with a few drops of water, or with a fluid of the same nature as that which is to be filtered. A single drop of fluid may be filtered by placing a narrow piece of filtering paper of a ≺ form close to the drop on a glass slide, and inclining it so that the clear fluid runs downwards from the apex of the ≺.

Solutions of *crystalloid* substances may be separated from *colloids* by dialysis. For this purpose the mixed fluids are placed in a vessel, the bottom of which is formed of bladder or parchment-paper. The lower surface of the dialyser is in contact with water in a basin. Under these circumstances the crystalline matters pass through and diffuse through the water beneath, while the colloid is retained in the dialyser.

Straining through muslin is sometimes a convenient method of separating fine and coarse particles from each other, or for separating a crystalline deposit from viscid mucus. By projecting a stream of water from the wash-bottle, the crystals may be washed through the muslin into a vessel placed beneath to catch them, while the mucus

remains behind. In the separation of starch particles from gluten, a similar plan may be pursued. The muslin may be tied over a glass or funnel with a piece of thread, or it may be conveniently fixed in its place by one of the vulcanised India-rubber rings commonly sold at stationers' shops.

109. Cells for the Examination of Deposits.—The thin glass cell, pl. V, fig. 31, will be found very convenient for the examination of deposits from fluids, especially when they exist only in small amount. If the deposit is very abundant, it will only be necessary to place a small quantity upon a glass slip, and cover it with thin glass. For the examination of urine, sputum, &c., I have been in the habit of using the animalcule cage.

Animalcule Cage.—The advantage of this apparatus consists in the facility with which the depth of the stratum of fluid to be examined may be altered, according to the quantity of the deposit which it contains. This is a point of great practical importance when the amount of sediment is very small, for by submitting only a very thin stratum of fluid to examination, we might often overlook the presence of a small quantity of an important deposit, such as a few fat-cells, or small crystals of oxalate of lime in urine. If, on the other hand, the deposit be very opaque and abundant, the cover may be pressed down so as to come very nearly into contact with the glass upon which it is placed, and an extremely thin stratum may in this manner be examined. The most useful forms of animalcule cages for examining urinary deposits are represented in pl. I, fig. 8, pl. V, fig. 30. In cases where exceedingly thin objects are to be examined with the aid of very high powers, and it is necessary to prevent the too firm pressure of the thin glass, a fragment of hair, or small pieces of paper or card, according to the thickness of the object to be examined, may be introduced beneath the thin glass.

110. Removal of the Deposit from the Vessel containing it.—This is effected as follows:—The upper end of the pipette being firmly closed with the forefinger, and the tube held by the thumb and middle finger, the lower end is carried down to the bottom of the vessel containing the deposit, fig. 27. If the forefinger be now raised very slightly, but not completly removed, a few drops of the fluid with the deposit will rush up into the tube. When a sufficient quantity for examination has entered, the forefinger must again be firmly pressed upon the upper opening, and the pipette carefully removed. A certain quantity of the deposit is allowed to flow from the pipette on to the glass slide or cell, by gently raising the forefinger from the top. The deposit is then covered with the thin glass cover, and subjected to examination in the usual way.

111. Method of Collecting a very small quantity of a Deposit from a Fluid.—When the quantity of deposit is very small, the following plan will be found of practical utility. After allowing the lower part of the fluid which has been standing, to flow into the pipette as above described, and removing it in the usual manner, the finger is applied to the lower opening, in order to prevent the escape of fluid when the upper orifice is opened by the removal of the finger. The upper opening is then carefully closed with a piece of cork. Upon now removing the finger from the lower orifice, the fluid will not run out. A glass slide is placed under the pipette, which is allowed to rest upon it for a short time. It may be suspended with a piece of string, or supported by the little retort stand. Any traces of deposit will subside to the lower part of the fluid, and must of necessity collect in a small drop upon the glass slide, which may be removed and examined in the usual way.

Another plan is to place the fluid with the deposit removed by the pipette, in a narrow tube, closed at one end, the bore of which is rather less than a quarter of an inch in diameter. This may be inverted on a glass slide, and kept in this position by a broad elastic India-rubber band. The deposit, with a drop or two of fluid, will fall upon the slide, but the escape of a further quantity is prevented by the nature of the arrangement, pl. IX, fig. 61.

112. Separation of the Deposit from the Fluid in which it was suspended, for Preservation.—After allowing time for the complete subsidence of the deposit, the supernatant fluid is poured off, and the glass filled up with water, or some fluid which corresponds in density to that which was removed, as glycerine, saline solutions, &c., in cases in which the endosmosis of water into cells is to be feared. After again allowing time for the subsidence of the deposit, the operation of pouring off the fluid is repeated, and more water, or the preservative solution, added, and again poured off, until the deposit is considered to be free from the original fluid. Two or three washings generally suffice. In this way a deposit may be thoroughly saturated with any fluid in which it is to be preserved.

After being thoroughly washed, the deposit may be removed with a pipette in the usual way, and placed upon a slide, or in a small test tube, which may then be corked up and labelled. The latter plan is the most satisfactory with which I am acquainted for preserving small quantities of deposits, and if the tube be nearly filled with the preservative fluid, the deposit will keep for a length of time.

Of separating the Fine from the Coarse Particles of a Deposit.—This is readily effected by stirring the whole of the deposit up with some water. When a short time has been allowed for the subsidence of the

densest particles, the fluid is poured off into another vessel. After another short period has elapsed, all but the deposit is again poured off into a third and fourth vessel. In this manner, several different sediments are obtained, each containing particles of different size and density, which may be subjected to examination, or mounted separately.

113. Of Preserving Specimens permanently.—The various methods employed for preserving objects have been fully described in "How to work with the Microscope." It is only necessary to refer here to those of the greatest use to the medical practitioner. Some things may be preserved as dry objects in air, being carefully protected from the dust by the thin glass cover, but almost all the specimens of interest to us require to be immersed in fluid and preserved in fluid media, if their natural characters are to be retained.

After what has been already remarked with reference to the use of glycerine, I need scarcely repeat that according to my experience, this is by far the most valuable preservative medium for general purposes. But as many microscopists prefer other solutions, I propose to draw attention to some of those which have been most strongly recommended.

Canada Balsam has been more used than any other preservative medium. Some objects may be dried and mounted in Canada balsam, and a plan has been already described (page 24), by which objects may be mounted in the medium without being dried in the first instance. Canada balsam has this very great advantage over other media—that when once mounted, the specimen retains its character for years, and is probably as *permanent* as anything can be. But unfortunately the most important character of the great majority of objects of interest to us are not retained in specimens mounted in balsam. Although many of my friends still mount their specimens in this medium, and the plan finds special favour in Germany, I must venture to speak against it, for I think that many of the views now entertained concerning the structure of certain organs would never have originated if the specimens had not been mounted in Canada balsam. The most important anatomical peculiarities of most animal tissues are entirely destroyed by the process, and it is impossible to form any idea of the relative position of structures lying one over the other, for in consequence of the contraction which has taken place, fibres which really lie above or below one another, appear in the mounted specimen upon precisely the same plane, and delicate lines as of nerve fibres which in the moist specimens are evidently quite distinct from each other, and pursue a somewhat tortuous course on many different planes, appear in balsam preparations to be fused

together forming one fibre, and seem to run in perfectly straight lines. Capillaries shrink, and oftentimes vessels distinct from one another appear to be connected. But perhaps the greatest differences of opinion arising out of this plan of preparation are those which are now held with reference to the existence of very minute tubes connected with capillary vessels and lymphatics. The size injection employed seems to make slight rents in the capillaries, and to run into the spaces existing in various tissues, for example in the narrow channels between the individual epithelial cells of cutaneus or mucous epithelial structures. The size slowly hardens in these tube-like interstices, and in the process of drying contracts slightly, causing well defined outlines to each portion, and thus the appearance of minute *capillary tubes filled with injection, results.*

Although this view has met with very warm support, it appears to me to rest upon a most unsatisfactory basis, and until I obtain stronger evidence from the preparations of others or from my own observations I feel compelled to dissent from it.

So with reference to the arrangement of the ducts of the liver. Even now the existence of the finest ducts which I injected many years since is scarcely admitted, although a system of *far finer ducts* amongst the liver cells in every part of the lobule has met with general acceptance, and I believe that the inferences deduced have arisen almost entirely from the appearances seen in examining balsam preparations by observers who endeavour to make it appear that the objections they raise to the use of glycerine are as strong as, and more reasonable than, those which may be made to balsam. Upon paper this appears to be so, but when the two processes are practically compared a very different conclusion is arrived at. The suggestion has certainly been repeated in Germany by author after author that the appearances described by me may have been artificially produced by the mode of preparation followed! Such observations only show that a most imperfect idea has been formed of what may be *actually seen* by the plan of preparation advocated by me, and that those who offer the opinion have either not tried the plan at all, or, having tried it have not succeeded, or have had no opportunity of seeing specimens prepared according to the principles laid down.

When a specimen is to be preserved in any fluid medium, it must always be allowed to soak in it for a considerable time before it is mounted. The best plan is to place the specimen in a few drops of the preservative solution in a watch-glass, protected from dust by a glass shade, for two or three days before they are to be permanently mounted.

The method of employing syrup and glycerine has been already referred to (p. 51). If weak solutions are used, the growth of fungi may be prevented by adding to the fluid a drop of carbolic acid, or a fragment of camphor.

Glycerine jelly is a very useful medium for preserving anatomical specimens. The mixture may be made as follows :—A certain quantity of gelatine or isinglass is allowed to soak for some time in cold water, until it swells up and becomes soft. It is then placed in a glass vessel and melted by the heat of warm water. It may be clarified, if necessary, by first adding to the cold gelatin a little white of egg, then boiling the mixture and filtering through fine flannel. To this fluid an equal quantity of strong glycerine is added and well mixed with it. This mixture may be kept for any length of time, and a very slight heat is sufficient to render it perfectly fluid. Mr. Rimmington, operative chemist, Bradford, prepares some very clear and transparent glycerine jelly. This may be obtained in small bottles free by post for *1s. 4d.*

Gum and glycerine is also a very useful preservative medium.

Naptha and Creosote Fluid.

Creosote ...	...	...	3 drachms.
Wood Naptha ...	...		6 ounces.
Distilled Water ...	...		64 ounces.
Chalk as much as may be necessary.			

The naptha and creosote are first mixed together, and to the mixture as much prepared chalk as is sufficient to make a smooth thick paste, is to be added. Then pour in gradually the water, mixing it with the other ingredients in a mortar. Add two or three small lumps of camphor, and allow the whole to stand for a fortnight or three weeks, occasionally stirring it. The almost clear supernatant fluid is then poured off ready for use.

Carbolic Acid.—The preservative qualities of this substance are now well known. A solution for preserving and mounting tissues may be made by adding to 100 parts of distilled water, 1 part of carbolic acid. Both animal and vegetable tissues may be preserved in this medium. Carbolic acid water is, I think, likely to prove very valuable, and will probably supersede the use of the creosote fluid above given, indeed I only repeat the formula for the latter, because I have, as yet, no facts which enable me to offer a positive opinion concerning the value of any other fluid composed almost entirely of water.

Chloride of Calcium.—For preserving many vegetable tissues as

well as specimens of bone, hair, teeth, and other hard substances, a saturated solution of chloride of calcium has been recommended.

Chromic Acid.—A solution of chromic acid is prepared by dissolving sufficient of the crystallized acid to render the liquid of a pale straw colour. It preserves structures exceedingly well, but renders tissues granular. It is also very useful for hardening many of the softer animal tissues.

Upon the whole I am still of opinion that the strongest glycerine and glycerine jelly are the most advantageous media for preserving animal tissues, and carbolic acid water and creosote fluid for the preservation of various specimens, for which a fluid possessing the highly refracting properties of glycerine is not suitable.

I believe that our knowledge concerning the distribution of nerves and the ultimate arrangement of the secreting portions of various glands, the relation of cells to the capillaries and nerve fibres, and other most important but delicate points of anatomical enquiry will be rapidly advanced, if students will act upon the principles laid down in pages 50 and 51, and follow the directions there given, modifying the details as experiment and observation show to be desirable. Canada balsam specimens, although advantageous for showing the general arrangement of vessels in various organs and other comparatively rough points, will not, I think, enable us to add much to our existing knowledge.

114. Of the new Binocular Arrangement adapted for the Highest Magnifying Powers.—Messrs. Powell and Lealand have recently succeeded in devising a plan by which a binocular arrangement is adapted to the highest powers. The ordinary binocular now in use is suitable only for the examination of objects by powers magnifying less than 200 diameters, but the new one can be used with the $\frac{1}{80}$.

By the prisms represented in section in pl. VIII, fig. 54, it will be observed that of the total number of rays which have passed through the object glass, the greater part are transmitted through the prism B and the straight tube of the microscope, but some suffer reflexion from its lower surface, and are received upon the reflecting surface E of the prism C in an oblique direction as shown by the dotted lines, and after emerging from the surface, enter the diagonal tube of the microscope.

The last of the two images is less intense than the first, but still quite light enough to be seen very clearly. The two images thus formed are exactly similar, and the two pictures appear to the observer as one in relief. There is, however, no true stereoscopic image, for the one picture seems to be in every respect, save in

intensity of illumination, the counterpart of the other. By this arrangement microscopic work with very high powers is far less fatiguing than when the monocular body is employed, and I believe the new arrangement will be found most useful in practice.

Modifications of the principle adopted by Messrs. Powell and Lealand in their binocular for high powers, have been suggested by Mr. Wenham, with the view of utilising some of the light lost in their system, but I have not had an opportunity of comparing the working of Mr. Wenham's prisms with those of Powell and Lealand. From Mr. Wenhams's description there is obviously some difficulty in obtaining perfectly satisfactory results. "The two prisms need not be pressed into contact—if so, Newton's rings are formed ; they may be set a visible distance asunder, but great care is needed in adjusting the small prism so as to get both reflections combied, otherwise a blurred image will be seen in the slanting body."

I have examined many objects by the arrangement of Messrs. Powell and Lealand, and find that it works exceedingly well in practice, and I can strongly recommend it to those who work with very high powers.

115. Of Finders.—Several different plans have been employed for the purpose of finding any special object upon the glass slide, or any particular part of a specimen without loss of time.—See H. to W., § 67, pls. XVIII, XIX. But the most simple and efficient method is that recently proposed by Mr. Bridgman, of Norwich, and made by Mr. Baker, of Holborn. Attached to the side of the body of the microscope is an arm capable of being moved upwards and downwards in such a manner that it may fall upon one end of the slide. If the end be anointed with ink or black varnish, a mark may be made upon the end of the slide when the point for observation is in the centre of the field. In order to find this same spot at any future time, it is of course only necessary to place the slide in such a position that the original mark exactly corresponds with the point of the finder, and the part of the specimen must then be again in the centre of the field. The plan is so simple and efficacious, that it will, I think, completely supersede the various finders now in use.

CHAPTER III.

Of the Chemical and Microscopical Examination of the Solids and Fluids of the Animal Body.—Of taking Specific Gravities.—Evaporation, Incineration, &c.—Dialysis; Colloids, Crystalloids, &c.—Apparatus required for Chemical Investigation.—Microscope for Examining Substances Immersed in Corrosive Liquids.—Method of Examining Objects under the Influence of Heat and Cold.—Reagents.—Method of Applying Tests to Substances intended for Microscopical Examination.—Effects of Reagents upon Animal Structures.—Of obtaining Crystalline Substances from the Fluids and Textures of Animal Bodies.—Of the Detection of Ammonia and Organic Matters in the Expired Air.—Method of Collecting Matters Suspended in the Air of Rooms, Hospitals, Sheds, &c., for Microscopical Examination with the Highest Powers.—Of the Spectrum Microscope.—Of Spectrum Microscopic Analysis.—Of Removing Stains from the Hands.

By the aid of the microscope we are enabled to distinguish many substances with certainty, but amorphous particles are very often met with, the nature of which it is impossible to ascertain by microscopic investigation only. It is therefore necessary to study the effect of certain reagents upon the substance under the microscope. We may learn by microscopical examination that a texture is *granular*, *fibrous*, *opaque*, *perfectly clear*, &c., but nothing of its physical and chemical properties, and since these appearances are manifested by several different materials, it is necessary to resort to a chemical examination to determine the nature of the particles under examination. If the composition of any body having well-defined microscopical characters has been once determined, we are enabled afterwards to recognize it by resorting to microscopical examination only, but every specimen of granular matter requires chemical analysis, which may be conducted while it remains upon the glass slide, and the reactions induced may be studied under the microscope.

Some bodies always produce well-recognized crystals when treated

with certain chemical reagents, and we know that although there may be in nature other crystals of precisely the same form, but of a different composition, these latter could not have been produced under the circumstances present, and hence in such a case we may sometimes feel as confident of the nature of the substance as if an ultimate analysis of it had been performed.

In almost every branch of microscopical enquiry, the greatest assistance is derived from the use of chemical reagents. By a knowledge of the behaviour of certain substances with particular chemical reagents, and the application of this information to microscopical investigation, we are often enabled to distinguish peculiarities of structure, to ascertain the chemical composition of minute quantities of matter, and to demonstrate clearly the existence of particular compounds in the animal frame with the greatest certainty; some of which would probably entirely escape our observation, if we subjected them separately to the most careful chemical analysis, or to the most searching microscopical examination.

The application of chemical analysis to microscopical investigation has thrown a new light upon the nature of many physiological changes which are constantly taking place in organized bodies in health, and has enabled us to investigate more satisfactorily the modifications which occur when these processes are subjected to the influence of conditions which counteract healthy actions. Such matters are of the deepest interest to us as practitioners of medicine. In the various forms of disease which are constantly being brought under our notice, we ought to study as minutely as possible the nature and course of morbid actions, which it is our duty to investigate fully. From what we learn by scientific research we may be led to suggest means to modify or counteract morbid actions, and may, perhaps, even be able to prevent their occurrence in other cases.

The laboratory is a very necessary adjunct to the dissecting-room, the museum, the post-mortem room, and the clinical wards of our hospitals; and he who desires to apply all the means at present at our disposal to unravel the mysteries of disease, to help him to form a correct diagnosis, or enable him to recommend the right course of treatment, will do well to make this particular branch of chemistry, with microscopical examination, an essential part of his study.

The works of Vogel, Schmidt, Scherer, Hœfle, Gorup von Besanez, Hoppe Seyler, and others, which have been published within the last twenty years, have done much to advance this branch of investigation; while those of Golding Bird, Schwann, Robin and Verdeil, and Lehmann, and the excellent Atlas of plates

by Dr. Funke, show the vast importance which the combined methods of chemical and microscopical investigation are very fast assuming.*

It is not within the compass of the present work to do more than refer to the general principles upon which chemical examination is conducted, and to give examples of those processes which are of the greatest importance to the student of medicine, and which he may be called upon to perform in the practice of his profession.

As an instance of the great advantage of the application of a few simple tests to microscopical investigation, I may refer to the different effects of ether upon fat globules (which are so commonly found in different tissues), and crystalline bodies composed of phosphate or carbonate of lime, which sometimes resemble oil globules so nearly in refractive properties, in form, and in general appearance, as to have led to many mistakes. The application of a drop of ether has no effect whatever upon the latter, but it dissolves the former. If, however, the oil globule is covered with a membrane which prevents the action of ether upon it, it is necessary to add a little acetic acid or a drop of solution of potash or soda, in order to dissolve the membrane, when the ether will at once act upon the fat. This instructive observation may be repeated upon the oil globules in a drop of milk. Phosphate of lime is readily soluble in dilute acids, while fat is not acted upon by these reagents. Not unfrequently organic material is deposited with the phosphate of lime, so that it is necessary to allow the globules to soak for a few minutes in the acid before concluding that it exerts no action upon them. By such simple proceedings we are enabled at once to decide a very important question, and one that has led to some discussion and difference of opinion, in consequence of the solubility or insolubility of the globules in acids and ether not having been clearly proved.

The detection of the presence of mere traces of urea, uric acid,

* "Anleitung zum Gebr. des Mikroskopes zur Zooch. Anal. u. zur Mikroskop. Chemisch. Untersuch." Dr. Julius Vogel, 1841. "Chemische und Mikroskopische Untersuchungen zur Pathologie," Dr. J. J. Scherer, Heidelberg, 1843. "Entwurf einer Allg. Untersuchungsmethode der Säfte u. Excrete des Thierischen Organismus," Dr. Carl Schmidt, 1846. "Chemie und Mikroskop am Krankenbette," Dr. Hœfle, 1850. Franz Simon's "Animal Chemistry," translated by Dr. Day, for the Sydenham Society. Becquerel and Rodier's "Pathological Chemistry," translated by Dr. Speer. "Physiological Chemistry," Dr. Lehmann, translated by Dr. Day, Cavendish Society, 1851. "Atlas of Physiological Chemistry," Dr. Otto Funke, Cavendish Society, 1852. "Traité de Chimie Anatomique et Physiologique," Robin et Verdeil. "Urinary Deposits," Dr. Golding Bird, new edition by Dr. Birkett, 1857. Bowman's "Medical Chemistry." "Anleitung zur Zoochemischen Analyse," Gorup-Besanez. "Lehrbuch der Physiologischen Chemie von Dr. W. Kühne." Bloxam's "Chemistry."

and other substances, in different tissues and fluids by the application of reagents, and subsequent microscopical examination, will be referred to in the present chapter.

On the Chemical and Microscopical Examination of Animal Solids and Liquids.

Preliminary Observations.—In the first place we should note carefully the general characters which the substance exhibits; its form, colour, size, weight, hardness, &c.; and fluidity, transparency, tenacity, &c., in the case of liquids. Portions of solid textures, and the deposit from fluids must be subjected to microscopical examination, but their reaction should always be ascertained in the first instance.

116. Reaction.—The reaction of any moist substance is found out by testing it with a piece of blue and reddened litmus paper. If the matter be dry, or the reaction of a vapour is to be tested, the paper must be first moistened with a drop of distilled water. The *blue paper* is *reddened* by *acids*, and the *red paper* is turned *blue* by alkalies. The reddened litmus paper is prepared by adding a very small quantity of acetic acid to the infusion of litmus into which it is to be dipped. As the change of turmeric is only visible when the alkaline reaction is very decided, it is not much employed in animal chemistry. If the *acid reaction* is due to the presence of *carbonic acid*, the blue colour will be restored upon gently warming the paper over a lamp upon a glass slide, or upon a warm plate.

An *alkaline reaction* may depend upon the presence of *volatile* or *fixed alkali*. The red colour is restored upon warming the paper which had been rendered blue by the presence of volatile alkali (ammonia or carbonate of ammonia), while it is not restored if the change is produced by the presence of a fixed alkali (potash, soda, or their carbonates, or an alkaline phosphate, &c.).

117. Specific Gravity.—*Solids.*—The specific gravity of animal solids may be taken in two ways. *First.* By weighing in air, and afterwards in water, which is the process usually followed, and that which affords the most accurate results. The precautions necessary to be observed in carrying out this process will be found in "Bowman's Practical Chemistry," and other analytical works on chemistry. *Secondly.* The specific gravity of solids may be obtained by placing small portions in certain saline solutions, the specific gravity of which has been previously ascertained by experiment: this latter method has been employed lately for ascertaining the specific gravity

of the brain in different cases of disease.* The solutions are prepared in considerable quantities at a time, and kept in large bottles numbered according to the specific gravity of the fluid in each. The strong solution of the salt is first prepared, and this is diluted with such proportion of water as will make several different mixtures, varying in specific gravity from 1030 to 1052. The density of the solutions may be ascertained by the specific gravity bottle, by the urinometer, or by the aid of the little glass bulbs, pl. IX, fig. 55. The specific gravity bottle affords the most satisfactory results. Several glasses are nearly filled with the solutions from different bottles, and arranged in regular order. The piece of tissue is thrown into one, and, if it sinks, it must be placed in the fluid of the next higher specific gravity, and so on, until it neither sinks towards the bottom nor rises to the surface, when the specific gravity marked upon the bottle will correspond to that of the substance itself, since a solid will displace an equal bulk of a solution which is of the same specific gravity as itself. The soluble substances employed for making the solutions, may be sugar, various salts, glycerine, and other bodies, which do not exert any chemical action upon the tissue, whose specific gravity we wish to determine. Dr. Aitken recommends sulphate of magnesia, as the action of this salt on the cerebral tissue is very slight.

Specific Gravity—Liquids.—First. By the converse of the last operation, namely, by placing little glass bulbs, the specific gravity of which is marked upon them, pl. IX, fig. 55, in the solution, the density of which we wish to know, until one is found which neither sinks nor swims. This will indicate the specific gravity of the fluid. This method is neither so correct, nor so easily applicable to general purposes as the two following.

Secondly, by the *hydrometer* or *urinometer*. The number which is on a line with the surface of the fluid, when the instrument comes to rest, indicates its specific gravity. This method is tolerably correct, if the observer is careful to obtain the best instruments; but many which I have examined, indicated a specific gravity eight or ten degrees from the truth. The hydrometer or urinometer should always be tested by the specific gravity bottle. It may be remarked that the degrees marked upon the stem should gradually diminish in length, from above, downwards, pl. IX, fig. 58. If they are equal, as in A, the instrument may at once be pronounced incorrect, without resorting to an experiment. The degrees at the lower part of the

* Dr. Bucknill "On the Specific Gravity of Cerebral Substance"—(Lancet, 1852). Dr. Sankey in the "British and Foreign Medico-Chirurgical Review," Jan. 1853, page 40. Dr. Aitken, "Glasgow Medical Journal," No. I., 1853, and "The Science and Practice of Medicine."

stem should be less than those near the top, as shown in B. The necessity of this inequality in the degrees will be rendered evident by referring to the figures in plate IX. In fig. 57 A, representing a dense fluid, the stem is of course almost entirely above the surface of the liquid, but in fig. 57 B, a fluid supposed to be but little heavier than water, only a very small piece of the stem rises above the surface. Now, in the first figure, the greater weight of stem above the surface of the fluid, tends to press down the bulb with greater force than the small portion exposed in fig. B. Hence it is necessary that this should be allowed for in graduating the instrument, and the degrees at the lower part of the scale must be shorter than those at its upper part. Mr. Ackland, at Messrs. Horne and Thornthwaite's, Newgate Street, graduates urinometers most accurately.

Thirdly, by the *specific gravity bottle*, which consists of a small glass flask. When quite dry, it is accurately counterpoised in a delicate balance, filled up to a certain point with distilled water, and weighed. The distilled water is then poured out, and it is filled up to the same point exactly with the liquid to be tested, and again weighed. The specific gravity is then readily calculated from these data. Some bottles are made to hold exactly one thousand, five hundred, two hundred and fifty, or one hundred grains of distilled water, and are provided with a perforated stopper, through which the excess of fluid escapes, after the bottle has been filled, care being taken not to include air-bubbles, pl. IX, fig. 56. The outside of the bottle is wiped dry, and the whole weighed. The weight shows the specific gravity at once, upon deducting the weight of the thousand-grain bottle; or, when a five-hundred-grain bottle is employed, the amount only requires to be doubled. If the bottle holds two hundred and fifty grains, the weight must be multiplied by four, and so on.

118. Evaporation and Drying.—The evaporation of animal fluids, and the desiccation of animal solids, must always be conducted over a water-bath, or in a little hot water or air oven, otherwise there is great danger of decomposition occurring. For operations upon small quantities, the water-bath represented in pl. IX, fig. 59, will suffice, or the cans of the injecting apparatus used for melting injections made with size, may be removed, and basins placed over the holes. A very simple form of water-bath is made by placing a small porcelain basin with a little water in it over the lamp, and upon the first basin, a second containing the substance to be evaporated, pl. III, fig. 13.

In endeavouring to obtain crystals of organic substances, it is always advantageous to evaporate the solution over the surface of sulphuric acid under a bell-jar, or, what is better still, in vacuo. And when evaporation has been conducted by heat, it is always desirable

to let the vessels cool, before weighing, over sulphuric acid. Extracts may also be kept in this way from day to day without absorbing fresh moisture. In some instances, the evaporation may be conducted by simply exposing the liquid placed in a basin or watch-glass, and covered lightly with paper, to the air; or, where very slow evaporation is necessary, the watch-glass may be covered over with a bell-glass. When quantitative analysis is to be performed, much greater care must be observed in the process of drying, which must be completed, if not conducted, in vacuo over sulphuric acid. Drying is one of the most important and difficult operations to be performed in physiological chemistry.

119. Incineration.—By incinerating a small portion of any organic substance, upon a piece of platinum foil, or in a platinum or porcelain crucible, we are enabled to ascertain whether it contains inorganic salts, or consists entirely of organic matter. In the latter case the substance leaves only a black residue, which burns off entirely after a short time. In order to obtain the inorganic constituents perfectly free from carbon, it is sometimes necessary to keep the mass, for a considerable time, at a dull red heat. The addition of a drop of nitric acid, causes the rapid oxidation of the carbon. If the temperature be too high, the process is often much retarded, in consequence of the fusion of some of the salts, as the phosphates and chlorides, and the inclusion of small masses of carbon, which are thus protected from the action of the atmosphere.

The platinum basin or foil may be supported over the lamp upon a piece of wire, bent in the form of a triangle, or upon one of the small rings attached to the spirit-lamp, pl. III, fig. 12. It may be removed from the lamp with the aid of an old pair of forceps.

120. Dialysis.—Colloids and Crystalloids.—By the recent researches of Professor Graham many very interesting points with reference to the physical constitution of several substances entering into the formation of the organism have been brought to light. He has shown that substances exist in what is termed a *colloid state*, in which condition they will not permeate a porous diaphragm; while, on the other hand, crystalloid substances will readily pass through such a diaphragm when in a state of solution in water, § 108. The fact is one of great practical importance, and has been most successfully employed for the purpose of separating poisonous matters of a crystalloid nature from their solution in the animal colloids (dialysis). The crystalloids readily diffuse themselves through a large quantity of water, while the diffusive tendency of colloids is very low. Professor Graham has shown that certain *mineral* substances exist in a colloid as well as in a crystalloid form. Hydrated silicic acid and soluble alumina are examples.

Perhaps the most interesting example in the living organism of an organic body, which may exist in both conditions, is the material of which the red blood corpuscle consists, which sometimes, as in the case of the guinea-pig, passes from the colloid to the crystalloid condition soon after it has been removed from the circulation and allowed to become stationary.

Crystalline substances may be dissolved out of the various tissues by placing them in a large quantity of distilled water. The weak saline solution may then be concentrated, and the crystalline material obtained in its characteristic form. In the living organism in health, the crystalloids pass through, while the colloids are retained by the colloid matter forming the walls of vessels, the outer part of gland cells, &c. In certain altered conditions of the fluids, or of the membranes, or of both, colloid, as well as crystalloid matters, filter through in a dilute state.

Dialysis may be conducted upon a small scale, by means of the little vessels described in page 78.

Apparatus.

The chemical apparatus which is necessary for chemical analysis as applied to microscopical investigation is very simple, and the greater number of instruments have already been referred to. The following are among the most important pieces of apparatus :—

A few conical glasses of different sizes. Apparatus for taking specific gravities. Test-tubes of various sizes, arranged on a stand, pl. X, fig. 68. Spirit-lamps, with various supports, or, where gas is laid on, a gas-lamp. Small porcelain basins, watch-glasses ; a simple water-bath ; or, if several evaporations are to be conducted at once, the injecting can may be used. A small platinum capsule, a strip of platinum foil, a blow-pipe, pipettes, and glass stirring rods, with a box of reagents in small bottles, pl. X, fig. 73, and test-papers, complete the apparatus. All these may be obtained, packed in a box of convenient size.

121. Microscope for Examining Substances immersed in Acids and Corrosive Fluids.—In examining in the ordinary microscope, preparations which require to be immersed in strong acid, it is not easy to prevent the fumes from injuring the brass work of the instrument. Considerable inconvenience is also experienced in examining fluids while hot, as the vapour which rises, condenses on the object-glass, and renders the object invisible. These inconveniences are entirely obviated by the ingenious microscope invented some years ago by Dr. Lawrence Smith, of the United States. ("American Journal of Science," second series, vol. xiv, 1852).

The inverted chemical microscope is represented in pl. IX, fig. 62, in which also the form and position of the prism are shown.

By this arrangement the object-glass is always kept perfectly clear, while of course the definition is not in any way interfered with. In order to adapt this instrument to drawing the outline of objects with the glass reflector, § 76, it would only be necessary to have the body fixed at a right angle with the axis of the object-glass, and a camera lucida or neutral tint glass reflector adapted to it.

122. Arrangements for applying Heat to Objects under Microscopical Observation.—By placing a brass plate upon the stage of the instrument just described, and allowing one end to project over the edge so that it may be conveniently heated by a spirit-lamp, any substance may be kept warm upon a glass-slide, while being subjected to microscopical examination. When a high temperature is necessary, I have adopted the plan represented in pl. IX, fig. 63. A square copper tube is arranged to lie flat upon the stage of the microscope. A spirit-lamp is placed at its lower opening, while the heated air escapes from the upper end. At that part where the glass-slide is to be placed, the lower wall of the tube is composed of glass, while at the upper part is an opening which allows the heated air to come into actual contact with the glass-slide. A small thermometer may be inserted in the tube near the position of the object. This arrangement, however, is by no means perfect. It is difficult to regulate the temperature very exactly. The temperature of the slide is several degrees below that of the air in the tube, and sometimes deposits are condensed on the under surface of the slide, interfering to some extent with the illumination of the object.

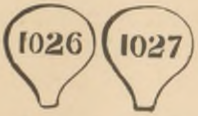
Max Schultze has recently contrived another arrangement, consisting of a brass plate which is fixed by clamps to the stage of the microscope, and extended at the sides so as to form two projecting arms beneath each of which a small spirit-lamp may be placed. A hole is made for the transmission of the light, and close to the place where the slide with the object is situated, is the bulb of a little thermometer, the stem of which is so arranged that the degrees can be easily read off.* In conducting observations upon bodies which are warmed, the loss of fluid from evaporation must be provided against by the use of the moist chamber and immersion lens, or by the little reservoir and conducting thread, § 103.

Dr. Ransom, of Nottingham, has been long engaged in investigations which require the application of heat and cold to the object while under observation. He says—

"The mode of using heat for those examinations I have found best

* This apparatus has been made by Geissler, of Bonn.

Fig. 55.

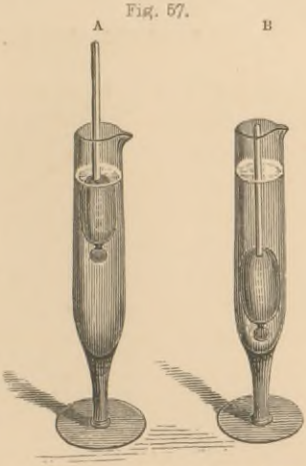


Bulbs for taking the specific gravity of fluids. § 117.

Fig. 56.

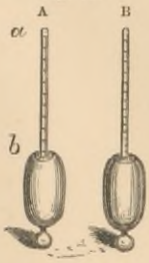
Specific gravity bottle, with tubulated stopper and counterpoise. § 117.

Fig. 57.



Glasses for collecting deposits and for taking the specific gravity of fluids. § 117.

Fig. 58.

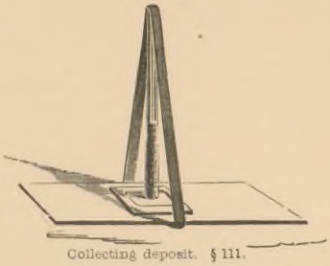


Urinometers. A, an imperfect instrument, in which the degrees are equally divided. B, a good instrument, in which they gradually diminish from above downwards. § 117.

Fig. 59.

Small water bath, with basin. § 118.

Fig. 61.

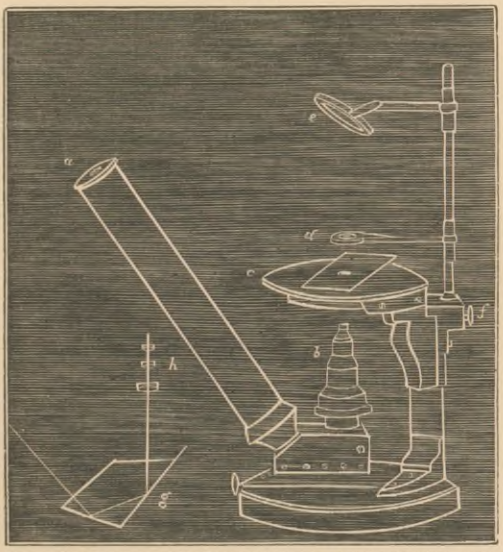


Collecting deposit. § 111.

Fig. 60.

Rings for water bath, for adapting the bath to hold any size basin § 118.

Fig. 62.



Inverted microscope of Dr. Laurence Smith. *a*, tube of microscope, with eye-piece *b*, object glass on a box, which contains a prism resembling that marked *g*. *c*, stage, with slide upon it. *d*, support on which polarising apparatus or condenser may be placed. *e*, mirror. *f*, screw which elevates or depresses the stage in focussing. *g*, prism, showing the direction in which the rays of light passing through it are refracted. *h*, position of achromatic object glass. § 121.

Fig. 63.

Apparatus for examining objects while exposed to heat. The chimney through which the heated air passes is made of thin copper without being soldered. Both sides are perforated, the lower one being filled up with a piece of glass, while over the upper opening the slide with the object is placed. § 122.

[To face page 96.

so far, is that recommended by Max Schultze, only in order to employ with it cold also, I have ordered one to be made of copper instead of brass as the former metal is so much better a conductor, and I trust I shall be able with this new stage to preserve an object at any required temperature, and to read off easily the actual temperature which the object has from 30° F to 160° F." The principle of this new hot stage is to conduct the heat to or from the object, and not to use currents of air or water. It may be used not only for stimulating movements, but for watching the extremes upwards or downwards, which either arrest them or destroy them. Such a stage must be separated from the microscope by a non-conducting substance.

Reagents.

The reagents required by the microscopist are not very numerous. They should be perfectly pure. Of the greater number only a very small quantity is required; but of alcohol, ether, and one or two other reagents, it is necessary to have half a pint or more.

The usual reagents should be kept in stoppered bottles of about the capacity of two ounces.

123. Alcohol.—Alcohol of different strengths will be required for the purpose of dissolving certain substances, and for separating them from other constituents, which are insoluble in this reagent. Alcohol should always be diluted with distilled water, and it is better to prepare a considerable quantity at a time. It is convenient to have two or three bottles which will hold about two quarts each. The strength of each should be written upon a label attached to the bottle.

The importance of alcohol, as a preservative solution, is well known. Within the last few years, the Government has permitted the use of *Methylated alcohol*, which pays no duty. It may only be used for various purposes in the arts, chemical processes, &c. It answers admirably for preserving anatomical preparations, and is a great boon to all engaged in putting up large specimens. Any person wishing to use this alcohol, must in the first instance make application to the Board of Inland Revenue, Somerset House, for permission. This application must be accompanied with the names of two respectable householders, who are willing to serve as bond that the applicant only uses the spirit for the purposes stated in his application. The probable quantity required annually must also be stated. It may be obtained at the price of 5*s.* 6*d.* per gallon, sixty degrees over proof, of Messrs. Lightly and Simon, and of other distillers, in quantities of not less than ten gallons at a time.

124. Ether.—An ounce or two of ether will be quite sufficient for

microscopical purposes. It should be kept in a stoppered bottle, provided with a glass cap, to prevent loss by evaporation. A little should also be kept in one of the small glass bottles with capillary orifices, § 138, for the convenience of applying it to granules, highly refracting globules, &c., under the microscope. Methylated ether may be used with advantage.

125. Nitric Acid should be kept of two different degrees of concentration: one the strongest that can be procured, and another containing about twenty per cent. of the strong acid. This last is the acid most used by the microscopist, especially in separating muscular fibre cells. It is prepared by mixing one part of the strong commercial acid with four parts of distilled water.

126. Sulphuric Acid is sometimes required undiluted, but a small bottle of diluted acid (one of acid to five of water) should also be at hand. The pure colourless acid should always be procured;—it is to be purchased for about 1*s.* 6*d.* a-pound, but only very small quantities are required.

127. Hydrochloric Acid may be obtained perfectly colourless. It may be kept in the pure state and diluted as required.

128. Acetic and other Acids.—Two specimens of acetic acid will be found convenient. One, a solution of the strongest acid which can be procured; the other, containing about twenty per cent. This is prepared by dissolving one part of the strongest liquid acid, or of the pure *glacial acetic acid* in four of water. The glacial acetic acid is now commonly employed for photographical purposes, and can, therefore, be very readily obtained.

Citric, Oxalic, and Lactic Acids have also been recommended for microscopical enquiries. One part of the acid to from 10 to 20 parts of water, makes a solution of a convenient strength.

129. Chromic Acid is usually required very dilute. For the purpose of hardening tissues, a watery solution of a straw colour (1 or 2 per cent.) will be found strong enough. It is easily prepared by dissolving a little of the crystallized chromic acid in distilled water. It may be kept in solution containing 10 per cent. and this may be diluted as required.

The crystallized acid may be prepared by decomposing 100 measures of a saturated solution of bichromate of potassa, by the addition of 120 to 150 measures of pure concentrated sulphuric acid. As the mixture becomes cool, crystals of chromic acid are deposited, which should be dried and well pressed on a porous tile, by which means the greater part of the sulphuric acid is removed, and the crystals obtained nearly pure.

130. Solution of Potash should be kept of two or three different

degrees of strength. One, the strongest which can be obtained; another, made by mixing one part of the strong acid with three or four of water. A solution consisting of one part of liquor potassæ to eight or ten of water, will be found of a useful strength for the examination of many preparations.

131. Solution of Soda is generally required very dilute. It may be made by mixing one part of the strong solution of the shops with five or six of water, or, about twenty-five grains of the fused soda may be dissolved in an ounce of distilled water. These solutions, for many purposes, will require to be still further diluted. Lime water and baryta water have also been employed in microscopical enquiries.

132. Ammonia.—Solution of ammonia, made by mixing one part of the strongest liquor ammoniæ with three of water, will be found sufficiently strong for all the purposes for which this reagent will be required.

133. Nitrate of Barytes.—A cold saturated solution of the salt forms a test solution of convenient strength. It should be filtered before use. A solution of nitrate of barytes is employed as a test for sulphuric and phosphoric acids, either free or in combination, as sulphates and phosphates. The precipitated sulphate of baryta is insoluble both in acids and alkalies; while the phosphate of baryta is readily soluble in acids, but insoluble in ammonia.

134. Nitrate of Silver.—A solution of nitrate of silver is prepared by dissolving one hundred and twenty grains of the crystallized nitrate in two ounces of distilled water, and filtering if necessary. Nitrate of silver is employed as a test for chlorides and phosphates. The *white* precipitate of chloride of silver is soluble in ammonia, but insoluble in nitric acid. The *yellow* precipitate of tribasic phosphate of silver is soluble in excess of ammonia, as well as in excess of nitric acid.

135. Oxalate of Ammonia and other Salts.—Some crystals may be dissolved in distilled water, and, after allowing time for the solution to become saturated, it may be filtered. Oxalate of ammonia is used as a test for salts of lime. Oxalate of lime is insoluble in alkalies and in acetic acid, but soluble in the strong mineral acids. In testing an insoluble deposit for lime, it may be dissolved in nitric acid and excess of ammonia added; the flocculent precipitate is readily dissolved by excess of acetic acid, and to this solution the oxalate of ammonia may be added. The precipitation of oxalate of lime is favoured by the application of heat. Many deposits of earthy phosphates are dissolved with great difficulty by acetic acid, hence the necessity of first adding nitric acid, as above directed.

Various salts have been employed in examining and preserving

animal tissues and morbid growths. Common salt, chloride of calcium, chloride of potassium, alum salts, some of the alkaline sulphates and phosphates, arseniates and many metallic salts have been recommended, but I have not, myself, gained any advantage by their use, and have found that where tissues are to be preserved permanently it is better to remove from them the last traces of saline matters. For if these are allowed to remain, decomposition often occurs, and the preparation is spoiled by the precipitation of granules of some slightly soluble salts. Soluble saline matters will always pass out of textures, by diffusion, if the sections be permitted to remain in a comparatively large quantity of distilled water, or weak glycerine, for some time.

The use of osmic acid has been already referred to in page 31.

136. Iodine Solutions.—An aqueous solution is easily prepared, by dissolving a few grains of iodine in some distilled water, until the solution acquires a brownish-yellow colour. A solution of iodine is sometimes useful for colouring certain substances, cell walls, fibres, basement membrane, &c. Iodine solutions are valuable tests for starch and allied substances. Iodine and strong sulphuric acid are used for detecting *cellulose* and *amyloid* bodies. The sulphuric acid should be added very cautiously, and a weaker solution sometimes acts if the tissue be soaked for a short time.

A darker solution of iodine may be obtained by employing a solution of iodide of potassium to dissolve the iodine (one grain of iodine and three grains of iodide of potassium, to one ounce of distilled water). In this way the 'iodine paint' so much employed by medical practitioners is prepared. For testing bodies suspected to consist of starch, the following solution is recommended by Professor Schultze. Zinc is dissolved in hydrochloric acid; the solution is permitted to evaporate in contact with metallic zinc until it attains the thickness of a syrup; and the syrup is then saturated with iodide of potassium. The iodine is next added, and the solution, if necessary, is diluted with water. Professor Busk gives the following directions for preparing this solution: one ounce of fused chloride of zinc is to be dissolved in about half an ounce of water, and to the solution (which amounts to about an ounce fluid measure), three grains of iodine dissolved by the aid of six grains of iodide of potassium in the smallest possible quantity of water, are to be added. (On "Starch Granules."—Transactions of the Microscopical Society, new series, vol. i, p. 67). I have employed a solution prepared in this manner, and can speak very highly of its utility. In making it, it is necessary not to *fuse* the chloride of zinc much, or to use a very high temperature, as decomposition is very apt to take place. In testing starch with this solution, it is advisable to add a very little

water, as the solution frequently will not act in its concentrated form.

The iodine solutions above recommended may be made with glycerine when required for testing specimens prepared according to the plan I have particularly recommended.

Iodised serum.—Serum of blood has been strongly recommended by Max Schultze for microscopical investigation. It may be kept for months if a piece of camphor be placed in it. The pure serum effused in some cases of ascites may also be employed. About six drops of tincture of iodine or of solution of iodine in hydriodic acid may be added to an ounce of liquor amnii from an embryo calf. Frey recommends a fluid composed of 1 ounce of ovalbumen, 9 ounces of water, 40 grains of chloride of sodium, and 60 drops of the iodine solution. In using these solutions the thinnest sections of tissues that can be obtained should be allowed to soak for some time in the iodised serum.

Method of Applying Tests to Substances intended for Microscopical Observation.

137. Tests kept in Glass Bottles.—The matter to be tested may be placed upon a glass slide, and, if necessary, a drop of water added, to moisten or dissolve it, as the case may be.

In these operations only a small drop of a solution is required, and it will be found most convenient, in applying it to the object, to take a drop from the bottle by dipping a stirring-rod into it, and withdrawing it immediately. Enough will be found adhering to the stirring-rod for the purpose required. The rod should not be dipped in the test fluid a second time, without being first well washed in water. If this direction be not scrupulously attended to, there will be great danger of conveying some of the substances intended for examination into the test bottle, in which case the whole contents would be spoiled. Carelessness on this head has led to great inconvenience and most serious mistakes. The observer must always avoid the chance of removing a portion of a deposit on one glass slide, and mixing it with that on another. Claws of echinococci, and other minute bodies, in themselves highly characteristic, may be transported, and find their way into deposits in which we should not expect their presence; and from such an accident the existence of hydatids might be very erroneously inferred in a case in which no such disease existed; the claws of the echinococci having been introduced through want of care. Accidents of this kind can always be avoided if ordinary precautions be taken.

In applying a reagent the drop should not be allowed to touch the deposit until the rod has been removed. This can be effected by placing the drop near the substance intended for examination, and then allowing it to come in contact with it, either by inclining the glass slide, or by leading it with a glass rod, to the matter to be tested.

Without the greatest attention to cleanliness, the microscopical observer will be constantly led into error, and thereby bring discredit upon himself and upon the science. Nothing is more common than to find a specimen which we are examining under the microscope covered with a vast number of starch granules, which have been introduced from without. Usually these are derived from the squares of thin glass which were formerly kept in a little starch powder to prevent fracture. An intimate friend showed me one day some microscopic preparations which contained curious bodies of the nature and origin of which he was not aware. Upon examining the slide, I found a number of scales from the wing of a moth, which had no doubt been floating about in the air and had fallen upon the preparations. In all cases, specimens which are about to be mounted should be carefully protected by glass shades.

138. Tests kept in Glass Bulbs with Capillary Orifices.—By far the most convenient method of applying chemical reagents to minute quantities of matter, is that by which a drop is allowed to issue from a small glass vessel, having a capillary orifice, by which means a quantity even much less than a single drop can be readily obtained, while there is no danger of any portion of the preparation being introduced into the test solution.

In order to prepare a convenient vessel for containing the test solution, a small bulb, about an inch in diameter, was blown at one end of a piece of glass tube, the other being drawn out to a moderately fine capillary point, and a small cap, made either of glass or gutta percha, was adapted to the end, pl. X, fig. 64. These bulbs were easily filled, by expanding the air within them, by the heat of a spirit-lamp, and then inverting them so that the orifice dipped below the surface of the solution which was to be introduced, and which was already placed in a small capsule. As the bulb cooled, the liquid rushed into it, to supply the place of the previously expanded air. A small bubble of air should, however, be retained in the bulb, by the expansion of which, by the heat of the hand, some of the fluid is expelled, the bulb being inverted. The bulbs containing the strong acids and alkalies should be furnished with glass caps, but gutta percha will answer for the other tests.

Mr. Highley has had some small bottles made of the form shown

in figs. 65 and 66, pl. X. These are capped with glass, and as the bottom is flat, they stand very well. They are fitted up in small cases, and will be found exceedingly convenient to the microscopical observer, pl. X, fig. 73. It is better to have the cap made of a conical shape, corresponding to that of the end of the bottle, otherwise a little of the fluid is liable to collect between the cap and the neck, and it runs down the sides when the cap is removed.

It will be convenient to keep small quantities of the test solutions, in most frequent use, in the small capillary tubes or bulbs just described. A small box containing twelve bulbs will be quite sufficient for all ordinary purposes. For the examination of the urine, not more than six or seven will be necessary.

139. Capillary Tubes with India-rubber tied over the Top.—Dr. Lawrence Smith, of the United States, recommends that the tests should be kept in bottles of two ounce capacity, and instead of a stopper, he inserts a tube in the form of a pipette, the upper open end being covered with a piece of vulcanised India-rubber, pl. X, fig. 69 at *a*. By pressing this while the lower end is beneath the fluid, a portion of the air is of course driven out, and a little fluid rushes in to supply its place as soon as the pressure is removed. The tube may then be removed from the bottle, and by again pressing the India-rubber, a drop, or a portion of a drop, is very readily expelled.

Pipettes may also be fitted to perforated corks and used in the same way, the upper end of the pipette may be closed with a small cork or an India-rubber bulb adapted to it. Upon the whole I prefer the dropping bottle figured in plate X, fig. 70.

140. Application of the Reagent to Minute Quantities of Matter.—With the aid of the bulbs or other arrangements just referred to, the most minute traces of different substances may be readily detected. The solution of the substance, consisting perhaps of only one drop, is placed upon a glass slide. This drop may be very readily divided into four or five smaller drops, if necessary, to each of which a separate test may be applied. For instance, suppose we have a minute quantity of the ash of an animal tissue, or of the solid residue of an animal fluid, to examine, and we wish to ascertain if it contains carbonates, sulphates, chlorides, and phosphates, and whether phosphate of lime and magnesia are present, we may proceed as follows :—the portion of ash, which may, perhaps, be half the size of a pin's head, or even less, is removed from the platinum foil, upon which it has been ignited in order to remove organic matter, and placed upon a glass slide. It is moistened with a small quantity of water, and then treated with a minute drop of nitric acid. If effervescence takes place, a carbonate is present. The *acid* solution is then divided into

three portions, with the aid of a small stirring-rod, and the solutions, tested as follows :—

1st portion.—If a drop of solution of nitrate of silver gives a cloudy precipitate, chlorides are present.

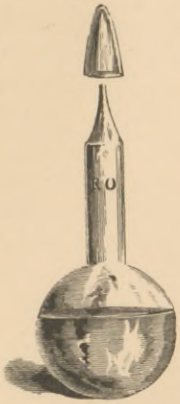
2nd portion.—If nitrate of barytes produces a white precipitate in the acid solution, sulphates are present. Upon the addition of excess of ammonia, the precipitate produced by nitrate of barytes will be increased, if phosphates exist in the solution. The precipitate of phosphate of baryta is flocculent, and readily distinguishable from that of sulphate of baryta (which is dense and granular), by its solubility in acids.

3rd portion.—If lime or magnesia be present, in the form of phosphate, a precipitate will be produced upon adding excess of ammonia to the nitric acid solution. The mixture may be stirred a little, with a piece of glass rod or platinum wire, and then allowed to stand for some time. The thin glass cover is now applied, and the precipitate subjected to microscopical examination. *Phosphate of lime* occurs as a granular amorphous sediment, while the ammoniaco-magnesian, or triple phosphate, is easily found crystallized in a beautiful stellar form, or as minute prismatic crystals. See "Urine Urinary deposits and Calculi."

141. Testing for Carbonates.—As carbonates are often present in very minute quantity in the ash of organic substances, a slight modification of the plan above given may be pursued, and the smallest traces detected. If only a few bubbles of carbonic acid are given off upon the application of the acid to the substance, or if, in consequence of the solubility of the carbonate present, they are evolved very rapidly, they frequently elude observation.

In testing for minute traces of carbonates, we may proceed as follows :—The portion of ash, deposit, or tissue (as the case may be), is placed upon a glass slide, and lightly covered with a piece of thin glass. A minute drop of nitric or acetic acid, not too strong, is then allowed to escape from one of the bulbs. This is drawn by capillary attraction between the glasses, and soon comes into contact with the substance to be tested. Any bubbles which may be given off are thus confined, and they may generally be seen clear enough. In some instances, however, advantage is derived from subjecting the specimen to microscopical examination, when the evolution of gas can be seen ; and the bubbles set free cannot possibly be mistaken for air-bubbles, which had been included in the interstices of the tissue previously, and afterwards expelled upon the addition of the fluid, because they may be seen to increase gradually in size and number, as the action of the acid continues. In testing for carbonates, the possibility of

Fig. 64.

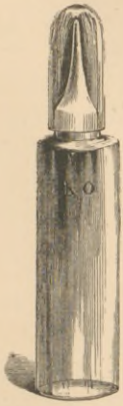


Bulb, with capillary orifice, for testing small quantities of matter. § 138.

Fig. 65.

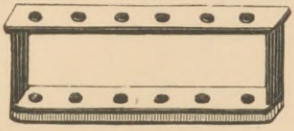
Test bottle, with capillary orifice. § 138.

Fig. 66.



Small test bottle, with capillary orifice. § 138.

Fig. 67.



Drainer, for draining test tubes.

Fig. 68.

Test tubes on rack. § 104

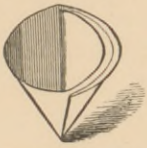
Fig. 69.

Pipette, serving as the stopper to the bottle. *a*, vulcanised india-rubber, by pressing which fluid may be expelled from the tube. *b*, ground to fit the neck of the bottle. *c*, the orifice. § 139.

Fig. 70.

Dropping bottle. § 101, p. 69.

Fig. 71.

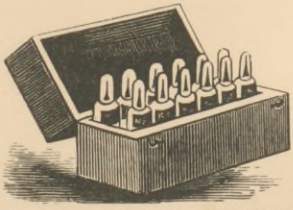


This figure shows the manner in which blotting-paper is to be cut and folded for the purpose of filtering § 108.

Fig. 72.

Retort stand, funnel, and glass, arranged for filtering § 108.

Fig. 73.



Small box containing twelve reagents in tubes, with capillary orifices for testing small quantities of matter. § 138.

[To face page 104

this occurrence, however, must always be borne in mind, and the fallacy carefully guarded against.

Sometimes in testing a deposit of carbonates, the effervescence which is produced upon the addition of the acid, depends upon a little carbonate of ammonia being dissolved in the fluid. We must be careful to ascertain, in the first instance, if the fluid be free from a soluble carbonate, in which case we may conclude the effervescence is caused by the action of the acid on the insoluble particles.

Effects of Reagents upon Animal Structures.

The effects of the application of cold strong acids to animal textures are very variable; in some instances the tissue is completely destroyed, while in others scarcely any effect seems to be produced. The mineral acids generally coagulate albuminous tissues, and render their microscopical characters confused and indistinct. Tribasic phosphoric acid, however, is an exception to this statement. Acetic acid dissolves many of the substances allied to albumen.

The appearance of some structures is scarcely altered by the application of a strong acid; for instance, the blood corpuscles shrink a little, but exhibit their usual form and general characters for some time after the addition of strong nitric acid, and the cells of the epidermis and nail, although turned of a yellow colour, are not destroyed; the latter are separated somewhat from each other, but their outline is often made beautifully distinct. Most of the mineral constituents of the body, insoluble in water, are directly dissolved by the acids.

142. Acetic Acid.—Acetic acid is one of the most useful reagents to the microscopical observer. The glacial acid should be obtained. Acetic acid has the property of dissolving granular matter composed of an albuminous material, and causes the cell wall to become very transparent, although it often renders the nucleus darker and more distinct. In many instances the action of the acid upon the cell wall depends partly upon endosmosis; the cell becomes much larger, and the wall more pulpy and thicker, and approaches more nearly in density and refracting power to the solution in which it is immersed. In numerous instances, by adding a saline solution to cells which have been previously rendered transparent by acetic acid, they again contract, and the outline becomes distinct. In some cases, however, the outer part of the cell is actually dissolved by the acid, and its contents set free. Acetic acid will be required of various strengths, the most useful proportion being one part of the strong acid to three or five of water. Acetic acid is very frequently used to make epithelial

structures transparent, in order that the arrangement of the minute vessels and nerves in papillæ, &c., may be demonstrated, as in the case of the tongue, skin, &c. Sections of preparations which have been hardened by maceration in alcohol, often require boiling slightly in acetic acid before they can be rendered transparent. The action of acetic acid on white fibrous tissue is very characteristic, as it converts it into a transparent jelly-like mass, in which a few nuclei are visible. Upon the yellow element, on the other hand, this reagent exerts no action whatever. The action of acetic acid upon epithelial cells and pus-globules will be discussed in a subsequent chapter.

Acetic acid may also be employed for testing crystalline bodies as phosphates and carbonates. By it we may distinguish phosphate or carbonate of lime from oxalate of lime (all of which are insoluble in water). It dissolves the two former, while it does not affect the latter, even if it be boiled in it.

The action of acetic acid upon any particular tissue, upon any form of cells, fibres, &c., that are subjected to examination, should always be specially noted. Many tissues are quite insoluble in acetic acid, though they are not rendered opaque by it.

Citric, oxalic, and other acids have been recommended for special investigations, but I have not satisfied myself that they possess decided advantages.

In my researches upon the arrangement of nerves in various textures, and upon the structure of nerve centres, I have employed a mixture of glacial acetic acid and strong glycerine. I find that in the proportion of ten drops of the acid to an ounce of glycerine, the required action slowly takes place. Specimens may be placed for many weeks or months in a still weaker solution. Gradually the connective tissue acquires transparency, while the finest nerve fibres are rendered granular, in consequence of the albumino-fatty material being decomposed, and the fatty matter set free as granules or minute globules. The dark-bordered nerve fibres retain their smooth appearance, and are scarcely altered by the acid. If the nerve fibres are very soft it is desirable to add a drop of the glycerine solution of chromic acid to the acid glycerine (p. 55.)

143. Dilute Nitric Acid is much employed in microscopical research.—An acid composed of one part of acid to two or three of water, forms a good solution for hardening some structures, previous to cutting thin sections. The thin sections may sometimes be rendered very transparent by being treated afterwards with dilute caustic soda. For demonstrating muscular fibre-cells, nitric acid is a valuable reagent. For this purpose the solution should contain about twenty per cent. of strong acid, and the muscular fibre should be

allowed to macerate in it for some days, when small pieces may be removed with scissars, and after being carefully torn up with fine needles, subjected to examination.

When we wish to obtain portions of glandular structure isolated from each other, it is a good plan to soak the tissue for some days in dilute nitric acid (one part of acid to six or seven of water), when the areolar tissue becomes softened, and at the same time the gland structure is rendered more firm, and may be isolated very readily with the aid of needles. In this manner the gastric glands, the secreting follicles of the pancreas and salivary glands may often be very satisfactorily demonstrated. The so-called fibre-cells of organic muscles are to be isolated in the same way. For this purpose Reichert and Paulsen recommend a 20-per cent. solution.

By boiling animal tissues in strong nitric acid, they become destroyed, while any siliceous constituents remain behind unaltered. In this manner, the siliceous skeletons of the *Diatomaceæ* may be separated from any organic matter with which they may be combined. Nitric acid is also valuable for its action upon hard vegetable tissues.

144. Sulphuric Acid.—Hydrochloric Acid.—The pure acids only should be used for microscopical investigation. They may be obtained at most of the operative chemists. Concentrated sulphuric acid causes epidermic structures to swell up very much, and the cells to separate from each other so that they may be readily isolated. Boiling acid completely dissolves them. In the examination of hair, strong sulphuric acid will be found to render the outline of the cells very distinct.

Connective tissue becomes converted into jelly, and dissolved by weak sulphuric acid (one part to 1000) if kept in it for twenty-four hours, at a temperature a little below 100°. This process has been recommended for isolating the muscular fibres.

Hydrochloric acid is usually employed for dissolving out the mineral constituents of certain tissues, such as bone or teeth. As a rule, it is better to use dilute acid (one of acid to three or four of water), in which case, however, a longer time must of course be allowed, than when the acid is concentrated.

Hydrochloric acid renders muscular tissue transparent. A very weak solution of the acid in glycerine carries out this object advantageously. It is valuable for softening and dissolving connective tissue, such as that between the gland follicles, muscular fibres, and nerve fibres. For these purposes a 1-per cent. solution is strong enough.

145. Chromic Acid.—Bichromate of Potash, &c.—Chromic acid is of great use to the observer for the purpose of hardening exceedingly

soft and delicate tissues. It was first employed by Hannover, in 1840. It has since been used by every microscopist, and is especially valuable for hardening sections of the brain, spinal cord, and ganglia. For hardening such tissues a solution containing from ·5 to 1 per cent. is strong enough. Frey states that the best results are obtained by increasing the strength from time to time. Soft organs, such as the retina, should be soaked in very weak solutions for some time, to harden them very gradually.

H. Müller has recommended a fluid of the following composition, for hardening the retina, but it is adapted for many other structures. The tissues should soak in it for two or three weeks. It preserves the tender embryonic tissues well (Frey):—

Bichromate of potash	... 30 to 40 grains.
Sulphate of soda	... 15 grains.
Distilled water	... about 3 ounces.

Perchloride of iron, diluted with a large quantity of water, till of a very pale yellow colour, has been used by Führer and Billroth for hardening the spleen. Nitrate of silver has been used for staining the outer part of cells, as well as germinal matter. This substance has been very strongly recommended by Recklinghausen and His (p. 30).

146. Effects of Alkalies.—The action of alkalies, even when cold in a very dilute state, is to soften, and at length to dissolve most animal textures. Cell-membranes are almost instantly rendered extremely soft and transparent, while the nucleus appears to be altered but slightly. Alkalies are also employed for dissolving certain crystalline substances which are occasionally found in animal tissues, such, for instance, as deposits of alkaline urates, which are not unfrequently met with in the form of considerable deposits in the tissues of gouty persons.

147. Potash and Soda.—The action of potash and soda upon animal structures is very similar. Both dissolve substances of an albuminous nature, but the effect of soda is more gradual, and it has been found that for most purposes in microscopical research, this reagent possesses advantages over potash.

The solution of potash is the ordinary *liquor potassæ* of the pharmacopœia, and the solution of soda is prepared in the same manner. These solutions may be diluted with water to the required strength. Potash and soda are employed where a tissue is to be rendered more transparent for the purpose of demonstrating the arrangement of the nerves or other anatomical elements not soluble in this reagent.

These reagents dissolve the layer of epithelium covering mucous membranes, or render it perfectly transparent, so that the arrangement of the structures beneath the basement membrane can be easily demonstrated. In investigating the termination of the nerves and vessels in papillæ and other structures, they are very valuable.

For the purpose above mentioned, the alkalies should be diluted with water or glycerine. The changes are expedited by the application of heat, which, however, must not be too great, for fear of complete solution taking place. Where the structures are hard and dry, they may be warmed with the reagent in an ordinary test tube, a plan which is much recommended by Kölliker.

Solution of ammonia, lime water, and baryta water have all been employed in the investigation of animal tissues. Lime water has been strongly recommended by Rollett for investigations on connective tissues, tendon, &c.

Carbonates of Potash and Soda.—Some animal textures become hardened by prolonged maceration in carbonate of potash, but this plan does not appear to be so generally useful as others previously indicated. Epidermic structures are not much altered by these salts. Gurlt recommends skin to be hardened in solution of carbonate of potash for the examination of the sweat ducts.

The introduction of different chemical solutions by injection, has been discussed in p. 39. I strongly recommend this plan of subjecting the tissue to the action of the reagent.

Of obtaining Crystalline Substances from the Fluids and Textures of Animal Bodies.

Under this head it is proposed to give a sketch of a few of the simplest plans of obtaining various crystalline bodies from animal solids and fluids. It is, however, inconsistent with the plan of this work, to attempt more than to allude to a few of the most important; and, for further information, the student is referred to the works enumerated in the note,* and to the third volume of Dr. Miller's "Elements of Chemistry."

148. Formation of Crystals in Animal Fluids.—Some crystalline bodies are deposited from their solution in animal fluids by simple evaporation; others, less soluble, may be deposited by allowing the fluid to stand still for a short time, when certain changes occur in

* "Lehmann's Physiological Chemistry," translated for the Cavendish Society; Gorup-Besanez, "Anleitung zur Zoochemischen Analyse;" Bowman's "Medical Chemistry." Also the excellent "Lehrbuch der Zoochemie," by Heintz, which however is only published in German, and the work of Hoppe Seyler.

some of its constituents, which lead to the precipitation of some bodies in a crystalline form, such, for instance, as uric acid, or crystals of triple phosphate. In other cases it becomes necessary to add some reagent before the crystals are thrown down, while not unfrequently a long and often complicated chemical analysis is required, in order to isolate some of the substances which were previously held in solution, and obtain them in a crystalline state. The addition of water in some cases causes the most rapid crystallization, especially when the crystallizable material is dissolved in other media, contained in the interstices of tissue or in a colloid state. Instead of water, it may be necessary to add alcohol, in which fluid the crystals may be much less soluble.

Crystalline substances which are dissolved in animal fluids, may often be separated in a perfectly pure state by the addition of another fluid in which they are not so readily soluble. This last should be added very gradually, to allow time for the formation of the crystals, otherwise an amorphous precipitate alone results. Many organic substances, soluble in alcohol, may be crystallized by the addition of ether, while some are precipitated from their solution in water, by the gradual addition of alcohol. Glycerine is a neutral substance which takes up water and thus assists to promote crystallization in many cases.

149. Influence of certain Constituents upon the Crystallization.—In many instances, it is exceedingly difficult to separate some crystalline bodies from other constituents with which they are retained in solution. In consequence, their solubility is much increased, and their crystallization often prevented. The extractive matters of blood, urine, &c., exert this influence in a marked degree, and it is only of late years that several new bodies of definite chemical composition have been isolated. Creatine and creatinine may be instanced amongst the number, for these were not very long ago included under the indefinite term "extractives." Certain colouring matters of definite composition have also been separated, and it is very probable that, as the methods of analysis at our disposal become improved, many new crystalline bodies will be isolated from the extractive matters. A very small quantity of extractive matter entirely prevents the crystallization of urea, while the presence of chloride of sodium favours the separation of this material by forming with it a compound which readily crystallizes in large octahedral crystals even in the presence of extractive matters. The existence of carbonic acid in excess may cause carbonate of lime, triple phosphate, and other salts, to be held in solution. Excess of alkali prevents the precipitation of uric acid, and excess of acid, that of phosphate of lime. Fatty matters

dissolve cholesterine, and serum possesses the power of retaining small quantities of both the latter substances in solution.

Some crystalline bodies which are soluble at the temperature of the body, crystallize when the solutions containing them are cooled thirty or forty degrees. The effect of dilution upon retaining crystals in solution, need scarcely be alluded to.

Hence, before the presence of many substances can be detected by microscopic examination, certain chemical operations are required in order to separate them from their combinations in the animal body, or for the removal of other substances which interfere with their crystallization.

150. Separation of Crystals from Animal Substances.—From what was stated in the last section, it follows that in many instances this is a matter of some difficulty. Not unfrequently, even after crystals have been obtained, if not very soon separated from the fluid in which they were formed, they again undergo solution or become decomposed. If the crystals are not very soluble, the supernatant fluid, or mother liquor, may be poured off,—the crystalline deposit washed with ice-cold water, and subsequently dried on filtering paper or on a clean porous tile over sulphuric acid, without the application of heat. If the crystals will not bear the application of water, as much of the fluid as possible must be poured off, and the remainder absorbed with bibulous paper, or they may be placed upon a porous tile, and dried over sulphuric acid in vacuo. In many instances we are enabled to wash the crystals with water, holding a little acid or alkali, or some alkaline salt, in solution, or with alcohol, chloroform, ether, or some other fluid in which we know them to be quite insoluble.

In cases in which crystals insoluble in water are deposited in animal solids, they may be separated by agitation, when, being heavier than the water, they subside to the bottom, and the lighter animal matter may be removed by forceps, or if in a very minute state of division, poured off with the supernatant fluid. In other cases it may be separated by straining, while the crystals are washed through muslin.

151. Examination of Crystals under the Microscope.—Some crystals which have been entirely separated from the fluid in which they were originally deposited, may be examined in the dry way, in water, or other fluid in which they are known to be insoluble, or in Canada balsam ; but, as a general rule, it is necessary to examine the crystals as they lie in some of the fluid in which they have been formed. When they have been obtained by allowing a concentrated solution to cool, some of the inspissated fluid must be removed with the

crystals, placed upon a glass slide, or in a thin glass cell, covered with a piece of thin glass, and examined in the usual way—first using a low power (an inch), and afterwards a higher power (a quarter), because, although some of the crystals are of a large size, others amongst them, the form of which is very perfect, are often exceedingly minute. The crystals and mother-liquor should not be exposed to the air previous to examination, for in many instances water is absorbed, and partial solution takes place.

152. Of obtaining Crystals for Examination.—In order to accustom himself to the necessary manipulation required in the process, the student may evaporate a solution of common salt upon a glass slide, and when it has become sufficiently concentrated, it may be covered with a small piece of thin glass, and allowed to cool. When cold it may be subjected to microscopical examination, and beautiful cubes of chloride of sodium will be observed (pl. XI, figs. 74, 75.) Crystals of several salts may be made in the same simple manner, and from an attentive examination of them much may be learnt. Phosphate of soda, phosphates of soda and ammonia, sulphates of potash and soda, muriate of ammonia, and a variety of other salts, can be readily obtained in microscopical crystals in this manner.

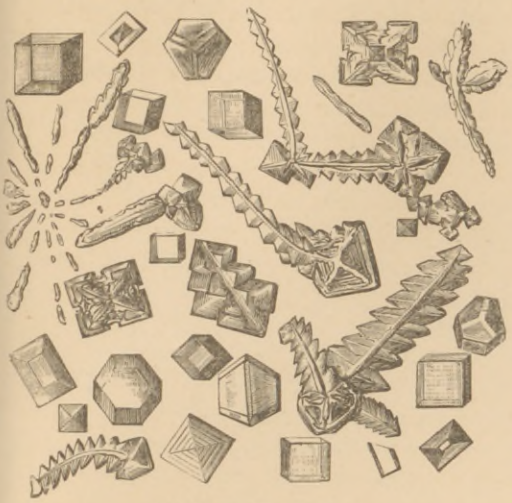
Different faces of the crystal, as it lies in the liquid, may be brought into view by slightly moving the thin glass cover with a fine-pointed instrument, such as a needle, while the preparation is in the field of the microscope. With a little practice, crystals may in this manner be made to rotate in the mother-liquor. Crystals which are precipitated by the addition of some reagent, such as nitrate of urea by nitric acid, must be examined in a little of the solution. The addition of water would, in many instances, destroy them immediately.

The influence of the crystals upon polarised light (H. to W. § 34), should be examined, and in cases in which the nature of the crystal has not been ascertained, its angles should be carefully measured, and accurate drawings made. The behaviour of the crystals with chemical reagents is next to be ascertained, and their solubility in water, alcohol, and other fluids must be noted. For these experiments different portions must be taken and separately tested in the manner referred to in §§ 138, 140.

A drop of the solution should also be evaporated rapidly nearly to dryness, and allowed to crystallize upon the slide without being covered over, when the substance will often be found to assume a variety of beautiful forms, such as crosslets, dendritic expansions, &c., which vary according to the rapidity with which the evaporation has been conducted, and other circumstances, pl. XI, fig. 76.

153. Of Measuring the Angles of Crystals.—The goniometer is

Fig. 74.



Chloride of sodium. ⅛ 152.
× 215.

Fig. 75.

Chloride of sodium. ⅛ 152.
× 215.

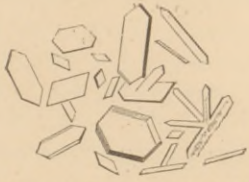
Fig. 77.

Urea. ⅛ 155
× 215.

Fig. 76.

Chloride of ammonium. ⅛ 152

Fig. 79.



Oxalate of urea, obtained by adding oxalic acid to concentrated urine
⅛ 155. × 215.

Fig. 78.

Nitrate of urea. *a*, crystals obtained from urine
b, crystals of pure nitrate of urea. ⅛ 155.
× 215.

Fig. 80.

Watery granules of the chloride of zinc creatine, and creatinine, from urine. ⅛ 156.
× 215.

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employed in the measurement of the angles of crystals. Although not much used in this country at present, it is important briefly to refer to its construction, as in some researches it is desirable that the angles of the crystals should be carefully measured. Crystals which nearly resemble each other in their general form, and even in size, will be found to exhibit differences in the measurement of their angles.

The simplest method of measuring the angles of microscopic crystals is that of Schmidt. The goniometer consists of a positive eye-piece, which is so arranged as to be easily rotated within a large and accurately-graduated circle. Across the focus of the eye-piece a single cobweb is drawn ; and to the upper part is attached a vernier. The crystals being placed in the field of the microscope, *and care being taken that they lie perfectly flat*, the vernier is brought to zero, and then the whole apparatus turned until the line is parallel with one face of the crystal ; the framework bearing the cobweb with the vernier is now rotated until the cobweb becomes parallel with the next face of the crystal, and the number of degrees which it has traversed may then be accurately read off.

The cobweb goniometer just referred to, will, I believe, be found to answer the purposes for which this instrument is required by the physiological or pathological observer, but for special crystallometrical investigations, a more elaborate apparatus becomes necessary. Dr. Leeson has applied the property of double refraction, possessed by Iceland spar, to the measurement of the angles of crystals under the microscope. A modification of his apparatus is described in " How to work with the Microscope," (§ 68). See also a paper by Mr. Highley in the fourth volume of the Quarterly Journal of Microscopical Science, page 77. Schmidt's goniometer is figured in pl. XVIII, fig. 125, of this work.

154. Preservation of Crystals as Permanent Objects.—The preservation of the more soluble crystals is attended with the greatest difficulty, except when dried, in which state their characters under the microscope are not well defined. Crystals which very readily deliquesce on exposure to air, must be dried in vacuo, removed quickly to a cell, the cover of which must be firmly cemented down at once. Some crystals may, however, be dried and mounted in Canada balsam ; others, such as oxalate of lime, cystine, triple phosphate, &c., can be well preserved in aqueous solutions, containing a little acid in the case of the two former substances, or an ammoniacal salt, in the latter instance, in which the crystals are known to be insoluble. Crystals which contain water of crystallization, may sometimes be preserved permanently in a drop of the mother-liquor ; but,

in many instances they alter much in form, and when we come to examine them, instead of finding a great number of small, well-formed crystals, as when the preparation was first put up, nothing remains but one or two large ill-shaped ones. The concentrated mother-liquor often acts upon the cement with which the glass cover is fixed on the cell, and very soon air enters, and the preparation is destroyed. Many crystals may be preserved in strong glycerine without much change taking place. I have some crystals of Guinea-pigs' blood which have been preserved for several years in this medium.

A preparation of nitrate of urea in my possession has kept well for a considerable time in a very thin cell, containing only just sufficient of the mother-liquor to preserve the form of the crystals. The cell is made of Brunswick black. Crystals of chloride of sodium appear to keep pretty well in their mother-liquor, and the same will be found to be the case with a great number of substances. The more soluble crystals of an organic nature can seldom be preserved unless they are perfectly pure.

155. Urea.—Traces of urea in an animal fluid may always be detected by the crystalline characters of the nitrate of urea. Upon adding a drop of nitric acid to a drop of cold concentrated urine, or other solution containing urea, placed upon a glass slide, a crystalline precipitate of nitrate of urea will immediately take place. Upon covering this with a piece of thin glass, and subjecting it to microscopical examination, the characteristic rhomboidal plates will be observed. Fig. 78, pl. XI, represents the appearance of nitrate of urea examined with a quarter of an inch object-glass, at *a* are shown some crystals of the impure nitrate, as obtained from urine; the other crystals in the figure were formed by adding some nitric acid to a solution of pure urea.

Another drop of the concentrated urine may be treated with a strong solution of oxalic acid, when we shall obtain crystals of oxalate of urea, the form of which is represented in fig. 79, under a quarter of an inch object-glass. When mere traces are suspected to exist in animal fluids or solids, we must proceed to separate the urea from albuminous or other substances, before the addition of the nitric acid.

If the urea exist in an albuminous solution (serum of blood, or in a dropsical fluid), we must remove the albumen by boiling with a few drops of acetic acid, and subsequent filtration. The filtered solution is to be evaporated to dryness over a water-bath, and the dry residue treated with cold alcohol. As a general rule, however, I think it preferable to evaporate the solution supposed to contain urea, at the temperature of 100°, or in vacuo, and treat the dry residue with alcohol,

which dissolves the urea. Much chloride of sodium separates from the alcoholic solution as it is evaporated. If to a little of the cold mother-liquor a drop of nitric acid be added, as above described, crystals of nitrate of urea will be formed, if urea was present in the original solution. In all cases, the fluid suspected to contain urea must be operated upon when quite fresh, as this substance readily becomes decomposed into carbonate of ammonia. Numerous crystals of urea, oxalate of urea, and nitrate of urea, are figured in the plates of my work on Urine, Urinary Deposits and Calculi.

In examining solid organs for urea, the fresh tissue may be broken up, and treated with several portions of hot alcohol, the solution filtered from coagulated matters, and evaporated. The residue may again be extracted with alcohol, and the pure crystals may be obtained by solution in water and subsequent evaporation.

Oxalate of Urea is easily prepared by adding crystals of oxalic acid to a concentrated solution of urea, or to urine evaporated to the consistence of syrup. As the mixture becomes cold, numerous crystals of oxalate of urea form, pl. XI, fig. 79.

Crystals of pure urea, obtained by decomposing a solution of the oxalate of urea with chalk, and carefully evaporating the filtered liquid, are shown in fig. 77. The cavities represented in many of the crystals contain fluid. Urea may also be obtained in a nearly pure form by adding ether, in which it is only slightly soluble, to the fluid which contains it.* Urea may be determined, quantitatively, by weighing the nitrate and calculating the proportion of urea it contains, by decomposing it with solution of chlorinated soda and estimating the volume of nitrogen according to the method of Dr. Davy,† or by Liebig's process.‡

156. Creatine—Creatinine.—Creatine exists in very small quantity in muscular fibre. Traces of it are also present in urine, in which fluid it was discovered by Liebig. According to Dr. Gregory, it is most readily prepared from the flesh of the cod fish; from twenty-five pounds of which, in one experiment, he obtained 164 grains of creatine. From crocodile's flesh I obtained it very readily; two pounds yielded more than seventeen grains of pure creatine. The flesh is to be chopped in small pieces, and well kneaded with water. After all the fluid has been expressed by powerful pressure, it is very carefully raised to the boiling-point, and the coagulated matter removed by filtration. The phosphatic salts are precipitated by caustic baryta.

* A plan recommended by Dr. Marcet.

† "Dublin Hospital Gazette," June 1st, 1855; "Archives of Medicine," vol. i, page 144; "Urine, Urinary Deposits, and Calculi, 3rd edition."

‡ *Vide* a paper by Dr. von Bose, "Archives of Medicine," vol. i, page 34.

The solution must be again filtered, and evaporated at a gentle heat (130°–140°) to about one-twentieth of its volume, or to the consistence of syrup; any scum which forms being from time to time removed from the surface. This concentrated solution may then be set aside. On cooling it forms a thin jelly, and, after standing for some days, crystals of creatine are deposited.

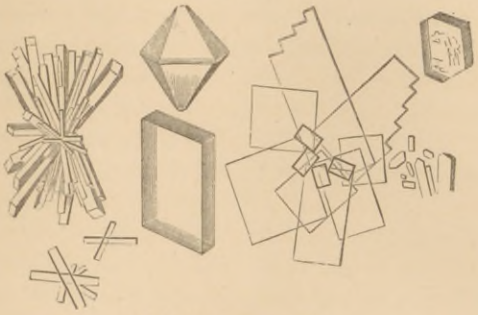
Crystals of creatine are represented in pl. XII, figs. 81 and 82, and those of creatinine in fig. 83. The first and last have been copied from the Atlas of Robin and Verdeil.

I have obtained crystals of creatine and creatinine from urine, according to Liebig's process, as follows:—A quantity of urine was neutralized by lime water and precipitated by chloride of calcium. The filtered solution, after being evaporated to a small bulk, was again filtered from the saline residue which crystallized out, and mixed with about one-fourth of its weight of a solution of chloride of zinc, previously concentrated to a syrupy consistence. After some days had passed, numerous warty masses of a compound of chloride of zinc and creatinine, with which the creatine was mixed, separated, pl. IX, fig. 80. These were re-dissolved in water and crystallized. The pure crystals were boiled in water with hydrated oxide of lead, and the chloride of lead and oxide of zinc separated by filtration. The solution containing the creatine and creatinine was concentrated. The crystals thus obtained were purified by re-crystallization, and treated with boiling alcohol, which dissolved the creatinine, leaving the creatine behind. By purification with animal charcoal and re-crystallization, excellent crystals were obtained. My assistant, Dr. Von Bose, obtained a considerable quantity of these crystals from urine in my laboratory.

157. Uric or Lithic Acid.—The presence of uric acid in a crystalline form, can be readily detected in animal fluids and solids, by microscopical examination, if it occur in a crystallized state.

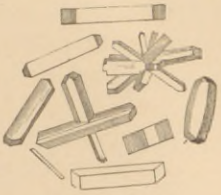
In order to ascertain if an amorphous or other deposit contain uric acid, or a urate, we must treat it with a few drops of potash, which will dissolve any of the acid that may be present. This alkaline solution is to be decomposed with excess of acetic acid, and, after the mixture has been allowed to stand for twenty-four hours or longer, any deposit that may have formed, is to be subjected to microscopical examination. The microscopic crystals of uric acid, obtained in this manner, are usually in the form of rhombic tablets, pl. XII, figs. 84 and 85, but sometimes they assume the form of six-sided plates. Uric acid not unfrequently crystallizes from urine, without the addition of any free acid. The crystals vary extremely in shape. Common and rare forms are represented in

Fig. 81.



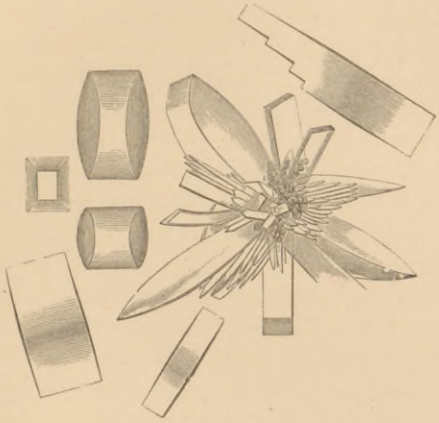
Crystals of creatine. § 166.

Fig. 82.



Creatine. § 166.

Fig. 83.

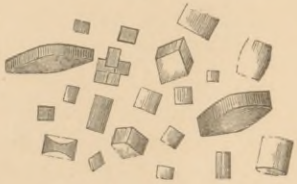


Crystals of creatinine. § 166.

Fig. 84.

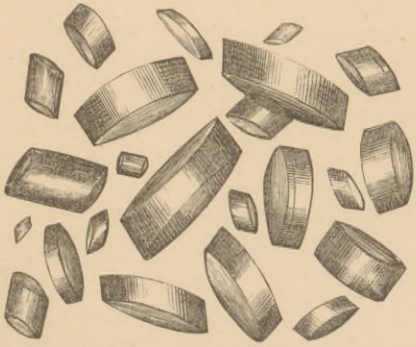
Uric acid, deposited from alkaline urates by the addition of excess of acid. § 157. × 215.

Fig. 85.



Uric acid from urine § 157. × 215.

Fig. 86.



Uric acid deposited from urine. § 157. × 130.

Fig. 87.

Rare form of uric acid crystals deposited from urine. § 157. × 215.

[To face page 116.

figs. 86 and 87. See also "Urine, Urinary Deposits, and Calculi," in which work very many different crystalline forms are given.

Uric acid is soluble in alkaline fluids, and when present in serum, exists in combination with an alkali. We shall be able to detect it in aqueous extracts, if uric acid or a urate existed originally in the fluids. All that is necessary is to concentrate the solution, and then add excess of acetic acid.

Dr. Garrod (Medico-Chirurgical Transactions, vol. xxxi), has proposed an excellent plan for detecting the presence of uric acid in the blood of gouty patients, which is very simple and easy of execution. A little of the serum is poured into a watch-glass, and a few drops of acetic acid added to it. Two or three very fine filaments of silk, or tow, are then placed in the mixture, and the whole allowed to stand in a still place, under a glass shade, for twenty-four hours or longer. Upon submitting the filaments of tow to microscopical examination, they will often be found studded with minute crystals of uric acid, frequently exhibiting some of the forms shown in the above figures.

The student will gain much practical information as to the characters and various forms which this substance assumes, by dissolving some of the crystals obtained from urine in alkaline solutions (potash, soda, alkaline carbonates, phosphates, &c.), and then causing the crystals of uric acid to be precipitated by the addition of excess of acid. To some specimens he may add hydrochloric, to others, acetic or nitric acids, &c. Upon examining in the microscope the crystals obtained by these various processes, he will notice a great variety of forms, but, upon careful examination, it will be found that most of them are mere modifications of the same form, and that a connection between them may be traced in many instances. See "Urine, Urinary Deposits, and Calculi."

158. Hippuric Acid is separated from its salts by the addition of a stronger acid (as hydrochloric acid) and the crystals which are deposited may be subjected to microscopical examination in the usual manner. Hippuric acid should always be sought for in animal fluids which are quite fresh, as it undergoes decomposition very rapidly, and becomes entirely converted into benzoic acid. The microscopical characters of these two acids are very distinct. Benzoic acid crystallizes in scales, while the crystals of hippuric acid occur in the form of beautiful prisms, pl. XII, fig. 88, not unlike those of the ammoniaco-magnesian phosphate. Hippuric acid is very soluble in hot water, and also in alcohol. Solutions of hippuric acid redden litmus paper strongly.

In order to detect small quantities of hippuric acid, the animal

fluid, which must be perfectly fresh, is evaporated nearly to dryness, and then treated with alcohol sp. gr. ·830. After the addition of a crystal of oxalic acid, the spirituous solution is evaporated to the consistence of syrup. The residue is next to be extracted with ether, which contains about one-sixth of its volume of alcohol. The solution is again evaporated, and the remaining extract treated with water, which dissolves the hippuric acid, while any fatty matter which is present is left behind in an insoluble state. The solution may be filtered into a watch-glass, and allowed to evaporate slowly that crystals may form.

Hippuric acid may always be obtained from the fresh urine of horses or oxen. After the administration of benzoic acid, it is found in human urine, as was demonstrated many years ago by Mr. Ure; and Lehmann has remarked the presence of hippuric acid in diabetic urine, in every instance in which he has sought for it. Lehmann states, that in diabetic urine, hippuric acid takes the place of the uric, which is absent in this condition. Some exception to this must however, be taken, as I have seen several cases of confirmed diabetes in which the urine contained a very large quantity of uric acid, and the fact has been observed by other practitioners. Indeed, in this country at least, I am quite certain that uric acid is often found in diabetic urine. Hippuric acid has been found in the blood of oxen by Verdeil and Dolfuss.*

159. Lactic Acid.—Lactates.—The presence of this acid is often detected with difficulty in animal substances, in consequence of its characteristic reactions being interfered with by the presence of many organic bodies. Its separation from other substances is attended with much trouble, especially when it is present only in very minute proportions.

Dr. Richardson has lately induced a rheumatic condition in dogs, accompanied by affection of the joints and heart, by injecting a dilute solution of lactic acid into the peritoneal cavity. It has been supposed that rheumatism is due to an excessive production of lactic acid, or to its accumulation in the blood. The presence of lactic acid is most readily determined by the microscopical characters of certain of its crystalline salts. Of these the *lactates of zinc, copper, and lime* are the most characteristic. In order to detect the presence of lactic acid in animal fluids, Lehmann proceeds as follows: the fluid is evaporated carefully over a water-bath, and the residue extracted with alcohol. After the separation of some of the salts by evaporating this alcoholic solution, and allowing them to crystallize

* Lehmann's "Physiological Chemistry," Cavendish Society, vol. ii, page 212.

out, the remaining mother-liquor is treated with sulphuric or oxalic acid. The sulphate or oxalate of potash is then precipitated by means of alcohol, and the impure lactic acid remains in solution. To this solution baryta water is next added, and the excess of baryta removed by carbonic acid. The solution filtered from the precipitate is evaporated to a syrupy consistence, treated with alcohol, filtered, again evaporated, and then allowed to stand for some time, in order that any baryta salts may crystallize out. The syrup is next removed, and decomposed with sulphate of lime. The solution filtered from the sulphate of baryta is evaporated to a small bulk, when crystals of lactate of lime, in the form of double brushes, pl. XIII, fig. 89, with crystals of sulphate of lime, may be observed upon microscopical examination. The crystals of lactate of lime may be dissolved in alcohol and sulphate of copper added. After the removal of the excess of sulphates of lime and copper by evaporation and crystallization, the remaining solution is to be concentrated, and the crystals of lactate of copper examined in the microscope, pl. XIII, fig. 90. If distinct and measurable crystals are not obtained in this manner, Lehmann dissolves the residue in a little water to separate any butyric acid that may be present, and after being strongly boiled, the solution is filtered, and a zinc bar placed in it, which in the course of a short time, becomes covered with crystals of lactate of zinc, the angles of which may be measured with the goniometer, pl. XIII, fig. 91.

160. Taurine.—Pulmonic, or Pneumic Acid.—*Taurine* is obtained in the form of beautiful six-sided prismatic crystals, by decomposing bile with hydrochloric acid. The bile is to be boiled with the acid for several hours. After filtration and evaporation taurine crystallizes out. This substance is found in the contents of the intestine, and commonly in the fœces. It has been detected in the urine in jaundice. Taurine is represented in pl. XIV, fig. 98. The so-called pulmonic acid was discovered in the lung tissue, by Verdeil. It is prepared as follows: perfectly fresh calves' lung is cut into small pieces, and extracted with tepid water. It is well pressed, in order to remove all the liquid. The fluid is treated with sulphate of copper to precipitate the albumen. The excess of sulphate of copper is removed by the addition of sulphuret of barium, or by adding baryta water and passing sulphuretted hydrogen through the liquid. The filtered solution is evaporated to the consistence of syrup, and time allowed for the formation of crystals. These may be re-crystallized from spirit, to which a few drops of sulphuric acid have been added. In this manner the crystals represented in pl. XIII, fig. 92, were obtained. It is probable, however, that these do not consist of

one simple substance. The so-called pulmonic acid of Verdeil has been considered by Cloëtta and others to be composed of taurine. Consult Scherer's memoir on "Hypoxanthine, Ann. der Chemie und Pharmacie," c. xii, p. 257, and Strecker's paper on Sarcine, "Quar. Jour. Chem. Soc.," vol. x, p. 121, July 1857.

161. Leucine has of late been found in many of the solids and fluids of the animal body. It is not very soluble in water (one part in twenty-seven), but more so in alcohol. It crystallizes from aqueous solutions, for the most part in spherical masses, which exhibit a radiated arrangement, pl. XIV, figs. 94 and 95. From alcohol leucine is deposited in the form of pearly scales, somewhat resembling cholesterine. Dry leucine can be sublimed without change. Leucine has been found in the saliva, pancreatic juice, and in the pulmonary tissue of the ox (Cloëtta*). Frerichs and Städeler have detected leucine in the blood, urine, and bile of patients suffering from typhus, small pox, and other exanthemata. Scherer obtained six ounces of pure leucine from twenty pounds of ox pancreas, as well as fifteen grains of guanin and thirty of xanthin. Dr. Thudichum found leucine in the urine of a man, whose liver yielded a large quantity of it.† It was obtained by concentrating the urine. This substance is probably formed in the liver, and in health rapidly converted into other compounds. In certain diseases it is to be detected in very considerable quantity. Crystals of leucine may often be seen in sections of livers of persons who have died of jaundice. Frerichs has given several figures of leucine crystals in the liver and also in the urine. It occurs especially in the urine of patients suffering from acute yellow atrophy of the liver.‡

No satisfactory tests for leucine are yet known. If it can be obtained pretty pure by repeated recrystallization, the dried leucine may be sublimed. The sublimate of aggregations of rhombic plates could hardly be mistaken for anything else. Urate of soda and many other substances crystallize in spherical globes like leucine. Crystals of this form, however, which are soluble in alcohol and again crystallize in spherules, from an aqueous solution, can hardly be anything but leucine. This substance cannot, therefore, be recognized by the form of the crystals alone.

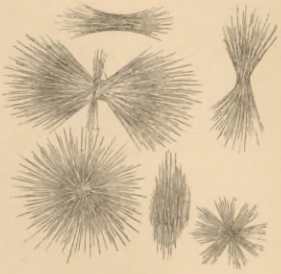
Leucine may be obtained in quantity by allowing cheese, albumen, or flesh, to decompose with about fifty parts of water for six

* "Chemical Gazette," 1856, page 61.

† "A Treatise on the Pathology of the Urine," 1858.

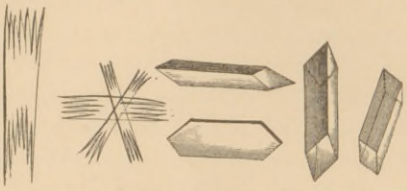
‡ "Pathologisch Anatomischer Atlas zur Leberkrankheiten," von Dr. Fried. Theor. Frerichs, Braunschweig, 1858. See also Dr. G. Harley's work "On Jaundice."

Fig. 89.



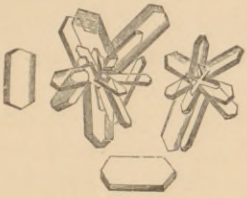
Crystals of lactate of lime. ϟ 159.

Fig. 88.



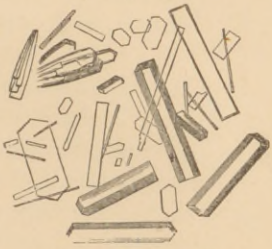
Hippuric acid Robin and Verdeil. ϟ 158.

Fig. 90.



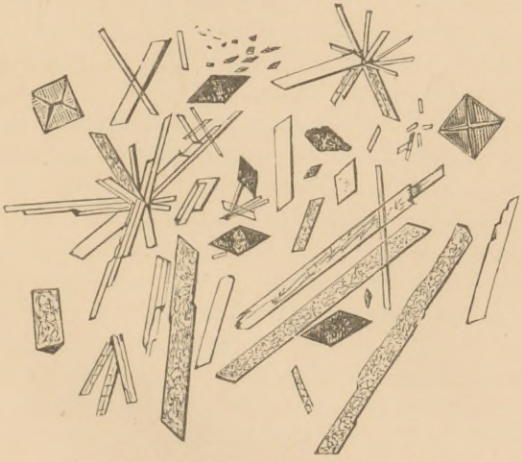
Lactate of copper. ϟ 159.

Fig. 91.



Lactate of zinc. ϟ 159.

Fig. 92.



Crystals from Calf's lung, the so-called pulmonic acid. ϟ 160. × 215.

Fig. 93.

The so-called pulmonic acid, after Verdeil. Probably taurine. ϟ 160.

[To face page 190.

weeks. Decomposed liver yields a large quantity. The fluid is to be boiled with milk of lime. After precipitation of the lime by the cautious addition of sulphuric acid, the filtered solution is treated with acetate of lead. After filtration, the solution is evaporated to the consistence of syrup, and the leucine crystallizes out. The addition of alcohol favours the separation of the leucine. Lastly; it is dissolved in water, treated with sulphuretted hydrogen, and the leucine obtained pure by recrystallization. The best plan for obtaining leucine is to fuse yellow elastic tissue, horn, wool, epithelium, or white of egg, with an equal weight of hydrate of potash. As soon as hydrogen begins to be evolved and the dark brown mass changes to a yellow colour, it is removed from the fire. The mass is treated with hot water and the highly alkaline solution is to be slightly supersaturated with acetic acid. Tyrosine first crystallizes by evaporation, but the leucine may be obtained by concentrating the mother-liquor. It may be purified as before mentioned.

In order to obtain leucine from urine, Frerichs recommends that after concentration, the fluid should be digested with cold absolute alcohol. The extractives are gradually dissolved out. Upon treating the residue with boiling spirit of wine, the leucine is dissolved out, and crystallizes as the solution cools. It may be purified by recrystallization. If leucine is present in very large quantity, it crystallizes if the concentrated urine be allowed to stand for a week or ten days.

162. Tyrosine crystallizes in long white needles, which are often aggregated to form brush-like masses, pl. XIV, fig. 96. It is hardly soluble in cold water, but is readily dissolved by alcohol, ether, boiling water, the mineral acids, and alkalies. Tyrosine is probably formed in the liver with leucine. It has been detected in the urine of persons suffering from typhus fever, by Frerichs and Städeler. It has been detected in many of the animal fluids. Tyrosine may be obtained from pancreas and albuminous matters by boiling with weak sulphuric acid or by boiling horn, feathers or hair, with sulphuric acid and water for forty hours. The dark brown liquid is to be made alkaline with milk of lime, warmed, and then filtered. Sulphuric acid is added to neutralization, and crystals of tyrosine are deposited upon evaporating the liquid.

A very delicate test for this substance has been proposed by Hoffman. A solution of nitrate of protoxide of mercury, nearly neutral, is to be added to the solution suspected to contain tyrosine. If this body be present, a reddish precipitate is produced, and the supernatant fluid is of a very dark rose colour. Frerichs' tests for tyrosine are as follows: The matter supposed to be tyrosine is mixed

with sulphuric acid in a small capsule. After the lapse of half an hour water is added. The solution is then boiled, and excess of carbonate of lime added. To the filtered solution a few drops of a solution of perchloride of iron which is free from acid is added. A dark purple colour is produced if tyrosine is present. In order to obtain tyrosine from urine it is necessary to add a solution of acetate of lead until a precipitate is no longer produced. Sulphuretted hydrogen is passed through the filtered liquid. The sulphuret of lead being separated by filtration, the clear solution may be concentrated by evaporation, when tyrosine, if present, will crystallize out. De la Rue found tyrosine in the cochineal insect. This is doubtless one of the substances resulting from the disintegration of albuminous substances. I have found it in considerable quantity in urine which contained much uric acid, and had been left to stand in a warm place for many weeks. Leucine and tyrosine were detected by Dr. G. Harley, in the urine of a dog four days after dog's bile had been injected under the skin.—(*On Jaundice*, p. 96.)

163. Fatty Matters.—Some fats crystallize in characteristic forms, from their ethereal or alcoholic solutions.

Margarine may be readily obtained from human fat; it is deposited from its alcoholic solution in round spherical masses which appear almost black by transmitted light, in consequence of being composed of dense aggregations of minute crystals, pl. XIV, fig. 97. Almost the whole of the oily fat remains in solution in the alcohol. Heintz has proved that margarine really consists of a mixture of palmitine with stearine.

Minute stellæ of this substance may be obtained from a concentrated alcoholic solution of human fat, and not unfrequently crystals separate spontaneously from the oily fat in which they have been previously dissolved. This crystallization may sometimes be seen in the contents of the fat vesicle of adipose tissue, particularly if putrefaction has commenced, and also in many mixed fatty matters which have been extracted from animal substances. It is remarkable that in certain cases colouring matters are taken up by the crystalline portion of the fat only. For example, in cases of cholera I found that the adipose tissue in the submucous areolar tissue of the small intestine exhibited dark reddish-brown stellæ upon the surface of the oily fat, producing a very beautiful appearance. The colour was derived from the altered and dissolved blood colouring matter, which had permeated the vessels and had been taken up in large proportion by the crystallizable fat of each vesicle.

The so-called margarine crystallizes from its solutions in tufts composed of somewhat wavy, minute, acicular crystals, or in separate,

Fig. 94.

Crystals of Leucine. *a*, crystallised from water; the remainder from an alcoholic solution. § 161.

Fig. 95.

Crystals of Leucine. § 161.

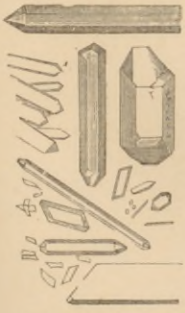
Fig. 96.

Tyrosine, crystallised from water. § 161.

Fig. 97.

Crystals of Margarine, after Robin and Verdeil. § 163

Fig. 98.



Crystals of Taurine.

Fig. 99.

Stearic acid. Robin and Verdeil

Fig. 100.

Margaric acid.

[To face page 132.

free, short crystals, which are usually somewhat curved. "Margaric" acid also crystallizes in minute tufts composed of very small and much-curved crystals.

Stearine may be obtained in large quantity from mutton fat; it is only slightly soluble in hot alcohol, from which solution it readily crystallizes in a form much resembling that of margarine, but the needle-like crystals are for the most part thinner, and their direction is straight. Stearine also very commonly crystallizes in quadrangular tablets.

In examining the crystals of these fatty matters, deposited from ethereal or alcoholic solutions, obtained by digesting the dried animal substances in alcohol or ether, a large number of oil-globules will also be observed. The characters of stearic acid under the microscope are shown in pl. XIV, fig. 99, and those of the so-called margaric acid in fig. 100. These figures were taken from the excellent atlas of plates by Robin and Verdeil, "Traité de Chimie Anatomique et Physiologique," a work that may be consulted with great advantage by all interested in the microscopical characters of the various crystalline substances met with in, or obtained from, the animal body.

These crystalline fatty matters are not unfrequently found in morbid growths, and very commonly in various fluids and solids of the body. In vomited matters, masses of crystalline fat are very often observed, and in vomit containing sarcinæ, stellar crystalline fatty masses are very frequently present.

164. Cholesterine is a non-saponifiable fat, and occurs in many situations in the human body. A small quantity of chloresterine is always present in bile, and the colourless gall-stones consist almost entirely of this substance. It may be extracted from many of the tissues in a state of health; I have even obtained it from the healthy crystalline lens of the eye. In diseases it often occurs in serous fluids, especially in the serum of ovarian and other serous cysts, and occasionally in the fluid of hydrocele. It is present in many tissues in a state of fatty degeneration, and may be even extracted from the epithelial cells of the air passages in bronchitis. I have obtained it also from the epithelium and oil globules in the casts of the uriniferous tubes in fatty degeneration of the kidney. It has been often stated that cholesterine is never present in the urine, but I believe it is to be invariably detected in cases where oil casts exist in sufficient quantity for analysis.

Cholesterine may always be recognized by its crystalline form, but the angles of the crystals vary considerably in different cases, pl. XV, fig. 101, and may usually be obtained by the slow evapora-

tion of alcoholic solutions; but where only mere traces of this substance are present, it is necessary to remove the other fatty matters before the cholesterine can be obtained in the crystalline state. By boiling with water and oxide of lead, the saponifiable fats form a plaster, and the cholesterine is dissolved by treating the latter with dilute alcohol, from which solution it may be obtained in a crystalline form by subsequent evaporation.

Cholesterine is coloured of a dark red colour by the action of sulphuric acid.

Seroline.—This is another non-saponifiable fat discovered by Boudet in serum, but differs from cholesterine in not forming distinct and well-defined crystals; it separates in large transparent flakes from alcoholic solutions, fig. 132.

165. Myelin is a colourless glistening semi-fluid substance prone to form drops, and capable of being drawn out into long threads which curve and twist into the most peculiar forms. If the observer examines a portion of the white matter of the brain or spinal cord in water, he will recognise this substance without difficulty. The masses often exhibit double contours, and not unfrequently many lines may be discerned equidistant from one another, but varying much in thickness and intensity, pl. XV, fig. 105*a*. It is present in the liver, and may be detected in almost all the tissues. In many tissues myelin forms in considerable quantity in the outer part of cells, fig. 104.

This substance was first described by Virchow, but Beneke has shown that it may be obtained from all the tissues of the body, and that it exists in plants. It is soluble in hot alcohol, ether, and turpentine. Cholesterine is a necessary constituent of myelin, and can always be obtained from it.

Iodine tinges myelin of a reddish brown colour. If sulphuric acid be added, a blue or violet colour is induced. This reaction probably depends upon the presence of cholesterine. Beneke showed that myelin gave the reaction characteristic of the biliary acids, upon the application of Pettenkofer's test.

Pettenkofer's Test for Biliary Acids. The following directions are given by Pettenkofer. Pour a portion of the suspected fluid into a test tube, and add English sulphuric acid, guttatim, to about $\frac{2}{3}$ the volume of the fluid, whereby the temperature is considerably raised. The addition must be made so gradually that the temperature shall at no time exceed 145° F., as otherwise the choleic acid is too much changed; then add 2 to 5 drops of ordinary cane sugar solution, containing 1 part of sugar to 4—5 parts of water, and shake the whole. If choleic acid be present, a more or less deep violet red

Fig. 101.

Cholesterine. *a*, from pneumonic lung *b*, from fluid round an hydatid cyst. *c* from the brain. × 215. § 164.

Fig. 102.

Serolin in flakes. After Robin and Verdeil. § 164.

Fig. 103.

Myelin from the brain. × 215. § 165.

Fig. 104.

Fig. 104A.

Epithelial cells. Air cell of lung. Cattle plague. Myelin particles in outer part. × 1800. § 165

Fig. 105.

Cerebral matter in water, showing double contours of myelin. × 215. § 165.

Fig. 105A.

Myelin particles from the external portion of cells in air-cells of the lungs × 2800. § 165.

Fig. 106.

Excretine crystallised from an alcoholic solution. × 215. § 166.

[To face page 121.

colour will be produced according to the amount of bile in solution.

Improved mode of applying Pettenkofer's test. Neukomm (über die Nachweisung der Gallen Säuren, &c., 1860), proposes the following modification. "A single drop of a $\frac{1}{20}$ per cent. solution of choleic or glycocholeic acid will yield a splendid purple violet colour if it is brought in contact with a drop of dilute sulphuric acid (4 parts of water to 1 part of sulphuric acid) and a trace of sugar solution, in a porcelain cup and then gently warmed over a spirit lamp. As one cubic centimeter equals about eight drops, it is thus possible to demonstrate $\frac{6}{100}$ milligr. of biliary acid with complete accuracy." As a further test he suggests, "the biliary acid or salt is to be sprinkled with a small quantity of concentrated sulphuric acid, moderately warmed, and then water added. The resinous flocculi that subside are to be separated from the acid, washed with water, but not so as to remove all the sulphuric acid, and then again gently heated in a porcelain cup till coloration ensues. If the residue be taken up in a small quantity of alcohol, and the green solution be evaporated, the interior of the cup will be coated with a deep indigo blue film even when but little acid has been used. If the biliary acids or the sulphuric acid should be impure, or the temperature raised too high, the pigment film will be green." See abstract of Beneke's Memoirs "On the Occurrence, Diffusion, and Action of the constituents of the bile in the animal and vegetable organism," by Dr. Duffin, "Archives of Medicine," vol. iv, p. 192, 1865.

166. Excretine.—This substance was discovered by Dr. Marcet a few years ago. It is only present in human fœces.—"Phil. Trans." 1857, page 403. "Archives of Medicine," No. II, April, 1858. In order to obtain it, the following process is employed. A quantity of excrement is introduced into a long-necked flask, and is exhausted with boiling alcohol ·850. The mixture is filtered, and the solution mixed with a little thick milk of lime, diluted with a quantity of water equal to that of the alcoholic solution. After standing for a few hours, a light precipitate will subside to the bottom of the vessel. This is separated by filtration, washed several times with water, and dried over the water-bath. The dry residue is placed in a flask, and alcohol added. Next a little ether is to be poured in, which much increases the solvent power of the alcohol for excretine. This operation is repeated three or four times, the alcohol and ether being allowed to remain on the residue three or four hours before being poured off. The filtered alcoholic solutions are to be evaporated in as cold a place as possible; and after the lapse of a day or two, crystals of excretine will make their appearance. They are to be

separated, and the mother-liquor allowed to remain, that another crop of crystals may form. The impure excretine is to be dissolved in hot alcohol, agitated with animal charcoal, and re-crystallized. This substance is not easily crystallized, unless its alcoholic solution be allowed to evaporate slowly in a cold place. Frequently nothing more than a few non-crystalline globules are obtained, but this will crystallize if re-dissolved in alcohol and exposed to the cold.

Dr. Marcet has ascertained the composition of excretine to be as follows :

Carbon	80·427
Hydrogen	13·515
Oxygen	3·278
Sulphur	2·780

Its atomic weight is 578, assuming that an equivalent contains one equivalent of sulphur.

167. Crystallizable Substances from the Blood.—The beautiful compound known as *hæmato-globulin*, *hæmato-crystallin* is held in solution in the red blood-corpuscles of man and animals. It was first examined by Funke, and afterwards by Kunde.* The subject has lately been very carefully investigated by Lehmann.† In the "Medical Times and Gazette" for 1852, will be found a very interesting paper on the subject by Dr. Parkes.‡ The most important crystals are figured in pl. XVI.

The crystals of hæmato-crystallin are very readily obtained by diluting blood with some fluid. A drop of blood may be placed upon a glass slide, and after the addition of a drop of water, alcohol, or ether, the whole should be lightly covered with thin glass. A hair, or a small piece of thin paper or wood, may be placed between the glasses, in order that a stratum of fluid of sufficient thickness may be retained. It is preferable to use defibrinated blood. Often the corpuscles and a little serum may be removed from the clot by firm pressure, and from this, very perfect crystals may frequently be obtained. The blood-corpuscles do not become ruptured by endosmosis, their contents being set free and undergoing crystallization as the solution gradually becomes concen-

* Dissert. inaug. Lips. 1851 (O. Funke). Zeitschrift f. rat. Med. N. F. Bd. I, II. See also Funke's "Atlas of Plates," translated by the Cavendish Society, 1853.

† "Lehrbuch d. Physiolog. Chemie," vol. i, second edition, 1853. Bei. d. k. Sächs. Gesel. d. Wiss., 1852—1853.

‡ See also a paper on "Albuminous Crystallization," by Dr. Sieveking, in the "British and Foreign Medico-Chirurgical Review," for October, 1853, in which some excellent woodcuts of blood-crystals are given.

trated by spontaneous evaporation which goes on at the edges, as has been very generally stated, but the soft semi-fluid matter of which the entire red blood corpuscle is composed, passes from its plastic to its crystalline condition. Although under many circumstances the outer part of the corpuscle may become hardened so as to give rise to a firm envelope, this is not necessary, and there is no true cell wall developed upon the surface of the red blood corpuscle. See chapter V. The time which elapses before crystallization takes place, varies from an hour to several hours, or days, in different specimens of blood. The blood corpuscles of the Guinea-pig are most favourable for experiment, as the matter of which they are composed crystallizes very readily. Crystals may also be obtained from the coagulum of blood.

The form of the crystal often varies slightly in the same specimen, but the blood of different animals yields crystals of very different forms. The prismatic form is that most commonly obtained from the blood of man, the carnivora, and fishes. Tetrahedral crystals are met with in some of the rodentia, as the Guinea-pig, pl. XVI, fig. 107, while six-sided tables are formed in the blood of the squirrel, mouse, and some others, fig. 112. By the kindness of Professor Lehmann, I have had an opportunity of seeing some beautiful rhomboidal crystals which he obtained from the blood of the hamster (another of the rodentia). Blood crystals form more readily in daylight than in the dark, but most rapidly when the slide is exposed to the light of the sun. I have never succeeded in obtaining crystals of the blood of the ox or sheep. From pig's blood crystals were obtained with some difficulty, after passing oxygen and carbonic acid through the fluid and diluting it with alcohol and water. The crystals from pig's blood are in the form of prisms and acicular crystals. Frog's blood cannot be made to crystallize, in consequemce probably of the density of the material of which it consists; but Professor Lehmann tells me he has obtained crystals readily from the blood of the Italian lizard. Teichmann has however succeeded in obtaining crystals from frog's blood, by the addition of a very large quantity of water at a very low temperature. Zeitschrift für rat. Med. N. F. Band III, Heft 3.—"British and Foreign Medico-Chirurgical Review," April, 1854.

Guinea-pig's blood crystallizes in the course of half an hour, or even sooner, if it be diluted with a little water or alcohol. I have often obtained crystals from Guinea-pig's blood without the addition of any fluid, and without any evaporation whatever. One blood corpuscle becomes a single crystal, and if the slide on which the drop of blood is placed and covered with thin glass be gently warmed, the

corpuscles break up, and each little fragment assumes the crystalline form, and becomes a minute but perfectly formed tetrahedral crystal, Chap. V. Dog's blood also crystallizes in the course of a short time upon the addition of a little alcohol. Human blood crystallizes after the addition of water, slowly, if only just removed from the body, but more rapidly if the blood be not quite fresh. The crystals shown in pl. XVI, figs. 108, 110, were obtained by diluting a drop of fresh blood from the finger, with a drop of distilled water; and after covering the mixture with thin glass, the slide was placed in a light place. Crystallization commenced about forty hours after the addition of water to this specimen of blood.

Lehmann has discovered a process by which large quantities of blood crystals may be prepared. This consists in passing ogygen and carbonic acid through the blood which has been diluted with much water. The blood which answers best, is that of the dog and Guinea-pig, but as far as I know, no one has obtained crystals from the blood of the ox or sheep. This depends probably upon the material of the blood corpuscles being less readily dissolved than that of most animals. The following plan yielded an abundant quantity of crystals from the blood of the dog and Guinea-pig. The defibrinated blood was diluted with half its volume, or with an equal volume of water. Sometimes it was necessary in the case of dog's blood, to add a little alcohol or ether until rupture of the corpuscles had taken place, which can always be ascertained by microscopical examination. Through the solution, oxygen was passed for a quarter or half an hour, and then carbonic acid was transmitted through the same fluid during half the time that the oxygen had been passed. In the course of an hour, or longer, an abundant precipitate, consisting entirely of blood crystals, was produced. This was separated by filtration, and dried. If the crystals are required quite pure, they must be re-dissolved in water until the mixture has a specific gravity of between 1004 and 1002, and then alcohol must be added until the specific gravity is reduced to ·970. Crystals will be deposited in a few hours. It is often exceedingly difficult to obtain pure crystals after resolution in water. Dr. Teichmann pursues rather a different plan for obtaining blood crystals to those just referred to. After separating the serum and fibrin as far as possible, the blood is diluted with four or five times its bulk of water. The fluid is precipitated with sulphate of copper. The precipitate is washed and pressed well, but not dried. It is extracted with alcohol containing about one part of concentrated sulphuric acid, to three hundred parts of alcohol.*

* Henle and Pfeuffer's "Zeitchrift," vol. viii, page 141.

BLOOD CRYSTALS.

Fig. 107.

Blood crystals. Guinea-pig. × 215. p. 128.

Fig. 108.

Human blood crystals. × 215. p. 128.

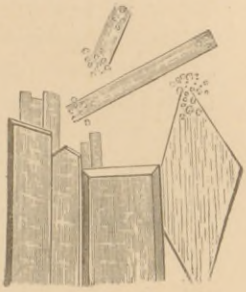
Fig. 109.

Crystals of hæmatoidin from human liver × 215 p. 129.

Fig. 110.

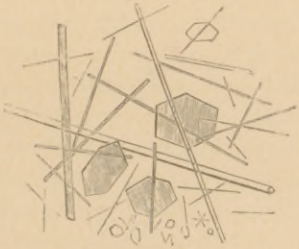
Blood crystals. Human. × 215. p. 128.

Fig. 111.



Blood crystals. Cat. × 215.

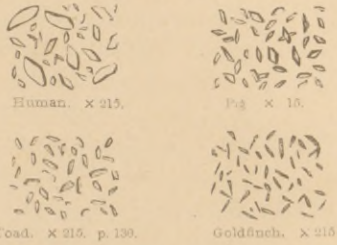
Fig. 112.



Blood crystals. Mouse.

Fig. 113.

HÆMIN CRYSTALS.



Human. × 215.

Pig × 15.

Toad. × 215. p. 130.

Goldfinch. × 215

Fig. 114.

Feathery crystals of hæmatoidin, found in the urine a fortnight after slight rupture (?) of one kidney. Human subject. × 215. p. 129

Fig. 115.

Rhombicdal and feathery crystals of hæmatoidin, from a softened clot. Human. × 215. p. 130.

$\frac{1}{1000}$ of an Inch ____ × 215.

It is excessively difficult to preserve specimens of these blood crystals as permanent objects. I have succeeded, however, in keeping some human blood crystals mounted in the dry way ; some from dog's blood have been mounted in Canada balsam, while the beautiful octohedral crystals from Guinea-pig's blood have kept pretty well in the fluid to which spirit had been added, although they soon exhibited a tendency to change colour. In glycerine, crystals from Guinea-pig's blood have been preserved for many years. Crystals of hæmatoidin may, however, be preserved in glycerine or in Canada balsam.

Hæmatoidin is a modified form of hæmatin. It is not easily decomposed, is insoluble in water, alcohol, ether, and acetic acid, but readily soluble in alkalies. This is the substance which is found in old clots and extravasations, and not unfrequently in the walls of some of the smaller vessels, perhaps marking the situation of old hæmorrhages. It crystallises in very beautifully defined rhombic crystals, pl. XVI., fig. 109. It also forms long filaments, and not unfrequently slightly curved elongated crystals, collected into bundles, which sometimes take the form of oval and dumb-bell shaped masses, pl. XV, fig. 114. This substance seems closely allied to a yellow crystalline material obtained from the bile. It would indeed be very difficult to distinguish hæmatoidin crystals found in clots from some crystals which have been produced in biliary matters. Hæmatoidin may therefore be the same substance as that obtained from bile under the names cholepyrrhin, biliphæin, bilifulvin, and more recently, bilirubin. Zenker and Funke have shown that from the yellow crystals of bilifulvin, red crystals of hæmatoidin may be obtained.

Hæmatin may be obtained from hæmato-crystallin. It occurs in old extravasations of blood, and may be detected in the fœces. It is not crystalline, and when dried it forms a brown powder containing nearly 9 per cent of iron. A thin layer of a solution of hæmatin appears of a greenish colour, while a thick one is dark red. Hoppe Seyler names a substance closely allied to hæmatin, methämoglobulin. This may be a mixture of hæmatin and some albuminous substance.*

The influence exerted by the blood colouring matters upon the

* The following references to papers on blood crystallization will be useful to those who wish to perform original investigations :—

Nasse in "Müller's Archiv.," 1841, page 439. Kölliker in "Zeitschr. f. Wiss. Zool.," 1849, i, page 260. Reichert in "Müller's Archiv.," 1849, page 97. Remak in "Müller's Archiv.," 1851, page 481. Funke "Zeitchr. f. rat. Med. N.F.," i, pages 184, 192 ; ii, pages 192, 288. Kunde "Zeitschrift, f. rat. Med. N.F.," ii, page 271. Lehmann in "Ber. der k. Sächs. Ges. d. Wiss. zu Leipzig," 1852, pages 23, 78 ; 1853, page 102. Robin and Verdeil, "Traité de Chimie Anatomique et Physiologique," ii, page 335. Teichmann, in "Zeitschr. f. rat. Med. N.F.," iii, p. 375, viii, page 141.

solar spectrum, and the application of spectrum analysis to the detection of blood will be referred to in § 173, p. 138.

Hæmin. Dr. Teichmann also obtains beautiful crystals of a dark red colour, by treating the clot of blood, moist or dry, with glacial acetic acid. He tells me that the crystals of hæmin thus obtained have the same form in all animals, while the crystals just described differ much in form and colour in different animals. Blood that has been kept for some time yields these crystals as well as fresh blood. Crystals of hæmin obtained from the blood of the human subject, pig, toad, and goldfinch are represented in pl. XVI, fig. 113.

168. Crystallization of Bile.—The glycocholates of potash and soda were first obtained in a crystalline form by Platner. The crystallizable substance of the bile may readily be obtained as follows :— Perfectly fresh ox-bile is rapidly evaporated to dryness over the water-bath, and the dry residue powdered and extracted with absolute alcohol; the dark green alcoholic solution is quickly filtered into a small flask or bottle, and then ether is gradually added until the white precipitate at first formed ceases to be re-dissolved upon agitation. Care should be taken to add the ether very gradually, for otherwise a bulky amorphous precipitate occurs, which does not become crystalline. The bottle is to be lightly corked, and allowed to stand in a still place. After a few days, stellar masses of beautiful and almost colourless crystals appear; these increase until tufts of a considerable size are produced. The crystals may be subjected to microscopical examination, immersed in a drop of the solution in which they were produced, and are beautiful objects; or they may be carefully washed with alcohol, to which a tenth of its bulk of ether has been added, and rapidly dried in vacuo. Crystallized bile is represesented in pl. XVII, fig. 116. An excellent paper "On the Constitution and Physiology of the Bile," by Dr. Jno. C. Dalton, junr., will be found in the American "Journal of the Medical Sciences," for October, 1857.

When dried, the crystals may be mounted in a cell from which the air is completely excluded. If exposed to the air while moist, they rapidly deliquesce. I have preserved some of these crystals, in the solution in which they were formed, in a thin glass cell for some months. Ox-bile and pig's-bile may be crystallized, but no one has yet succeeded in obtaining any crystals from human-bile. Sometimes considerable difficulty is experienced in causing bile to crystallize, and often repeated trials must be made with perfectly pure alcohol and ether, before a satisfactory result is obtained.

Crystals of glycocholic acid, of taurocholate of soda and of cholic acid are represented in pl. XVII, figs. 117, 118, 119.

169. Of Detecting Ammonia in the Breath.—Ammonia was first detected in the expired air by the Rev. J. B. Reade, about fifteen years ago, and Dr. Reuling has obtained evidence of the presence of a large quantity in typhus fever, pyemia, and poisoning by urea. In the latter condition it has been detected in the breath, and also in the blood, by Dr. Frerichs, who attributed the coma to the ammonia in the blood, instead of to the accumulation of urea as had been supposed by previous observers. This subject, however, has been recently investigated by Dr. Richardson. His researches gained the Astley Cooper prize for 1856.*

Dr. Reuling proposed to test the expired air for ammonia by hæmatoxylin, which forms with this substance a rose-red colour; but the best plan is the one originally employed by the Rev. Dr. Reade and recommended by Dr. Richardson. An ordinary miscroscopic glass slide is moistened on one side with hydrochloric acid and breathed upon. The ammonia combines with the acid, and a chloride of ammonium is formed which crystallizes in crosslets and dendriform masses. Dr. Richardson recommends the following modification of this process:—An instrument of the form of a straight breast-pump is employed to breathe through; a drop or two of hydrochloric acid is placed in the bulb, and a perfectly clean slip of microscope glass placed across the trumpet-extremity of the tube, and secured by an India-rubber band. The alkali as it passes over the bulb, combines with the acid, but some of the acid and alkaline vapours pass over together and condense on the microscope glass. As this becomes dry, crystals are formed. A very considerable excess of ammonia may be detected in the breath in typhus fever and many other low conditions of the system, but even in health traces are always to be found. Dr. Richardson found but one exception to this, in the case of a gentleman who lived entirely on vegetable food. Ammonia is more abundant in the breath of healthy persons after fatigue, than in the morning after sleep; and in hot weather a much larger proportion is expired than in cold weather.

170. Of Detecting Insoluble living or lifeless Particles in the Breath.—It is very easy to collect solid particles from the breath. By causing each successive expiration to come into contact, during a minute or two, with the surface of a piece of clean glass, the object in view may be attained, but by breathing through a glass chamber kept cool by the application of ice externally, a greater number of insoluble particles may be collected in the condensed moisture. The observer will be surprised at the number and size of the particles

* "The Cause of the Coagulation of the Blood," by B. W. Richardson, M.D. Churchill, 1858.

which are suspended in the expired air; oil globules, epithelial cells, and portions of mucus corpuscles (?) may sometimes be detected.

In examining the breath of cows, I was surprised to find large fragments of the food, starch corpuscles, several different kinds of very dark irregular insoluble particles somewhat resembling those of soot suspended in the air of London rooms, three or more different kinds of fungi sporules, bacteria, fragments of epithelium, and a number of bodies I was unable to identify. These all collected upon a clean plate of glass moistened with pure glycerine which was held for a few minutes in the current of the animal's breath.

Another method of obtaining insoluble organic and inorganic particles suspended in the breath, is to place some perfectly clean cotton wool in a glass tube which is so connected with a mouth piece, that the expired air must pass through. Any solid particles are obstructed by the wool. The air is, as it were, filtered by this process. The wool may be examined dry or after having been moistened with a little weak glycerine. This plan was very successfully employed by Mr. Crookes in his experiments upon Cattle Plague. He found that the poison or virus suspended in the breath of a diseased animal was obstructed by the cotton wool, a fact which was demonstrated by inoculating a sound animal with the wool which had been thus exposed. The animal received the disease. Mr. Crookes has sent me portions of wool for examination, and upon carefully comparing the exposed wool with some of the same wool which had not been so exposed, differences were observed under the highest magnifying powers. Minute particles were detected in the former which could not be found in the latter. I think it very likely that if such experiments were conducted with extreme care, some most valuable facts might be discovered concerning contagious diseases, and I have no doubt that ere long we shall be able to catch and preserve the living particles of *contagium* on their way from the infected to the sound organism. Gun cotton has been recommended, and it has been suggested that after exposure it might be dissolved in ether, and thus the particles obtained perfectly free. The great difficulty in all such experiments is to obtain the particles for experiment sufficiently clean and perfectly free from foreign particles. Still there is no doubt that if this matter be carefully studied, many new and valuable methods of investigation will soon be discovered and highly important facts bearing upon that most interesting question the nature of contagion, demonstrated.

171. Of Detecting Insoluble living or lifeless Particles in the Atmosphere.—The various particles suspended in the atmosphere of a room or ward of a hospital, may be very easily obtained for microsco-

Fig. 116.

Crystallised bile. The small crystals in the lower corner on the left are drawn as they appeared to the unaided eye. p. 130.

Fig. 117.

Glycocholic acid, prepared by decomposing glycocholate of lead with sulphuretted hydrogen.

Fig. 118.

Taurocholate of soda, prepared in my laboratory by Dr. Von Bose.

Fig. 119.

Cholic acid, prepared in my laboratory.

Fig. 120.

Glycocholate of soda, prepared in my laboratory.

Fig. 120*.

Crystals of chloride of ammonium, obtained by breathing for several minutes upon a glass slide, moistened with hydrochloric acid. p. 131.

1000th of an inch ⌊⌋ × 130.
" " ⌊⌋ × 215.

[To face page 132.

pical examination. The "dust" which has accumulated upon any shelf, will supply the observer with a great variety of highly interesting and important objects. The dust usually contains particles of carbon, starch granules, scales of moths, fibres of wood, fragments of cotton, flax, wool, hair, and feathers, sporules of fungi of various kinds, epithelium from the skin, and many other bodies. The particles may be collected at any time by exposing a shallow dish containing distilled water, to the atmosphere which it is desired to submit to examination. But the most effectual method is to place some ice in a perfectly clean glass vessel, and allow the moisture of the air to condense upon the outer surface. The drops of water should be collected in a suitable vessel placed beneath. The condensed fluid will of course contain any insoluble particles which were suspended in the air. The water is placed in a perfectly clean conical glass, to the lower part of which the insoluble particles held in suspension will gradually subside. They may then be removed with the aid of a pipette, placed upon a glass slide, and submitted to microscopical examination under the highest powers.

Another plan is to draw air through a tube, the interior of which may be moistened with a little perfectly pure glycerine, or to cause the air to impinge upon the surface of a moist glass slide. The necessary current of air is easily produced by connecting a glass tube with a reservoir of water, so arranged that when the water is allowed to flow out, air from the apartment must be gradually drawn through the tube. Many modifications of this arrangement will occur to the mind of the observer. He may put in force the plan which seems to him best adapted for the particular investigation he is about to undertake.

Air containing living particles may be collected in closed vessels, and if retained for a short time the living particles sometimes grow and multiply. Pasteur has proved some highly important facts with reference to the nature and kind of living particles present by obtaining air from different heights and from different localities. The living particles though too minute or too few in number to be detected, may be caused to germinate. Different kinds, and the same kind in very varying numbers, are obtained at different heights and under varying conditions.

Bibulous paper, or perfectly clean glass plates moistened with glycerine, may be suspended in the air of an apartment to catch the solid particles suspended in it. By proceeding in this way, however, the observer is overwhelmed with the vast number of the particles he obtains, and as may be supposed it is extremely difficult to identify bodies, which although very similar in appearance, may be essentially different in their nature. Minute living particles of pus or other germinal

matter in a state of active vitality, although capable of giving rise to the most terrible and fatal diseases if they obtained entrance into the living organism, would be very readily passed over, or being obscured by the mass of foreign matter present, could not be seen. It is said that Dundas Thompson detected such particles in cholera wards, so long ago as 1849 and 1854, and Eiselt subsequently discovered pus in the atmosphere of an ophthalmic ward.

My own researches have demonstrated how pus corpuscles and other masses of germinal matter divide and subdivide, giving off minute off-sets which detach themselves, and might be readily supported by the atmosphere. I have also shown that in contagious diseases, besides the particles of altered epithelium, pus, and allied forms of germinal matter, are other living particles exceedingly minute, which perhaps alone possess contagious properties. These would very easily pass from one organism to another. (See my report to the Cattle Plague Commissioners, 1866).

This is a branch of advanced and extremely delicate microscopical enquiry, which we have as yet scarcely entered upon. Though surrounded with very great difficulties, the investigation will probably yield the most remarkable and important results, and it is most desirable that it should be pursued by many different observers. It must be borne in mind that the very high powers recently made by Messrs. Powell and Lealand are likely to be extremely useful in examining living bodies suspended in the atmosphere, and there is even reason to think that we may be able to discover characters in some of these bodies by which they may be recognised again.

Spectrum Microscopic Analysis.

Of all methods for detecting certain chemical substances, in a solid, liquid or gaseous state, that by the aid of the spectroscope is the most delicate. Sir David Brewster claims to have been the first to have employed spectrum analysis, but the process was first brought to perfection by Bunsen and Kirchoff, whose wonderful discoveries have really laid open an entirely new field of research. Improvements in the method of observation have since been made by a great number of observers, and the spectroscope is now an exceedingly valuable instrument for chemical research.

This mode of analysis has been recently applied to the microscope. Already many important steps have been gained, and it is probable that much will be discovered by this new method of enquiry. The chief value of the spectrum-microscope is that it enables us to determine with ease and certainty the nature of many

substances present in such minute quantities and under such conditions that they could not be recognised by the ordinary methods of analysis.

172. Spectrum Microscope.—The spectroscope was first adapted to the microscope by Mr. Sorby ("Quarterly Journal of Science," 1865), who employed for obtaining the spectrum a simple triangular prism placed below the achromatic condenser. This plan was, however, afterwards much improved by Mr. Sorby and Mr. Browning, and the prism was placed *above the upper glass of the eye-piece.* The structure of the prism itself will be understood by reference to pl. XVIII, fig. 121. It consists of "two rectangular prisms of flint glass, between which is a rectangular prism of crown glass, and at each end another prism of crown with an angle of about 75°." These are all connected together with Canada balsam. The compound prism thus prepared is placed between two pieces of blackened cork, and inserted into a tube having a cap with an elongated opening at *a*, and a circular stop at *b*. The lower part of the tube fits on to the eye-piece as shown in the fig. 121. The beam of light admitted must be narrow, or the dark lines produced will not be distinct. It is desirable that there should be means for reducing or increasing the width of the narrow slit, and this is effected in Mr. Sorby's instrument by the aid of a screw. The arrangement will be understood by reference to fig. 122. The screw by which the slit may be altered in breadth is marked by *a* * in figs. 121 and 122. The upper lens of the eye-piece should be achromatic, and Mr. Sorby and Mr. Browning have arranged a special eye-piece for spectrum observations, the general structure of which will be understood by reference to the figure.

In using this spectrum eye-piece, the object to be examined should be selected with the ordinary eye-piece of the microscope, which should then be removed and the other placed in its stead, but, as Mr. Sorby has remarked, it is practically more convenient to use a *binocular*, as the spectrum eye-piece can be adapted to one tube, while the other is provided with the ordinary eye-piece; by the latter, the object can be carefully selected and immediately afterwards examined by the former, without its position being disturbed.

In order that the whole spectrum should be in focus at the same time, Mr. Sorby has had the upper lens (eye-glass) of the eye-piece rendered achromatic; and for the convenience of comparing two spectra side by side, he has adapted to the side of his special eye-piece a stage with a prism so arranged, as to reflect the rays towards the eye-piece. The achromatic lens is represented at *c*, fig. 121, the slit is seen at *d*; *e* is a right angled prism which extends half over the slit, and the light transmitted through this from the side stage *f*, passes through the slit a little on one side of the centre, while the light

which comes through the body of the microscope, passes through the slit a little on the other side of the median line, as shown by the lines *g h*. When the analysing prism, *i*, is placed over the eye-piece, two spectra will therefore be seen, which are situated close together, and can be easily compared. The two spectra may readily be made of equal brightness by regulating the width of the opening in the stage attached to the eye-piece.

173. Of Examining Substances by the Spectrum Microscope, and of the "Absorption Bands" seen.—There are many substances which although transparent, completely obstruct the rays passing through certain parts of the spectrum, thus producing dark lines technically called "absorption bands." Different substances give rise to "bands" in different parts of the spectrum; sometimes a portion of the red light is cut off, sometimes a portion of the green, and so on. The bands are sometimes very numerous. In some cases they are broad and comparatively faint, and in others they are very narrow, sharp, and well defined. The number and position of these bands may be very different, even though the general colour of the substance may be nearly the same, and thus we are enabled to distinguish them from one another.

Crystals.—By the aid of the spectrum-microscope, we may examine extremely minute crystals, or very minute quantities of various substances dissolved in fluids. When crystals are to be examined, Mr. Sorby recommends that they should be ground on moderately soft *Water-of-Ayr* stone, with a very little water. They may then be polished with a little jeweller's rouge spread upon paper laid over a flat surface. Scratches on the surfaces of a crystal may often be removed by rubbing it upon moist blotting paper. Many crystals may be mounted in Canada balsam in the usual manner.

Blowpipe Beads.—The spectrum microscope may also be employed for examining substances entering into the composition of fluxes, glass, &c. Mr. Sorby recommends that pieces of coloured pot mettle glass of a wedge shape, should be prepared so that the spectra of different thicknesses of known material may be compared with those of blowpipe beads coloured with an unknown substance.

Examinations of Solutions by the Spectrum-Microscope.—Solutions may be examined in little-wedge shaped cells of the form represented in pl. XVIII, fig. 127. The cell may be about a quarter of an inch in depth at its deepest part, gradually diminishing to about one-fortieth. By the aid of a cell of this kind we can easily ascertain the thickness of fluid which will give the best results. Such a cell with fluid can be placed on the stage of the spectroscope, and its spectrum compared with that produced by the object examined in the microscope.

Mr. Sorby tells me that he now keeps his solutions in tubes of the shape and twice the size represented in pl. XVIII, fig. 126, sealed hermetically, a bubble of air being left to allow for expansion. He makes most of his experiments in cells made from barometer tubes, having an internal diameter of $\frac{1}{8}$ or $\frac{1}{6}$ of an inch, and external diameter somewhat under $\frac{1}{4}$ inch. These are cut square and ground flat at both ends, and made about $\frac{1}{2}$ inch long. They are fixed on glass with Canada balsam. When filled with the liquid, the upper surface is quite level enough to enable us to examine it at once. In some cases, Mr. Sorby lays a bit of thin glass over the top, especially if he is working with alcoholic solutions or with reagents which easily oxidize. This form of cell is represented in pl. XVIII, fig. 123, half the real size. The great advantage of such cells is, that so small a quantity of material is enough, and the surface remains sufficiently level even when the microscope is included. The wedge-shaped cells are more suited to place on the side stage attached to the eye-piece.

The spectra are of course modified by the presence of various foreign substances, and the substances examined should therefore be as pure as possible; but one great value of this method of investigation is, that many substances may be recognized with certainty, although their general colour is completely altered by coloured impurities.

Mr. Sorby recommends the pale blue solution of chloride of cobalt in a concentrated solution of chloride of calcium as the best test object for the spectrum-microscope. If two lines are seen in the orange, the definition must be very satisfactory. A very weak solution of blood is also a good test, but not for accurate definition or for local adjustment. A solution of permanganate of potash, so dilute as to be of a pale pink colour, gives fine well-marked absorption bands. $\frac{1}{100}$ of a grain of blood in a cell $\frac{1}{10}$ of an inch in diameter, and $\frac{1}{2}$ an inch long, gives a spectrum as well marked as is possible (two absorption bands in the green)—more would cut off the whole of the green, and render the bands invisible.

Hoppe was the first to demonstrate the peculiar absorption bands in very dilute solutions of blood, and to show that the same bands were produced in the blood of different animals. Stokes (Proceed. Royal Soc., 1864, vol. xiii, p. 355), proved that the colouring matter of the blood was capable of existing in two states of oxidation, and that a different spectrum was produced according as the substance called by him *cruorine* was in its more or less oxidised condition. By protosulphate of iron, or protochloride of tin, the colouring matter is reduced to its slightly oxidised state. The deoxidising solution may be made by adding to a solution of protosulphate of iron, enough tartaric acid to prevent precipitation by alkalies. A small

quantity of this solution made slightly alkaline by ammonia or carbonate of soda, is to be added to a weak solution of blood in water. By exposure to air, oxygen is reabsorbed, and the cruorine solution now exhibits the spectrum characteristic of its highly oxidised state. See fig. 124, pl. XVIII, A B. In venous blood part of the cruorine exists in its purple or less oxidised condition, and this in passing through the lungs becomes reoxidised and converted into scarlet cruorine.

An ammoniacal solution of cochineal gives two absorption bands, very like those produced by blood, but they differ in relation, size and position, as may be easily proved if this and the blood spectrum be compared side by side, and these two substances can be most easily distinguished by the totally different spectra obtained by adding various other reagents.

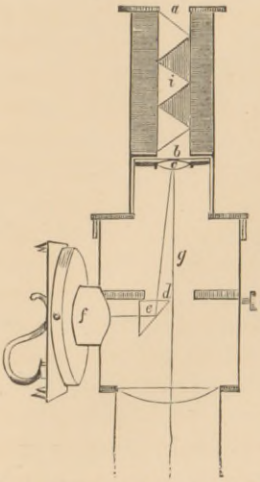
By varying the width of the slit, it is easy to modify the spectrum in such a manner as to see the absorption bands to the greatest advantage, but there are limits beyond which this should not be done; and we must then alter the thickness of the object, or the strength of the solution, if it is dissolved.

Mr. Sorby has not yet much studied animal colouring matters, but he tells me that he has been recently examining vegetable colouring matters. He has demonstrated the highly interesting fact that in the case of flowers of as nearly as possible the same tints but belonging to different plants, the colouring principle is very different, and each easily distinguishable by its spectrum.

174. Removing Stains from the Hands.—To many observers it is at least convenient that stains upon the fingers which can hardly be avoided in microscopical enquiries, should be removed, and a few directions are therefore given under this head.

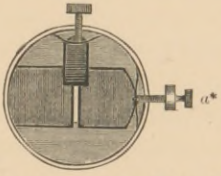
Brunswick Black may be removed by washing the skin with a little turpentine, or by rubbing on lard or oil, which may afterwards be washed off with soap and water. *Marine Glue* may be peeled off, or it can be dissolved off with a litttle naphtha or ether. *Chromate of Lead.* This substance stains the fingers of a very deep yellow colour, not to be removed by ordinary washing. A little hydrochloric acid at once dissolves the yellow precipitate. The hands should be plunged into water as soon as the stains have disappeared. The *Prussian Blue Fluid* can be removed by soap and water alone, or by rubbing on a little dilute potash first. *Carmine* stains can be obliterated by the application of ammonia or dilute hydrochloric acid. *Sealing Wax Varnish* and other varnishes soluble in spirits of wine, can of course be dissolved in this substance. The *Lime and India-Rubber Cement* can be removed by lard or oil, and subsequent washing; and *Canada Balsam* by turpentine or ether.

Fig. 121.



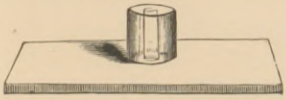
Mr. Sorby's spectrum eye-piece for the microscope, with arrangement for producing two spectra for comparison. § 172.

Fig. 122.



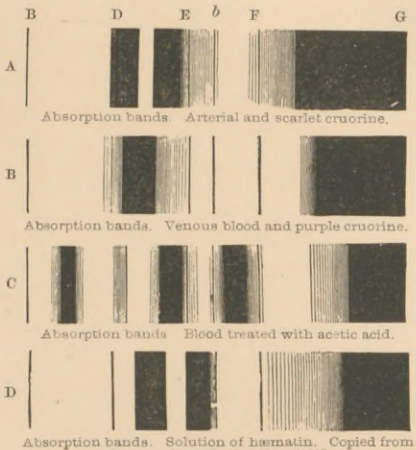
Arrangement for altering the length and breadth of the spectrum. § 172

Fig. 123.



Cell for examining solutions by the spectrum-microscope. Half the real size. § 173.

Fig. 124.



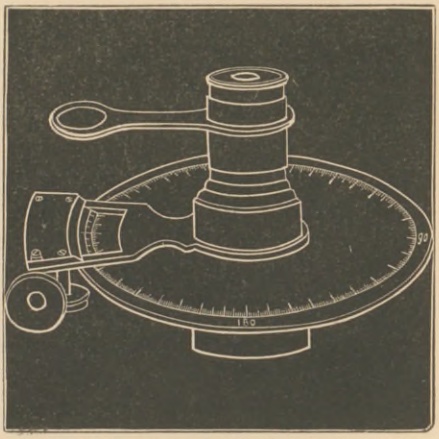
Absorption bands. Arterial and scarlet cruorine.

Absorption bands. Venous blood and purple cruorine.

Absorption bands. Blood treated with acetic acid.

Absorption bands. Solution of hæmatin. Copied from Stokes. Proc. R. S., 1864. § 173.

Fig. 125.



Goniometer for measuring the angles of crystals under the microscope. § 153.

Fig. 126.

Glass tube for containing solutions for examination under the spectrum microscope. Half the real size. § 173.

Fig. 127.

Wedge-shaped cell, for examining solutions in the spectrum microscope. § 173.

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PART II.

THE MICROSCOPICAL CHARACTERS OF STRUCTURAL ELEMENTS, OF LIVING CELLS, OF THE DEPOSITS FROM FLUIDS IN HEALTH AND DISEASE, AND OF ANIMAL AND VEGETABLE PARASITES.

CHAPTER IV.

Of the simplest Structural Elements met with in Health and Disease.—Granules, Globules, Cells, and Fibres.—Corpora Amylacea.—Cells.—Elementary Constituents of Cells.—Of the Nature and Structure of Cells.—False Cells.—Of Different Forms of Cells.—Epithelium.—Demonstration of Cell Structures.—Of the Use of Carmine in Demonstrating the Germinal or Living Matter of Cells.—Fibres.—Membrane.—Tubes, and Gland Follicles composed of Basement Membrane.—Capillaries.

I PROPOSE to devote the present chapter to the consideration of certain elementary bodies met with in the organism in health and disease. As various appearances under the microscope have received distinct names, it is absolutely necessary that every one using the instrument should be familiar with the terms employed to describe what is observed. No term should be used which has not had a very distinct and definite meaning assigned to it; and should any doubt exist in the mind of the observer with reference to the exact meaning of any word he employs, it is desirable that he should describe in detail what he understands by it. Considerable difficulty is always experienced by learners in consequence of different writers having employed the same term in a different sense, and much confusion and difference of opinion have arisen in consequence of the appropriate terms not having been selected with sufficient care. It is hoped that the reader will not too hastily glance over the next few pages, as an attempt has been made to affix a definite meaning to many words which are frequently used in this work.

Of the simplest Structural Elements met with in Health and Disease.

In various fluids and tissues in the healthy organism, we meet with *granules*, *globules*, "*cells*," and *fibres*, and in most of the solid organs we may distinguish *fibres* and *membranes*. Many tissues which in health are distinguished for their glass-like transparency, in disease often become more or less opaque. This diminished transparency may depend upon the formation or deposition of *granules*, *globules*, *cells*, or *fibres*. It may be so great as to obscure completely the natural structure of the tissue or elements suspended in a fluid, even although a very thin section or stratum be submitted to examination, or the alteration may only render the specimen confused and indistinct. In such cases it is often desirable to make the substance more transparent, which may be effected in two ways :—1. By immersing it in a fluid which refracts the light highly. 2. By the addition of some chemical reagent which dissolves or greatly alters the material which gives rise to the opacity.

The use of highly refracting fluids in microscopical investigation has been already referred to in §§ 74, 101, and the influence of chemical reagents has been discussed in §§ 142 to 147.

Granules, *Globules*, *Cells*, *Fibres*, and *Membranes* may be met with in the interstices of any texture, or may be suspended in a fluid. It is, therefore, very important to define the meaning of these terms, and they should never be employed in the description of morbid changes, unless the observer is quite satisfied that he is using the words in the proper sense. Should he feel doubtful if a character of the object is properly described by the word he uses, a note of interrogation should be placed after it, or the sense in which he uses the word or phrase should be fully explained in a note.

175. Granules are minute bodies of no determinate shape or size, and appear as separate dots or points when examined by the highest powers of the microscope. They cannot be measured. When *granules* are deposited in a tissue, it may be said to have a "granular appearance." When suspended in fluid, these minute particles of matter exhibit peculiar movements, dependent either upon the gradual evaporation of fluid at the edges of the glass with which they are covered, upon the existence of the force of gravity acting between the individual particles themselves, upon communicated vibrations, or upon electrical disturbance. This movement occurs alike in parti-

cles of organic and inorganic matter. It was discovered by Robert Brown, and termed *molecular motion*. The particles are often called *molecules*. Molecular movements may be seen in the chyle, in urinary deposits consisting of urate of soda in a state of minute division, and indeed wherever fine particles of matter are suspended in a fluid. These movements are frequently observed in the interior of cells when insoluble particles are suspended in a limpid fluid. In the interior of many "pigment cells" molecular movements may be observed.

Granules may be divided according to their composition into three principal classes, *fatty granules*, *albuminous granules*, and *earthy granules*. It is impossible to distinguish these from each other by their microscopical characters alone, and it is therefore necessary to resort to chemical analysis. For this purpose, the granular matter suspended in water is placed under thin glass in the usual way, but in order to obtain a sufficient thickness of fluid for examination, it is desirable to prevent the thin glass from coming into too close contact with the glass slide, by inserting a piece of hair or hog's bristle. The slide being placed under the microscope, a little of the reagent is forced out of one of the tubes with capillary orifices, § 138, upon the slide, so that it may gradually pass in between the glasses, while the effect it exerts upon the granules may be studied under the microscope.

Particles, which would be correctly termed "granules" when subjected to examination by low powers, may exhibit definite forms under the highest magnifying powers, in which case the term "granule" is not applicable. The granules in pl. XIX, fig. 129, when highly magnified, appear as shown in fig. 130, and assume the form of "globules." Others again still retain their indefinite granular character under the highest magnifying powers as in fig. 132, and these would therefore still be termed "granules." Some "granules" become resolved into well defined crystals when submitted to examination with the aid of the $\frac{1}{25}$ or $\frac{1}{50}$.

Fatty Granules.—Fatty matter in a granular state is found in the chyle, and sometimes in the blood, in a state of health, and in many tissues and fluids in disease. These granules are often very minute —so small, indeed, that they pass through basement membrane and through some kind of formed material. They are not affected by *acetic acid*, but are often dissolved or saponified by an *alkali*. They are readily dissolved by ether, and as the ethereal solution evaporates, fat, in the form of globules, often of considerable size, remains behind. Fat "granules" often appear as minute "globules" when highly magnified.

It is probable that many granules consist of a combination of fatty and albuminous matter. Much of the fatty matter in a granular state, which is suspended in albuminous liquids, deposited in tissues, forming the contents of cells, or resulting from the disintegration of tissues, contains a large quantity of cholesterine, which is easily extracted by treating the substance with alcohol, § 164. By evaporating the alcoholic solution, the cholesterine will be obtained in a crystalline form.

Albuminous Granules.—By this term I wish to imply all granules composed of any modification of albumen, fibrin, casein, or other substance belonging to this class. These granules are found in many of the cells of the healthy organism, and in a vast number of tissues at all periods of life. In the early stages of development, "granules" are very abundant. These consist of particles of living germinal matter, or are the result of its death. They are often suspended in fluid. Albuminous granules are usually soluble in acetic acid—always so in the earlier period of their formation. They are also soluble in alkalies. Ether has no effect upon them.

Pigmentary Granules are found in abundance in the cells of the choroid coat of the eye, pl. XIX, fig. 133, in the cells constituting the deeper layer of the epidermis, in the hair bulbs, in the bronchial tubes, in the cells composing melanoid cancer and various morbid growths, and in other situations. Their character may be studied in the pigment cells of the skin and coats of the blood-vessels of many batrachia, as the frog (pl. VIII, fig. 47), and newt, and many fishes. These pigmentary granules are formed from the germinal matter of the cell. They may be removed from the cell, and when they escape into the surrounding fluid they exhibit molecular movements. Under the highest powers they exhibit no definite form. The dark granules often found in sputum forming irregular masses, embedded in mucus, and appearing as if inclosed in a membrane, seem to consist in many cases merely of blacks which are inspired, but in others probably of pigmentary matter formed in the lung itself. Urates of soda and ammonia are often precipitated as granules which are soluble in hot water, pl. XIX, fig. 128.

Earthy Granules are also widely diffused in the animal body, deposited in solid tissues and suspended in the fluids. In old age, many tissues are largely impregnated with granules consisting of earthy matter. They may consist of phosphate or carbonate of lime, phosphate of ammonia and magnesia, and more rarely of other earthy salts.

If composed of carbonate, they effervesce upon the addition of an acid, and readily dissolve. If they dissolve without effervescence,

and the clear acid solution yields with ammonia a precipitate, in a *granular state*, it consists of phosphate of lime; if *crystallized*, of triple phosphate.*

176. Globules.—A "globule" is more or less spherical in form. Globules vary much in size, and, like granules, differ much in their chemical composition, as well as in other characters. Some are composed of albuminous matter, others consist of fat; and phosphate and carbonate of lime, and other mineral matters are the materials of which many are composed. The appearance of the globule, when examined by transmitted light, entirely depends upon the material of which it is composed and that of the surrounding medium. If both are colourless, and exactly, or nearly, correspond in their refractive power, the globules may be invisible, but if the globules and the medium in which they are immersed, differ in refraction, the outline of each globule will appear dark and well-defined, and its centre clear and bright. The width of this dark outline is determined by the difference in refracting power. For instance, the outline of an oil globule in water is distinct and well-defined, but narrow, while the outline of an air bubble in water is very much wider than that of the oil globule, figs. 134, 135, 136, and figs. 147 to 150.

If the globule is suspected to consist of an earthy material, it must be tested with chemical reagents. Phosphate of lime is readily dissolved by acids, without effervescence, and may thus be very easily distinguished from fatty matter, while the latter is dissolved by ether, which has no action whatever on the former.

Considerable confusion has been introduced with reference to the terms *granule*, *molecule*, and *globule*, and by some writers the two former have been used in the same sense as "globule." The word "globule" should be restricted to a body which has a distinct circular outline, with a clear bright centre; while by "granule" is understood a minute particle of no determinate form. The latter is, therefore, synonymous with the word "molecule." It seems to me very important that we should carefully distinguish the mere *molecule* or *granule* from the well-defined *globule*. We can discover the form of a globule without difficulty, but are quite unable to ascertain that of a granule or molecule.

* For the method of applying the test, see page 104. There is a possibility of error when a fluid or tissue in which the granules are deposited, contains carbonate of ammonia from decomposition. This salt, however, can always be very readily removed by the addition of water in which it is readily soluble, in the first instance. If the deposit which effervesces has been heated to redness, it cannot of course contain carbonate of ammonia. It must, however, be borne in mind that when salts of many of the organic acids, as citric, oxalic, lactic, acetic, &c., are incinerated, *carbonates* are found in the ash.

Air bubbles.—The student should familiarise himself with the character of air bubbles as they appear in various fluid media of different refracting power, or he will assuredly make the most ridiculous and unpardonable mistakes. Air bubbles and oil globules should be examined in spirit, water, glycerine, Canada balsam, and other media, as well as under various powers of the microscope. Air bubbles can always be obtained very minute, by placing a drop of gum water on the glass slide, and raising and depressing very rapidly a piece of thin glass which is well wetted with it.

Oil globules may be easily obtained for examination by shaking a few drops of oil in a bottle of weak gum water. Or a drop of milk in which they exist ready formed of all sizes, may be placed under the microscope, pl. XIX, fig. 136.

Globules composed of Fatty Matter are so frequently met with in the healthy organism and in morbid conditions, that every one must have observed them. They are found in the liver cell in health, and in the epithelium of the small intestines in considerable number, in the cortical portion of the suprarenal capsules, in the cells of the sebaceous follicles, and in those of the mammary gland, in the marginal tufts of the placenta towards the end of the period of gestation, in the muscular fibre cells of the uterus after delivery, and in the cells which are found in considerable number in the colostrum, or first portions of milk secreted by the mammary gland every time it is called upon to discharge its function. A minute oil globule in the "nucleus" of a cell has been termed its "nucleolus." In morbid conditions there is not a tissue in the body which may not become studded with oil globules,—even the transparent cornea, vitreous humour, and crystalline lens are not free from them,—nor is there a fluid in which they do not sometimes occur. In disease, fat globules are often found in epithelial cells, especially those of the liver, kidney, and many other glands, in muscular tissue, in nerve, fibrous tissue, cartilage, basement membrane, as of the lung in emphysema, in the cells of mucous membranes, and in those of the bronchial tubes in catarrh, inflammatory exudations generally, in the fluid which collects in serous cysts, and in certain cavities as the antrum, and in many other situations which will be enumerated in their proper place. When free to move in fluid, minute oil globules become aggregated together to form collections or masses which have often been mistaken for *cells*. This aggregation is a physical phenomenon, and depends upon the attraction of gravitation.

The deposition of oil globules seems to be constant wherever a tissue ceases to discharge its office, either in the natural course or in consequence of a morbid process having been set up. The deposi-

Fig. 128.

Granules of urate of soda.

Fig. 129.

Granules under a power of 215. p. 141.

Fig. 130.

Part of fig 129 more highly magnified. The granules become 'globules.'

Fig. 131.

Granules, consisting of fatty matter in a state of very minute division, from 'chylous' urine, resembling the 'molecular base' of the chyle. Some small cells are also observed. × 215. p. 141.

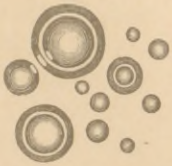
Fig. 132.

Granules, highly magnified

Fig. 133.

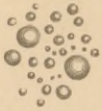
Pigment cells from the outer part of the choroid. Human. × 130. p. 142.

Fig. 134.



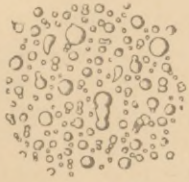
Air bubbles in water. p 144.

Fig. 135.



Free oil-globules.

Fig. 136.

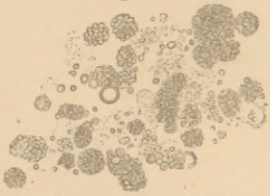


Oil globules from milk. × 215. p. 144.

Fig. 137.

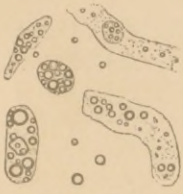
Oil-globules, free and enclosed in cells. × 215. p. 144.

Fig. 138.



Collections of minute oil-globules, the so-called inflammation corpuscles, compound granular corpuscles, &c., from softened brain. pp. 144, 179.

Fig. 139.

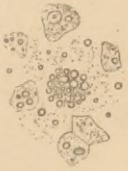


Casts of the uriniferous tubes, containing free oil-globules and cells filled with fatty matter, from a case of fatty degeneration of the kidney. p. 144.

Fig. 140.

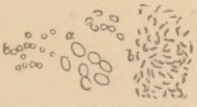
Oil globules *a*, and granules *b*, enclosed in cells.

Fig. 141.



Oil-globules in the so-called cells of the liver; in the centre is seen a collection of oil-globules not surrounded with any envelope. × 215. p. 156.

Fig. 142.



Vegetable organisms met with in urine. *a*, different forms of fungi. *b*, vibriones. × 215. p. 145.

Fig. 143.

Penicillium glaucum, in different stages of development, from acid urine. × 400. p. 145.

Fig. 144.

Corpora amylacea, from the brain. p. 156.

1000th of an Inch ⌊___⌋ × 215.
" " ⌊_____⌋ × 400.

[To face page 144

tion of fat globules, or more probably the *conversion* of albuminous material into fatty matter, appears to be a natural change prior to the absorption of many tissues. It would seem that in health this oily matter is absorbed, as fast as it is produced, but that in some conditions its removal is impossible. So also the proper activity of a tissue having been interfered with by disease, the appearance of fat globules seems to be a change which necessarily takes place. If the morbid alteration be limited in extent, and the system vigorous, absorption of the degenerated tissue may occur; but if the strength be reduced, the process continues, the functions of organs necessary to life become deranged, and death ultimately results. It is in such conditions of system that maladies, from which healthy men would recover, and trifling surgical operations prove fatal.

It is important to bear in mind that some forms of fungi closely resemble oil globules in their general appearance, but they do not refract the light so highly as the latter, while acetic acid generally renders them more transparent. Ether has no action upon fungi, but it dissolves the oil. The outline of small oil globules is thicker, in proportion, than large ones; but that of fungi is the same in all cases. Fungi are represented in pl. XIX, figs. 142, 143. Generally, oil globules in a specimen vary very much in size, while the cells of fungi if not all of the same dimensions, do not exceed a certain definite size. Practice alone, however, will enable the student to distinguish the difference with accuracy.

Globules composed of Albuminous Material are often of a very large size; they are found in many morbid products, in serous fluid from cysts, pl. XX, fig. 145, in soft malignant growths, and very frequently in the eye in disease of the choroid and retina. The outline of such globules is exceedingly narrow, and the globules themselves scarcely visible, except under the influence of a very dull light. These have been termed *colloid* bodies.

Globules composed of Earthy or Crystalline Matter.—Hard globules consisting of earthy matter, have a composition similar to that of granules composed of inorganic substances. Many large globules met with in the brain, pl. XX, fig. 146, contain a large quantity of carbonate of lime, while those which occur in the urine of the horse and of rodent animals, figs. 147 to 150, are composed entirely of this substance. Many calculi at an early stage of their formation might be termed globules. By the gradual deposition of new material externally, they often attain a very large size. See Urine Urinary Deposits and Calculi, "dumb bells of oxalate of lime." It should be stated that a certain proportion of animal matter is usually deposited with the earthy or crystalline material of which the globule is com-

posed. This is often seen when the highly refracting matter has been dissolved out by a chemical reagent.

Corpora Amylacea.—These are oval or circular masses, much resembling starch globules in their general appearance, which are found principally in the brain, but they have been met with in many other fluids and tissues of the body, pl. XIX, fig. 144. These bodies have been found in all parts of the organism in disease. They are often found in morbid products, and are very frequently associated with globules composed of phosphate and carbonate of lime. Virchow, in 1854, showed that they differed from the latter in their chemical characters, especially in their becoming blue upon the addition of iodine.* Mr. Busk considers that some of these bodies are absolutely identical with starch.† I have described some which could scarcely be distinguished from starch globules which existed in considerable number in a cancerous liver. See my lecture at the College of Physicians, 1861. The best iodine solution for testing their amylaceous nature is the chloride of zinc solution, the composition of which is given in § 136. Of the mode of formation of corpora amylacea or of their effects, nothing is known.

Of Elementary Parts or Cells.

177. Cells.—The "cell" used to be described as a perfectly closed sac within which were certain contents, and it was supposed that in its formation little particles became aggregated together to form collections, and that the "cell wall" was formed subsequently around these. It has since been maintained that the most important structure within the cell wall is the nucleus, and to this was attributed the process of multiplication. Many important changes taking place during the life of the cell have been referred to the action of the nucleus. But on the other hand it has been said that in the *matter between the cell wall and the nucleus* all those wonderful phenomena resulting in the production of characteristic tissues or cell products, occurred. It may be remarked that the "nucleus" is not constantly present in all cells which, nevertheless, divide and subdivide, and that in many instances no distinction into *wall*, *contents* and *nucleus* can be made. The human blood corpuscles exhibited no nucleus, and in order to explain the fact some authorities

* Virchow's "Archiv," Band VI., s. 125.

† "Quarterly Journal of Microscopical Science," vol. ii, page 106. The following references may also be given on *corpora amylacea*. Dr. Carter, "Edinburgh Medical Journal," August, 1855, and "Graduation Thesis," 1856. Dr. Arlidge, "Medico-Chirurgical Review," vol. xiv, page 470.

invented the hypothesis that the red corpuscle was a "free" nucleus, while others looked upon it as a "cell," the nucleus of which had been absorbed.

In the "nucleus" a bright spot which cannot be distinguished from an oil-globule may often be observed. This was called the "nucleolus." The oil globule, however, is a mere product of change, but the "nucleolus," where it exists, is a new centre of growth.

The cell "contents" are various. They differ no less in their physical characters than in their chemical properties and endowments. The "cell" itself may be destined to perform offices of the most temporary character, and its development, growth, and decay, may be comprised in an exceedingly short space of time, or the material of which the greater part of it consists may not be prone to alteration, and the structure may retain its primitive "cell-form" unchanged for ages. The "cells" cannot in all tissues be isolated or separated from each other, or from the so-called "intercellular substances" in which they lie. They do not appear as separate and individual structures, neither in many cases can any anatomical distinction be made between the cell wall and the substance which intervenes between contiguous cells. The "cavity" of the cell has been regarded as a little space, scooped out as it were in the material, of which the so-called cell wall and intercellular substance consist. These cavities it has been supposed result from differentiation taking place in a previously homogeneous plasma. To the entire contents of the "cavity" or cell (where they can be removed as an independent structure), Professor Huxley has given the name of *endoplast*, and to the walls of the cavity, or the cell wall and the intervening material or basis substance, that of *periplast* (1853.)

This observer looks upon the *periplastic substance* as the formative matter, and believes that it alone takes part in the differentiation which results in the formation of tissue. The *endoplast*, on the other hand, is regarded by Huxley as a substance of comparatively little importance, and he even goes so far as to assert that it is sometimes absent. He does not, however, state how he proved this, or whether it was absent in a cell actually growing and changing. It is quite certain that numbers of "endoplasts" which may entirely escape observation if the ordinary methods of investigation are followed may be demonstrated in the very same textures by special methods of enquiry. With reference to Huxley's theory, I would remark:—first, that as there is no instance known in which any form of tissue is produced without the matter termed endoplastic being present, we are not justified in inferring that this is non-essential, but on the contrary, we are rather led to the conclusion that it is of the highest importance;

secondly, that in the natural growing state, the periplastic substance is continuous with the endoplast. It is probable that the former is formed by the latter, in fact, that the *endoplastic* gradually undergoes change and becomes converted into the *periplastic* matter; and lastly, that while periplastic matter cannot produce more periplastic matter like itself, the endoplastic substance can give rise not only to more matter like itself, but may become resolved into periplastic substance. It seems then that the endoplastic matter must be of higher importance than that which surrounds it. It unquestionably exists before the periplastic substance is formed, it exists whenever the latter is being produced, it alone is active, capable of increase, of growth, of formation.

178.—Of the Nature and Structure of Cells.—The confusion resulting from the different views advanced, and the conflicting statements of different authorities have rendered it imperative to reopen the question of cell formation, and I think the matter may now be brought under the notice of the student in a much clearer form if approached from a point of view somewhat different to that usually taken. Instead of drawing conclusions from the structure of "cells" in fully formed tissues, let us examine "cells" or the bodies corresponding to them at different stages of growth, commencing at the earliest period of their existence. If we examine any embryonic matter, or any other rapidly growing material, we shall find that it is made up of small masses of transparent semifluid matter exhibiting no structure, but manifesting remarkable powers or properties. Each one of these masses is capable of moving, of dividing and subdividing, and of undergoing conversion into matter which did not exist before. From its transparency, this matter is often passed over when embedded in tissue, but it exists even in bone and teeth, at least wherever the formation of new bone or tooth structure is going on, and its presence can always be detected by the use of the carmine fluid, p. 53. When a number of particles of such matter are seen together, the mass has been said to consist of free "nuclei," "nuclear corpuscles," or to be composed of "granular matter." Oftentimes when the examination is made the living matter is dead and has undergone disintegration and decomposition. The "granular matter" supposed to enter into the formation of the substance under examination is, in fact but the debris resulting from change occurring after death. The living matter of the cell often undergoes great alteration very soon after death. In its natural living, growing state, it may be so transparent and clear as to be passed over entirely, but when death occurs, oil globules and earthy particles may be deposited. Frequently the living matter shrinks soon after death so that it occupies much less

space than when it was in its living state. The living matter, instead of being continuous with the formed material, is separated from it by an interval. This is often seen in cartilage, and the change which has taken place has led many to the erroneous conclusion that a "cell," "granular corpuscle," or "endoplast," lay free in a cavity which existed in the matrix of the cartilage. The true relation of the living matter to the formed matter can be readily demonstrated in perfectly fresh embryonic cartilage, especially that of the young newt or frog tadpole, in which the anatomical elements are very large.

The student may form a good idea of living, growing, active matter if he examines a white blood corpuscle, a mucus corpuscle, or a pus corpuscle, pl. XX, figs. 151, 152, and 153, under a power of 400 diameters, and upwards. Under still higher magnifying powers, he may see particles of the same active matter far more minute. It is this matter which is alone concerned in the production of everything that lives, and it was always derived from matter which existed before it. All germination, all growth and multiplication depend upon this, and as every kind possesses the power of germinating, of giving origin to matter like itself, I have termed it *germinal* or *living matter*. This living or germinal matter exhibits phenomena not known to occur in any non-living matter whatever, and therefore the term *living* as I employ it, has a certain definite signification. Although we do not know the nature of the changes we call vital, we do know they differ essentially from any chemical or physical changes yet discovered.

A free mass of germinal matter soon becomes changed upon its external surface. Surrounding conditions alter it, and this part soon loses the power of germination, it ceases to be active and living. The matter formed in consequence of the changes which occur, protects that which still remains and prevents it from undergoing the same alteration or only permits this to go on very slowly. As this last passive matter is formed from the first, I call it *formed material*.

Every "cell" then consists of active germinal matter surrounded by passive formed material. This layer of formed material may be so soft and diffluent, as not to form a layer to which the term envelope or wall could be correctly applied,—and so transparent and structureless as to elude ordinary observation; or it may be so firm and thick, exhibit such remarkable structure and be present in such large quantity in proportion to the germinal matter, that the "cell" appears to be entirely composed of it.

Different kinds of germinal or living matter possess different power of resisting the influence of external conditions. Some kinds are easily killed—others are destroyed with difficulty. In many

instances the vitality of germinal matter is only retained at a certain temperature, and a difference of a very few degrees may be sufficient to destroy it. Some forms resist extreme cold, but as far as is known none can live at a temperature of 300°.

Some kinds of living matter may pass long distances through air or water without being destroyed. Sometimes they multiply during their transit, sometimes remaining quiescent, it may be, for a long period, they multiply only when they happen to fall upon a surface where the particular pabulum adapted for their nutrition, and circumstances favourable to their development, are present. It is probable that the *materies morbi* or *virus* of all contagious diseases consists of living germinal matter, capable of retaining its vitality in spite of the influence of some adverse conditions, and even when dry. This desiccation, however, is not complete—a little of the living matter is protected by the covering of formed material, and retains sufficient moisture to keep it alive. Thus, living particles of vaccine lymph, of the virus of small pox, of scarlet fever, and many other diseases, may retain their vitality although apparently dried up, just as many of the infusoria and lower vegetable organisms may live quiescent in a state of imperfect desiccation for a length of time, growing and multiplying rapidly as soon as favourable external conditions become established. See pl. VII, figs. 42, 43, showing the germinal matter of pus and vaccine lymph.

These particles of germinal matter are not to be regarded as low animal or vegetable forms, but rather as the direct but degraded descendants of the germinal matter of the normal tissues of the organism. Just as under certain conditions the germinal matter, known as pus, results from that of normal cells, so under other conditions not yet perfectly understood, the living particles inducing specific contagious maladies, and capable of multiplying in the blood of one person after another, originate.

It must not be supposed that we can form any conception of the *power* of the different forms of germinal matter from microscopical or chemical examination. Masses which could not be distinguished from one another, manifest the most remarkable differences in power. For instance, fig. 154, pl. XX, much resembles fig. 155, but the first represents cells found in ordinary inflammation tending to the production of the low form of germinal matter known as pus, while the last represents the brain cells of man at an early period of development. By chemical analysis every kind of germinal matter yields a substance resembling fibrin, another allied to albumen, fatty matter, salts and water.

Every cell in nature consists of germinal or living matter and

Fig. 145.

Deposit from fluid removed from the chest of a girl æt. 23. *a*, granular cells, probably from the walls of the cavity in which the fluid had collected. *b*, clawa of echinococci. The circular oil-like masses were rendered granular by acetic acid.

Fig. 146.

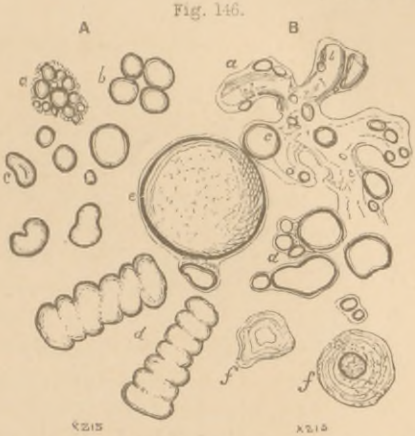


Fig. 146.—A, globules of earthy matter, cerebellum. Case of insanity. Consisting principally of carbonate of lime. *a*, collection of small globules. *b*, larger ones. *c*, globule resembling corpus amylaceum. *d* collections of globules incorporated together. × 215.

B, globules of earthy matter. Choroid plexus. Insanity. These were soluble in hydrochloric acid without effervescence, and consisted almost entirely of phosphate of lime. *a*, capillaries of one of the processes of the plexus, showing the globule external to the capillary wall. *b*, outline of a capillary loop. *c*, large globule external to capillary. *d*, small collections enclosed in a membraneous structure. *f*, globules acted upon by hydrochloric acid. × 215. p. 145.

Fig. 147.

Fig. 148.

Fig. 149.

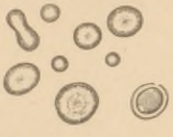
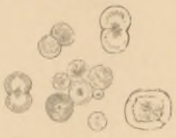


Fig. 150.



The appearance of crystals of carbonate of lime, from horse's urine, as examined in different media. 147, by reflected light in air; 148, by transmitted light in air; 149, in water; 150, in Canada balsam. p. 145.

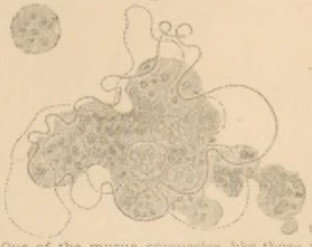
Fig. 151.

White blood corpuscle, showing transparent substance, which forms protrusions or outgrowths, granules embedded in this, also the large nucleus. × 2800. p. 149.

Fig. 152.

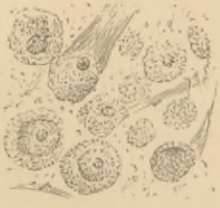
Mucus corpuscles, from trachea. Health. × 700. p. 149.

Fig. 153.



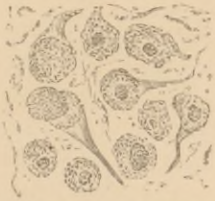
One of the mucus corpuscles like those in Fig. 152, magnified 2800. Showing alterations in form during a minute. p. 149.

Fig. 154.



Lymph on surface of peritoneum of intestine. Acute peritonitis. 4th day. × 700. p. 150.

Fig. 155.



Anterior portion of cerebrum. Human embryo 4th week. × 700 p. 150.

[To face page 150.

formed material, or passive or dead matter produced from the first, fig. 156, pl. XXI. The proportion and characters of the formed material vary wonderfully. Hence "cells" differ much in character. The student would be inclined to apply different names to things differing from one another so much as many of the so-called cells or elementary parts of certain tissues; yet everyone of these is capable of growth and change, and may be proved to consist at every period of its life, of germinal matter and formed material; and however different in their fully formed state, every one of them at an earlier period exhibited precisely the same characters.

The mode of production of some of the principal forms assumed by "cells" in the adult state, may perhaps be understood from the following description, with the aid of the drawings in the plates, and it seems to me that only by studying the changes through which the cell passes until it has acquired its permanent type, can the student hope to gain a correct knowledge of cell forms, or a clear conception of the wonderful process of the development and formation of tissues and organs.

I. The mass of germinal matter may absorb nutrient material from the surrounding medium, increase in size, divide and subdivide according to the process described on page 64, and thus one mass may give rise to many, which grow into masses like the first. In this case very little formed matter is produced, and this may be fluid, semi-fluid, or soft and yielding, so that the masses of germinal matter easily move, and divide, and subdivide in it, pl. XXI, fig. 158, *b*, *c*. The entire quantity of living or germinal matter increases rapidly and at a much greater rate than the formed material. This process occurs in the early periods of development of all textures, and in all morbid changes remarkable for rapid growth. It is seen commonly enough in inflammation when pus is formed, pl. VII, fig. 44, and occurs in cancer.

II. A mass of germinal matter may undergo change upon its external surface so that an envelope of formed material may be produced, and this may be thickened by the production of more formed material and its deposition layer after layer within that first formed, pl. XXI, figs. 156, *a*, *b*, *c*.

III. A *thick layer* of formed material having been produced, the living or germinal matter within may die, or may be the seat of some of the other changes mentioned below.

The small remaining particle of germinal matter may die, in which case we have a mass consisting entirely of formed material with a very small cavity in the centre depending upon the drying up of the materials resulting from the death of the germinal matter. In this case we have a mass of dead matter

incapable of course of formation, conversion or multiplication. As an instance, the outermost and oldest "cells" of the cuticle, or of a mucous membrane may be adduced.

The germinal matter may undergo very slow change, and remain as a small mass embedded in a great quantity of formed material.

The living matter may remain for a long time in a state of comparative quiescence within this protective covering, but if exposed to favourable conditions the formed material becomes softened, and the germinal matter makes its way through it at certain points, and grows rapidly when it comes into close relation with the pabulum in the medium around, fig. 161, *a*. In the case of the vegetable spore of mildew for example, the appearance represented in fig. 162 results. The germinal matter having occupied all the space left white in the drawing.

The germinal matter of an epithelial cell, as represented in *c*, figs. 156, 157, remaining alive, may increase again in size at the expense of the formed matter it has already produced. Such changes are common enough in inflammation, and will be at once understood by reference to fig. 158, *a*, *b*. At last the whole of the formed material is appropriated by the germinal matter, and we get the appearance represented in fig. 158 at *c;* in fact, a return to the characters observed at an early period of development. Although little or no difference can be discovered by the microscope between masses of embryonic germinal matter and those resulting from an increased supply of pabulum, as happens in the morbid process of inflammation, there is a degradation in the power of the rapidly-growing masses of germinal matter. They can never again give rise to the formation of any lasting texture, or to anything exhibiting definite structure or capable of performing any special office.

IV. A mass of germinal matter having undergone conversion into formed material upon the surface, so that a permeable membrane or cell wall has been produced, may give rise to the formation of a peculiar material within. In the substance of the germinal matter, a little particle makes its appearance, and gradually increases in size by the addition of new matter to it of the same kind. In this way fatty and starchy matters are formed, as it is said, *within* the cell. But these, like the external membrane or cell-wall, consist of formed material, and result from the death and change of particles of the germinal matter. The mode of production of starch will be understood by reference to figs. 163, 164, pl. XXI, and that of fat by referring to

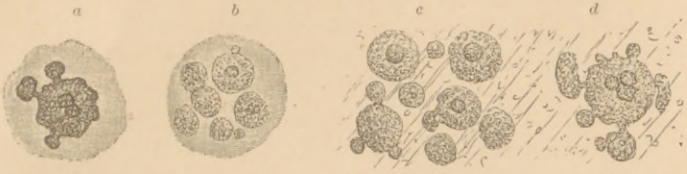
Fig. 156.

Production and accumulation of formed material upon the surface of germinal matter in an epithelial cell, as in cuticle.
× 700. pp. 151, 152.

Fig. 157.

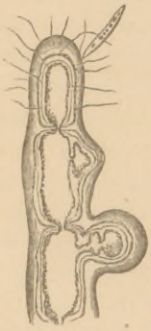
Drawings illustrating the production of formed material from the germinal matter in epithelial cells. p. 152.

Fig. 158.



Formation of Pus. To illustrate the changes in the germinal matter of an epithelial cell resulting from increased nutrition. Showing the manner in which the germinal matter of a normal cell, if supplied very freely with pabulum, may give rise to pus p. 137.

Fig. 159.



Growing extremity of the stem of a sea-weed, showing the manner in which the germinal matter divides, and the production of formed material, layer within layer, upon its surface. The outermost layer is the oldest, and is undergoing disintegration. Other organisms are living upon it. × 300.

Fig. 160.

Production of formed material upon the surface of germinal matter of mildew.
× 1800. p. 152.

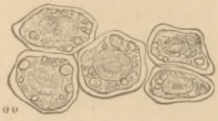
Fig. 161.

Further production of formed material in ordinary mildew. At *a*, a bud is formed by the passage of some of the germinal matter through pores in the very thick layer of formed material. × 1800. p. 152.

Fig. 162.

Passage of germinal matter through pores in formed material, and formation of thin layer of formed material upon germinal matter, *a*. Showing the manner in which fungi grow.
× 1800. p. 152.

Fig. 163.



Five young starch-holding cells of the potato, showing GERMINAL MATTER, with small starch globules precipitated amongst it. × 700 p. 152.

Fig. 164.

A fully formed starch-holding cell of the potato
× 350 p. 152.

1000th of an Inch _____ × 700.

[To face page 152.

figs. 165, 166, pl. XXII. In some cases the matter, instead of taking the form of distinct grains or particles in the interior of the cells, is added layer after layer upon the inner surface of its walls. But the deposition of this "secondary deposit" is not uniform. Nutrient matter is continually passing towards the germinal matter, and deposition will occur in the intervals between the lines in which the nutrient juices flow. At last a star-like appearance results. This will be understood by reference to fig. 167. The lacuna of bone is formed in somewhat the same manner.

V. A mass of germinal matter, lying a short distance external to a vessel, and having given rise to the formation of a certain amount of formed material, may continue for a long time to effect most important changes, although the mass itself appears not to change. Having one surface near to, or directly in contact with, the vascular wall, while the other is free,—nutrient matter may be absorbed by the germinal matter on one side, while on the other the production of formed material in the form of liquid or gas proceeds. This may become resolved by oxidation or other changes into matters which escape from the free surface and are readily carried away. Such are the phenomena which occur in the process of secretion. Different forms of secreting cells are represented in figs. 168, 170, pl. XXII.

VI. A mass of germinal matter may divide and subdivide into several masses. The intervening formed material, instead of being arranged round each mass of germinal matter, as in pl. XXII, fig. 171, may be continuous throughout, as in fig. 173. After a time the formed material may undergo condensation, and the shrinking that would take place may be compensated for, or more than compensated for, by the continual formation of new formed material. In this way a tissue like cartilage results, fig. 172. The formed material may be uniform, transparent, or granular, or it may exhibit a fibrous appearance, according to the conditions present during its production, and the movements of the masses of germinal matter which produce it. It has been assumed by many, amongst whom is Kölliker, that the formed material is deposited between the cells by a separate operation; but if this were the case the cells would simply become separated from one another as the texture advanced in age, and the changes in character which may be observed in them at different periods would not be explained.

After a time each mass of germinal matter lying at intervals through the formed material of cartilage may again divide and subdivide, each of these subdivisions giving rise to the production of formed material on its surface for a time, and then dividing and subdividing as before. In this case there will be primary and secondary

collections of masses, separated from one another by varying intervals of formed material, fig. 176.

In some cases the mass of germinal matter may form a condensed layer of formed material upon its surface, in which case the appearance of a cell-wall distinct from the matrix results, fig. 174. Or, the germinal matter may shrink and become disconnected with the formed material it has already produced, and now becoming hardened upon its surface, the appearance represented in fig. 175 results.

VII. Masses of germinal matter may separate from one another in a linear direction, and the formed material may accumulate as a thread between them. This is illustrated in the production of white fibrous tissue, yellow elastic tissue, and muscle, pl. XXIII, fig. 177, 177*, 178, 179. In some cases the oval mass of germinal matter may continue to move along the thread or fibre already formed, and thus add to its thickness. In this way the thick fibres of yellow elastic tissue result, and there is reason to think that in certain forms of muscle, particularly that of the heart and tongue, the fibrillæ are thus increased in thickness and new ones formed, figs. 178, 179. If the separation of the masses of germinal matter takes place in various directions, a tissue consisting of "stellate cells" results, as is well seen in fig. 177*.

179. Of the Different Kinds of Cells.—As cells differ in their chemical and physical properties and in the duration of their existence, so also, they may be distinguished according to the offices they perform, or they might be classified according to the peculiarities of form alone. The latter is the plan generally adopted in describing varieties of cell formation; and *scaly* or *squamous* cells, *tessellated* cells, *polygonal* cells, *columnar* cells, *spherical* cells, *spindle-shaped* cells, *fusiform* cells, *fibre* cells, and *caudate* cells, some of which are very complex, have been distinguished. It seems, however, more natural to divide cells into groups according to the offices they discharge in the organism. Thus we should have cells whose office is that of forming a protective covering to delicate structures placed beneath them; cells which are specially concerned in separating and elaborating certain materials derived from the blood, which form the special constituents of different secretions; cells which are capable of giving rise to currents in the fluid which bathes their surface, by the perpetual vibration of minute hair-like appendages or *cilia;* besides these there are cells with special endowments,—*contractile cells;*—cells whose nutritive changes are associated with the development of heat, light, or electricity, or the production of nerve force; cells taking part in the reception of external impressions, as touch, taste, smell, hearing, sight; lastly, there exists an almost endless variety of cells in different morbid growths, which differ essentially from the cells of

Fig. 165.

'Fat Cells,' showing the seat of formation of the fat (formed material), and the changes occurring in the cell as it advances towards its fully developed state. Frog. × 700. p. 153.

Fig. 166.

Adipose tissue, abdominal cavity. Newt. The nuclei of many of the fat vesicles are unusually distinct. × 15. p. 153.

Fig. 168.

Mucus-forming Cell, from the fauces of a boa, showing germinal matter and the formed material within the envelope. The lower arrow shows the direction in which the nutrient pabulum flows towards the germinal matter, the upper one that taken by the formed material as it passes from the germinal matter. p. 153.

Fig. 167.

Vegetable cell, showing the manner in which secondary deposits are formed, and how the channels through which currents flow towards the 'nucleus' result. p. 153.

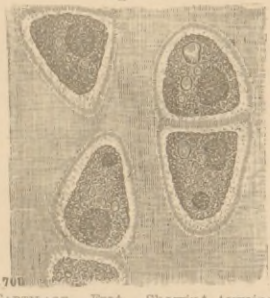
Fig. 169.

Columnar Epithelial Cells, from the small intestine of a dog, showing the position of the germinal matter *a*, the layer of highly refracting matter upon the surface. × 700. p. 153.

Fig. 170.

Liver Cells in different stages of growth, showing germinal matter and the production of soft formed material, which becomes resolved into several different substances (fatty, amyloid, albuminous, and biliary matters.) Human subject. × 700. p. 153.

Fig. 172.



Cartilage. Frog. Showing germinal matter and formed material (intercellular substance, of authors), with appearances resembling a cell-wall. × 700. p. 153.

Fig. 171.

To show how the appearance of separate cells is produced in formed material. p. 153.

Fig. 173.

To show how in some tissues the formed material is continuous. p. 153.

1000th of an Inch ——— × 215.

" " ——————— × 700.

[To face page 154.

healthy tissues, but which are nevertheless the direct descendants of the germinal matter of those developed under conditions which are not present in the normal state.

All cells possess the power of multiplying in number, of selecting certain materials and rejecting others, and of appropriating certain substances, so also they have their periods of growth, development, and decay, and the death of each takes place at its appointed time. Although the power of multiplying with wonderful rapidity in the normal state seems peculiar to some, while the most striking character of others is their power of selecting and slowly converting certain substances into the constituents of the secretions, the germinal matter of all, may, under certain circumstances, grow and multiply with great rapidity. Some seem destined to absorb large quantities of matter and pass it onwards into channels adapted to receive it.

The cell which possesses a remarkable power of multiplication, though assuming a great variety of forms, is distinguished by the large proportion of germinal matter it contains (pus and cancer cells). The *secreting cell* by its more or less spherical, or polyhedral form and soft granular formed material (cells of liver, kidney, pancreas, &c.). The cell concerned in *absorption* by its columnar form and by its thickened and spongy outer extremity (columnar epithelium of intestine, ducts of salivary, pancreatic, labial, and buccal glands, liver, &c.). The cell which only serves the office of a protective covering to delicate structures beneath, usually by its hardness and density, by its flattened form and imbricated or tessellated arrangement (squamous epithelium of skin, mucous membrane of mouth, æsophagus, vagina, &c., tessellated epithelium covering the surfaces of serous membranes, &c.).

The fully-formed blood corpuscle is not a *living* cell. It seems to be a little closed sac, its wall tolerably firm, but perfectly transparent and permeable to fluids holding various solid and gaseous substances in solution, in both directions. It is oval or circular in form, and becomes bi-concave or bi-convex according to the density of the medium in which it is suspended. Fluids of high specific gravity, and oxygen, flatten the corpuscles, while water, fluids of low density, and carbonic acid, cause them to become swollen and perfectly spherical. By allowing blood corpuscles to soak for some time in fluids of low specific gravity, it is said that they burst, and their contents escape, but really the matter of which the entire corpuscle consists, imbibes water, and gradually dissolves. The outer part of the matter of which the oldest corpuscle is composed is, however, often hardened and presents the characters of a cell wall.

The *cell wall* and *cell cavity* are not to be demonstrated in all

cases, and many structures which are still called *cells*, have been shown to consist of masses of material arranged in shapes like cells, but not invested with any membranous envelope. So also examples are not wanting in which granules, globules, and other matters have collected together, and gradually, firm, compact, *cell-like* masses have been formed. In different specimens of sputum, small collections of dark granules are often found. In many cases these are, without doubt, mere aggregations of particles of carbon introduced into the air tubes during inspiration, which by the action of the currents produced by the vibration of the cilia, become mixed with a little mucus, and at length formed into nearly spherical bodies which exactly resemble cells. Not unfrequently, the mucus deposited on the exterior so closely resembles a cell wall, that it is difficult to believe these granules are really not inclosed in a cellular envelope. The flattening and gradual extension, rather than rupture, which these masses undergo by pressure, the circumstance of their being found in all stages of growth, and the action of chemical reagents, prove conclusively that they are formed in the manner I have described. The so-called granular corpuscles, compound granular cells, or inflammation globules, appear to be formed at least in many cases in the same way. There is the same difficulty in demonstrating the existence of a cell wall in many other cases, and I have shown that the *liver-cell* is destitute of any membranous wall.*

It is not consistent with the plan of the present work, to describe in order the different structures met with in the human body, and I shall only introduce here, as examples of cells, a few of those with the characters of which it is essential the medical practitioner should be acquainted. Pus and blood corpuscles, cancer cells, &c., will be found in another place, and it is, therefore, unnecessary to discuss their characters here.

* "In a large number of animals, then, the contents of the tubular network may be said to be continuous; in some it is interrupted so as to form masses irregular in size, in which nuclei are scattered at intervals; and in others, the particles are more uniform in size, resemble each other very closely in general character, and each contains a separate nucleus. Between the numerous, well-defined, and separate masses, or liver-cells of the mammalian animal on the one hand, and the continuous mass which occupies the tubular network of the fish on the other, it is easy to demonstrate every intervening shade of difference; and more than this, at different periods of development of the embryo, and in various morbid conditions of the human liver, every degree of separation and of continuity may be observed. Again, by the action of various chemical reagents as described in page 40, the distinct and separate cells of the healthy mammalian liver may be made to fuse, as it were, so as to form continuous masses, like those occupying the tubular network of fishes."—"On the Anatomy of the Liver," 1856, page 49.

Fig. 174.

To show relation of germinal matter to formed material of cartilage. p. 154.

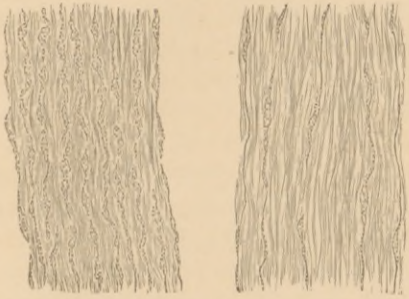
Fig. 175.

To show how an apparent cell-wall, distinct from the matrix, may result. p. 154.

Fig. 176.

To show how germinal matter divides to form collections of cells separated by matrix. p. 154.

Fig. 177.

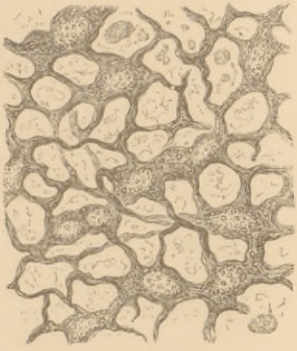


TENDON. Kitten at birth. × 215.

TENDON. Young cat. × 215.

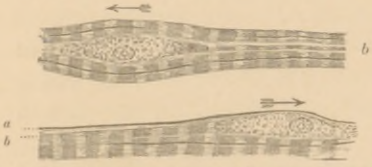
Showing germinal matter and formed material (intercellular substance, of authors) of tendon at different stages of development. p. 154.

Fig. 177*.



Stellate tissue on surface of fang of a human incisor tooth. × 700. p. 154

Fig. 178.



MUSCLE. Germinal matter and formed material. *a*, the sarcolemma. *b*, the contractile material. The arrows show the direction in which the masses of germinal matter are supposed to be moving. p. 154.

Fig. 179.

Portion of a fibre of yellow elastic tissue. Ligamentum nuchæ. Lamb. The mass of germinal matter, *a*, is moving in the direction of the arrow: behind it the formation of yellow elastic tissue is proceeding. p. 154.

Fig. 180.

Vaginal epithelium from urine. × 215. p. 157.

Fig. 181.

Bladder epithelium. *a*, from the general surface. *b*, from the fundus. *c*, scaly epithelium from the bladder. × 215. p. 157.

1000th of an Inch ——— × 215.

" " ——————— × 700.

[To face page 154.

180. Epithelium.—The term epithelium (*επί, upon θαλλω, to sprout*), is usually applied to those cells which lie upon the surface of membranes, such as the skin or mucous membrane, and those which are found in the cavities of glands, continuous with these surfaces. There are two principal varieties of epithelial cells, 1. Those that serve the part of a protective covering. 2. Those which take part in the separation or elaboration of substances entering into the composition of the secretions.

In the first class may be comprised scaly, tessellated, columnar, and ciliated epithelium, while the second includes the different varieties of glandular or secreting epithelium.

181. Scaly Epithelium can be readily obtained from the cavity of the mouth, and from several other situations.

Mouth.—The nuclei of the epithelial cells from the cavity of the mouth are very distinct, and can always be demonstrated without difficulty, see "sputum" in chapter V. If the cells be placed in a solution of potash for a short time, endosmosis takes place, they become somewhat globular, and ultimately the cell wall dissolves. The addition of acetic acid causes the granules in the interior of the cell to become less distinct, in consequence of their solubility in this reagent.

Vagina.—The scaly epithelium from the vagina is composed of very large, irregular, and often ragged cells, pl. XXIII, fig. 180. In consequence of the flattened character of the cells of scaly epithelium, portions of them will often be found folded upon each other, and creased, as it were, in various directions. The cells of the epidermis, as well as those of nail and hair, are very firm and solid masses of formed material, but may be regarded as modifications of scaly epithelium.

182. Tessellated or Pavement Epithelium.—This term has been applied to the cells of epithelium which form an even layer of uniform thickness, each individual cell being placed in juxtaposition with its neighbours, but not overlapping or exhibiting the imbricated arrangement often met with in the variety of epithelium just referred to. The epidermis of the frog presents a beautiful example of this form of epithelium; the inner layer of the choroidal coat of the eye, termed the membrane of the back pigment, the epithelium of serous membranes, of the lining membrane of the heart, arteries, and veins, and that of part of the pelvis of the kidney, pl. XXIV, fig. 182, also present more or less of this character. The nucleus of the cell is usually distinct and well-developed.

183. Glandular or Spheroidal Epithelium.—The cells are of a more or less rounded form, although in many instances, from mutual

pressure, they become polyhedral. It is this form of epithelium which takes part in the process of secretion in most glandular organs. It may be readily demonstrated in the convoluted portion of the tubes of the kidney, pl. XXIV, figs. 183, 191, in the sweat glands, in the secreting tubes of the stomach, in the follicles of the pancreas, in the liver, &c. The nucleus is usually well-developed, and frequently surrounded by a considerable number of minute granules, and, in many instances, small oil globules are also present.

184. Columnar, Prismatic, or Cylindrical Epithelium.—The general characters of this variety of epithelium may be well demonstrated by the examination of the intestinal villi, or Lieberkühn's follicles. The epithelium of the gall-bladder, of the ureters, and of the urethra, figs. 181, 184, is of this variety. In the evacuations of cholera, the sheaths of the villi will often be found entire, and an excellent opportunity for the examination of the arrangement of this variety of epithelium is afforded, pl. XXIV, fig. 188.

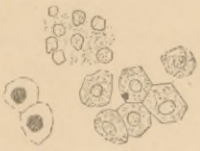
Upon examining a cell of columnar epithelium from the intestine, it will be often observed that at its summit the cell wall is considerably thickened, pl. XXII, fig. 169, pl. XXIV, fig. 189. The appearance somewhat resembles that which would be produced by the presence of very fine cilia, but careful observation has proved beyond a doubt that it is not due to this cause. Kölliker has carefully investigated this subject, and thinks he has discovered very minute pores passing through the cell wall, and apparently filled with granules of oil. It would seem that this is the manner in which the oily matter, mixed with the contents of the intestine, reaches the interior of the cell where it accumulates until globules, often of considerable size, are formed. I have long been familiar with the appearance alluded to, and have observed the thickening not only in the cells from the villi, but in other varieties of columnar epithelium. I have not been able to satisfy myself perfectly as to the existence of distinct pores. The yolk membrane (zona pellucida) of the ova of many insects, mollusks, and fishes, and probably also of mammalian animals, is perforated by a single opening, or by a vast number of minute pores, through which the spermatozoa pass, to reach the yolk within.* Certain forms of columnar or cylindrical epithelium take part in secretion. The germinal matter absorbs nutriment from below, and on its opposite surface undergoes change, giving off products of secretion, which accumulate in the cell, and at length escape from its orifice, pl. XXII, fig. 168.

* See the very interesting observations of Dr. Ransom. Also the article "Ovum," Cyclopædia of Anatomy and Physiology, and "Micropyle," Todd and Bowman's Physiology, vol. ii, page 569.

Fig. 182.

Tessellated epithelium, from pelvis of the human kidney.

Fig. 183.

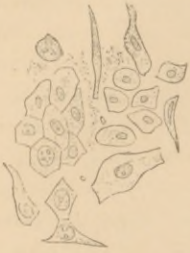


Glandular epithelium from convoluted portion of the tubes. Human kidney. × 215.

Fig. 184.

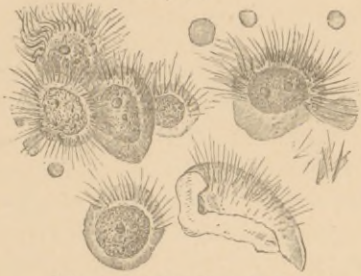
Epithelial cells of the urethra. Human.

Fig. 185.



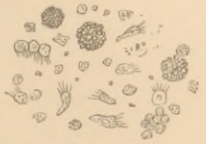
Cells from an epithelial cancer. × 215.

Fig. 186.



Ciliated epithelium, from the back of the tongue. Toad. × 700. p. 169.

Fig. 187.

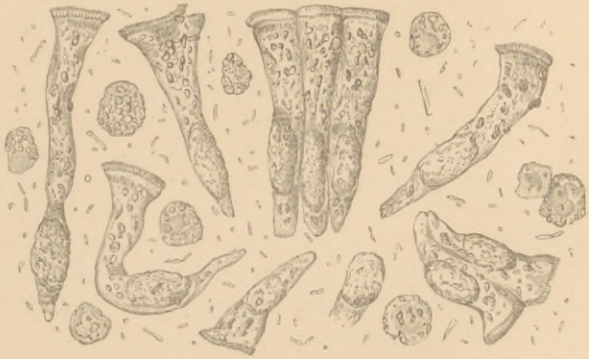


Ciliated epithelium. Granular cells and collections of oil globules from the serum of an ovarian cyst. × 215. p. 1 9

Fig. 188.

A sheath of a villus. Cholera. × 130.

Fig. 189.



Columnar epithelium, from the jejunum of a child who died of cholera. × 700. p. 158.

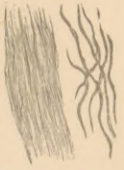
Fig. 190.

Membrane, p. 165.

Fig. 191.

Basement membrane and epithelium of tubes of human kidney. p. 165.

Fig. 192.



Fibres. Fibrous appearance. p. 163.

1000th of an Inch ⌊⌋ × 215.

" " ⌊_____⌋ × 700.

(To face page 168.

185. Ciliated Epithelium.—There are two principal varieties of ciliated epithelium, the one consisting of small cells of nearly the same length and breadth, and the other, of the prismatic or cylindrical form. Ciliated epithelium may always be obtained for demonstration from the back part of the mouth of the frog or toad, pl. XXIV, fig. 186, or from the branchiæ (the beard) of an oyster or mussel. The cells must be moistened with some of the mucus taken from the same surface, or with some of the fluid in the shell surrounding the animal, or with a little clear serum. If water be added, the movement soon stops, in consequence of endosmosis taking place. In examining ciliary movement, it is often advantageous to suspend in the fluid the smallest quantity of lampblack or carmine, so that the direction of the current produced by the cilia can be clearly demonstrated by the movement communicated to the insoluble particles.

In the human subject, ciliated epithelium is found in the following situations :—On the surface of the ventricles of the brain and on the choroid plexuses; on the mucous membrane of the nose and its sinuses; on the upper and posterior part of the soft palate, and in the Eustachian tube; in the cavity of the tympanum; on the membrane lining the frontal and sphenoidal sinuses; on the inner surface of the lachrymal sac and lachrymal canal; on the mucous membrane of the larynx, trachea, and bronchial tubes; upon the os uteri; within the cavity of the uterus; throughout the whole length of the Fallopian tubes, and upon their fimbriated extremities. About seven years ago I obtained a beautiful specimen of ciliated epithelium from the lining membrane of a large ovarian cyst, pl. XXIV, fig. 187. As far as I was able to make out, the cysts were originally developed in the ovary, and were not formed from the Fallopian tube.

186. False Cells.—Under this head I would include all those structures which resemble, and indeed often cannot be distinguished from, true cells, but which neither "grow," multiply, or perform function. Many cell-like structures consist of granular material, oil globules, or even perfectly transparent albuminous matter aggregated together sometimes around a central mass which may be easily mistaken for a mass of germinal matter or nucleus. In many instances the central mass is altogether absent, and the cell seems to consist only of granules or globules forming a collection. Not uncommonly, viscid matter is deposited external to the mass, and thus a sort of "cell wall" is formed. Microscopical observers are familiar with the presence of a multitude of cell-like bodies, which consist of mere collections of oil globules, &c., so as to form masses varying considerably in size, and usually of an oval or spherical form. The aggregation of such particles probably depends upon physical causes, and in some

instances is doubtless due to the attraction of gravitation. Strange to say, Professor Bennett, of Edinburgh, still maintains that the living cells, pus corpuscles for example, are formed by the aggregation of granules just as false cells may be produced artificially. Professor E. H. Weber has shown that when particles of resinous substances are made to move very gradually by the addition of a drop of alcohol to water, holding the substance in suspension in a state of very minute division, between two pieces of thin glass, certain currents are produced in definite directions during admixture. At the points of rest where two such currents meet, the undissolved particles are deposited, and thus the most regular figures, not unlike many forms of vegetable structure result.* Indeed, cell-like bodies are very often formed in fluids out of the body. I have very frequently observed them in solutions of organic matters undergoing evaporation. Although the solution was at first perfectly clear and free from any solid particles whatever, as evaporation proceeded, certain materials were deposited in a minute state of division. Owing probably to the motion of the fluid taking place during its concentration, these became aggregated into small collections. If I had observed these in certain fluids some years ago, I fear they would have been set down as "cells." Some of the collections of dark granular carbonaceous matter often met with in the bronchial tubes and many forms of the so-called granular corpuscles, and similar structures met with in sputum, are examples of false cells formed in the organism, to the characters of which, special attention should be directed. It is, however, exceedingly difficult to understand why the aggregations of oil globules, coloured particles, and other material in a state of minute division, should attain a certain definite size aud not exceed this. M. Hartig, in a paper on *aleurone*, a substance closely allied to starch, calls attention to such masses, which are seen in any liniment composed of oil and ammonia.† Such appearances are very liable to mislead, and it is the duty of every microscopical observer to study the circumstances under which such fallacies are now known to arise, and thus to avoid the introduction of erroneous observations and false conclusions, which, having once been received as facts, especially in cases in which the course of investigation has not been described in detail, can never afterwards be corrected. The whole subject is of the greatest interest, and our views of "cell formation," and the growth and

* E. H. Weber, "Mikroscopische Beobachtungen sehr gesetzmässiger Bewegungen, welche die Bildung von Niederschlägen harziger Körper aus Weingeist begleiten." Berichte über die Verhandlungen der k. Sachs. Gesellschaft der Wissenschaften, zu Leipzig, Math. Physisch. Classe, 1855, seite 57.

† "Aleurone."—"Annales des Sciences Naturelles," 1857, page 348.

development of structures is now undergoing careful revision, and, while we have learned to recognise the great importance of physical and chemical actions in the changes in all living beings, we are beginning to find that the physical and chemical doctrines so eagerly embraced, and almost universally accepted in the early days of the cell theory, and even now boastfully taught as sufficient to explain all the phenomena of living beings, are utterly incompetent to account for the simplest of the phenomena which occur in the simplest living thing. Although cell-like bodies may be formed artificially, there is not the least analogy between these and the living cells, except in mere external form. The essential part of the cell, the germinal matter, is absent, and cannot be produced artificially. This germinal matter, although perfectly transparent, we can now readily demonstrate by the use of alkaline colouring matter, § 101.

187. Demonstration of Cell Structures.—For the most part, cells are readily demonstrated. Care must, however, be taken that the medium in which they are placed does not produce a physical alteration. If, for instance, cells be immersed in a fluid, the density of which is less than that in their substance, endosmosis will occur, in consequence of which the mass will increase in size, and in many instances its characters will be destroyed. On the other hand, if the density of the external medium be greater than that of the fluid in the substance of the cells, exosmose will occur, and the cell will become smaller and appear collapsed. A fluid of the specific gravity of 1015–1030, will be found to be of the proper density for examining cells generally; but of course no general rule can be given on this head. Such a fluid, however, must be composed of a soluble substance, which although it increases the density of the solution, has no chemical action upon the cells. Albumen, sugar, gum, and glycerine, are the most useful substances for this purpose. A good effect is often produced by a viscid solution. If glycerine, from its highly refractive properties, be objected to, a solution of white of egg and water, or ordinary serum, may be employed. Solutions of albumen, although of very low specific gravity, are very slightly permeable. It must be borne in mind that very small quantities of syrup or glycerine have the power of increasing the density of a fluid in a very material degree, while comparatively large quantities of albumen may be held in solution without the specific gravity being much increased. Albumen, from its slight power of permeating animal membrane, is admirably adapted for the examination of delicate cell structures. A solution of albumen must be used perfectly fresh, or it may be kept from decomposition by a trace of creosote, carbolic acid, or camphor. Ordinary saliva and

vitreous humour answer well as media for the examination of some cells.

The microscopical examination of epithelium does not usually present much difficulty. The surface from which the epithelium is to be taken is gently scraped with a knife, and a small portion removed upon the blade. If necessary, it may be moistened with a drop of water; or with a solution of sugar, or serum, if the cells are delicate and there is danger of rupture from endosmosis. Generally, however, the addition of fluid will not be necessary. The chief reagents which will be found of use in the examination of epithelium, are acetic and nitric acids, strong and weak solutions of potash and soda, and tincture of iodine. Epithelium is not soluble in boiling water, alcohol, ether, ammonia, or dilute mineral acids; it is for the most part soluble in strong solutions of caustic soda and potash, and in strong acetic acid. Most forms of epithelium keep very well in the naphtha and creosote solution, in solution of carbolic acid, or in a dilute solution of chromic acid.

188. Of Demonstrating the Living Growing Part of Cells.—Different plans for demonstrating the germinal matter of cells have been already described, and the importance of acetic acid and alkalies in rendering the granular cell wall clear and transparent, has been alluded to.

The plan of colouring tissues by imbibition, was first adopted by Dr. Welcker, in his researches on elastic fibres and muscles. The eminent advantages of a solution of carmine for colouring the colourless germinal matter have been already referred to in § 101. Cells may be stained also with the colouring matter of bile, which may be easily obtained by extracting the inspissated bile with alcohol. In cases of jaundice many cells in different parts of the body are stained of a very deep yellow colour, and cells and casts of the uriniferous tubes, where the jaundice is associated with renal disease, will be found in the urine and form very beautiful objects.

189. Fibres.—The term fibre, as applied to microscopical objects, has not been well defined. Thus, the distinct *cylindrical* elementary cords of yellow elastic tissue, have been well named "fibres," while the elementary muscular fasciculus totally distinct from them in anatomical characters, has been termed a "fibre." This word has also been applied to the delicate line-like markings seen when a band of white fibrous tissue is examined. Although this seems to be composed of a collection of minute threads, it is impossible to separate a band of white fibrous tissue into a number of minute individual elementary fibres. This tissue may be truly said to exhibit a *fibrous appearance* under the microscope, but it is not possible to split it into fibres of any determinate size. Most observers, however, attach a

definite meaning to this word. By *fibre* is understood the elementary cords of a number of which many tissues are composed; the fibres may pass in various directions, interlace with each other, or be completely coiled up, but they must consist of the same structure throughout. In this sense, the term would seem inapplicable to the elementary muscular fasciculus. Structures presenting a granular and fibrous appearance, are represented in pl. XXIV.

Whenever we observe lines parallel to each other, much curved, or interlacing in various directions, whatever their length may be, we speak of this as a *fibrous material*, and say that the tissue has a *fibrous texture*.

190. Of the manner in which Fibrous Appearance may be Produced.—A "*fibrous appearance*" is very often fallacious—thus, a delicate membrane arranged in a number of plaits or folds, may be mistaken for fibrous tissue. Capillary vessels, when quite free from blood and stretched somewhat, have a *fibrous appearance;* but it is hardly necessary to say that no real fibres can be demonstrated. Delicate nerve-fibres appear in textures immersed in water and aqueous fluids as mere fibres and these are usually included in immense number in various forms of connective tissue; the masses of germinal matter or nuclei in connection with them being summarily dismissed as connective tissue corpuscles. Many of the drawings in some of the best German text books are most defective in this particular, representing nerves, capillaries, and other delicate structures distorted by preparation as mere "*binde gewebe.*" In describing appearances seen in the microscope, it is important to ascertain whether the appearance is produced by the presence of real fibres, or merely depends upon striations caused by the mode of development and growth of the tissue, and this can only be determined in many cases by very careful and patient inquiry. The matter which exists between the basement membrane of a gland tube or follicle, and the capillary vessels and nerve-fibres embedded in it, is often spoken of as a "*fibrous matrix*," or as "connective tissue," but at least in many cases in which this term has been employed, the fibrous appearance has been due merely to the crumpling of the capillary walls and basement membrane in consequence of pressure. If the vessels be injected with a perfectly transparent fluid, such an appearance is no longer visible, in consequence of the thin transparent membrane of which the capillaries are composed, being put upon the stretch. The most perfectly transparent material when thrown into longitudinal parallel folds, exhibits a striated appearance which without very careful examination would certainly, but most improperly, be termed *fibrous*.

191. Membrane.—This term is applied to a variety of structures. Basement membrane is restricted to that clear, transparent, and

excessively thin expansion, which separates the epithelium from the vessels and other structures beneath it, but which exhibits a continuity of structure with the delicately fibrous connective tissue in which these ramify. The term *limitary membrane* has also been used, but it possesses no advantage over the former. The general characters and disposition of basement membrane in the different glands, has been described by Bowman in his well known article "*Mucous Membrane*," in the "Cyclopædia of Anatomy and Physiology," published in the year 1845.

Basement membrane is often so thin, that its thickness cannot be measured, though it is certainly less than the 1-20,000th of an inch. The student will find that the best organ for obtaining easily a good specimen of basement membrane, is the kidney. A thin section may be cut with a sharp knife, or Valentin's knife, and after being well washed so as to remove the epithelium—the basement membrane of the tubes, and the vessels, alone remain. Frequently empty transparent tubes may be seen projecting from the edges of the section, and the membrane of which they are composed is sufficiently firm to prevent the tube from collapsing. In the finest ducts of the liver the basement membrane is of extreme tenuity, although its presence may be satisfactorily demonstrated in injected specimens, pl. XXV, fig. 194.

"Basement membrane," is always perfectly passive. That it results from changes occurring in germinal matter can be demonstrated by tracing its development. It is lifeless and quite incapable of giving rise to any new structures whatever. It cannot reproduce cells removed from its surface, but in many cases small masses of germinal matter remain upon it by which new cells are formed. The cells do not grow from the basement membrane, as has been supposed.

Besides being spread out as a smooth expansion covered with epithelium, the surface of the basement membrane and structures associated with it, are frequently increased by being thrown into deep projecting folds, or prolonged into little tongue-like processes projecting from the general surface. On the other hand, there may be a folding-in of the membrane to form little crypts or follicles, which are of course lined with epithelium. Such is the structure of the simplest form of *gland*. The more complex glands differ principally in the increased extent and more complicated arrangement of the interior of the follicle. This simple inflexion of mucous membrane increased very much in depth, becomes a *tubular gland*. When the tubes are connected together by transverse branches, we get a *network*. If the follicle be supposed to be divided into numerous small cavities by incomplete septa, while its aperture is altered into a constricted tube or duct, we have a *follicular gland*. If a number of these follicles be

Fig. 193.

Arrangement of muscular fibres, nerves, and tracheæ of the common maggot. The muscles represented are concerned in shortening the body. They are connected at each extremity with one of the segments. The contractile tissue of the muscular fibre in the centre of the drawing has been ruptured, and has contracted within the tube of the sarcolemma. A fine branch of the nerve trunk is seen to cross the sarcolemma and give off a still finer branch, which, after being followed for a short distance, appears lost upon the sarcolemma. If the nerve trunk be traced, many other branches distributed in a similar manner will be observed. The tracheæ, represented only in one part of the drawing, are black. × 40. p. 165.

Fig. 194.

Connection of duct with cell—containing network from a fatty liver of the pig. Injected with Prussian-blue fluid. The small trunk, *a*, gives off several smaller branches, *b*, distended by the injection which has reached the cell—containing network. × 215. p. 165.

1000th of an inch ⌴ × 40.
" " ⌴ × 315.

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arranged together, a *conglomerate gland*, like the salivary, pancreatic, or mammary gland, is formed.

In all these cases the basement membrane takes the form of the gland. In the case of a tubular gland, like the kidney, we may remove the whole of the epithelium from the interior, and a simple tube of basement membrane remains. This membrane intervenes between the epithelium and the capillary vessels, which are often connected with it, and through it everything separated from, or absorbed into, the blood, must pass. It has no visible holes, but is readily permeable to fluids. In many cases it permits the transudation of fluids in both directions; in other instances only in one, and sometimes it allows one fluid to pass in one direction, and another in the opposite.

In many cases there can be no doubt that basement membrane is modified connective tissue. It is continuous with it, and when thickened, the fibrous structure can be discerned, nerve fibres and capillaries often enter into its structure and cannot be separated from it. (See the drawings of sarcolemma of muscle, the tubular network of the liver, pl. XXV, fig. 194, and the uriniferous tube of the kidney represented in fig. 191, pl. XXIV, and consult my memoir "New Observations on the Structure and Formation of Nerve Fibres and Nervous Centres, 1864," reprinted from the Phil. Trans.)

In disease this texture is liable to undergo great alteration. It may be increased in thickness to such a degree, as to be nearly impermeable to fluids which passed through it very readily in health. It may become granular from the deposition of albuminous, calcareous, or oily granules. Oil globules may be deposited in it. It may be separated from the capillaries which supply it by collections of oil globules, the accumulation of fluid, or by the effusion of material in which cells differing in every respect from those found in the parts in health, are developed, or which becomes converted into a new tissue. Or it may be rendered so brittle, that it gives way in many places under very slight pressure; and when examined under the microscope, it is seen to contain a number of pores or apertures. Such a condition occurs in the lung tissue in some cases of emphysema, as was first demonstrated by Mr. Rainey. Its properties may become so altered that a fluid which it retains in the healthy state will readily pass through it, or a fluid which passes through in the normal state with the greatest rapidity may be entirely prevented from permeating it in consequence of alteration in its texture.

192. Capillaries.—The capillaries are tubes composed of delicate membrane by which the blood is distributed to the various tissues. The material to nourish the tissue must pass through the capillary wall from within outwards, while the substances resulting from the disinte-

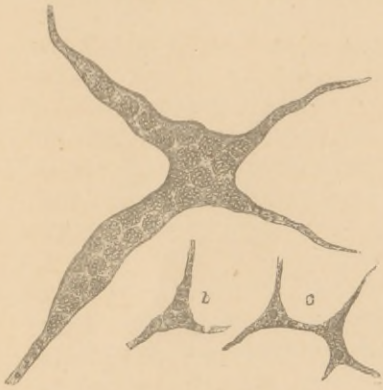
gration of the tissues must pass in the contrary direction. At definite intervals, often on alternate sides of the tube, are situated the masses of germinal matter or nuclei, which are probably intimately concerned in the preparation of materials for the nutrition of the tissues as well as in the absorption of certain substances from the tissues and their introduction into the blood, figs. 195 to 202, pl. XXVI. I think these masses of germinal matter may give origin to the so-called white blood corpuscles. As they alter much in size and sometimes project for some distance across the cavity of the capillary they will affect the rapidity of the capillary circulation to a very great extent. In certain cases of inflammation it appears that they increase in size to such an extent as to prevent the passage of the blood, pl. XXIX, fig. 225. These masses of germinal matter are extremely numerous, but they vary greatly in number in different vessels. They are very numerous in the capillaries of the brain, lung, and Malpighian bodies of mammalia, pl. XXVI, figs. 200, 202.

The blood is carried to the capillaries by the arteries, and returned to the right side of the heart by the veins. These channels are immediately continuous with one another, and the various structures of which the contractile coats of the arteries and veins are composed, gradually cease as the capillaries are approached.

The distribution of capillaries is different in every tissue, and the number of these vessels varies very greatly. Those structures in which active changes are going on being largely supplied with blood, while those in which the nutritive changes are slow, contain few vessels. Cartilage and fibrous tissue are probably the least vascular tissues of the body, and their anatomical elements are separated from the blood by a considerable distance. During their development, however, vessels exist. The liver, on the other hand, is one of the most vascular organs, and every part of each secreting cell is within the distance of about 1-3000th of an inch from the blood, while the surfaces of most of the cells are only separated from it by a membranous interval, less than the 1-20,000th of an inch in thickness.

The capillaries cannot be properly examined unless they have been previously injected. If the observer wishes to examine their walls, or desires to ascertain the relation which they bear to adjacent parts, they must be injected with a transparent injection, and examined in fluid in as fresh a state as possible (see chapter II.)

Fig. 195.



From periosteum of tooth. Young vessel with included corpuscles (white blood corpuscles). At *a* it was continuous with a small artery. *b*, a vessel at an earlier stage. *c*, two cells showing how the tube is formed. The germinal matter of the 'cell' gives rise to the included corpuscles. × 700. p. 166.

Fig. 196.

Capillary showing masses of germinal matter projecting into its interior. Areolar tissue. Mouse. × 700. p. 172.

Fig. 197.

Capillary vessel from the mucous membrane of the epiglottis. Man aged 71. × 700. p. 172.

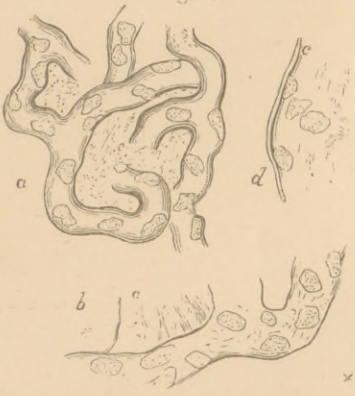
Fig. 198.

One of the masses of germinal matter from the interior of the capillary, fig. 197. × 700. p. 172.

Fig. 199.

Capillaries and small vein distended with blood corpuscles. Muscle. Cattle plague. × 130.

Fig. 200.



Capillary vessels from malpighian tuft. Human kidney. Showing nuclei connected with their walls. *a*, a few coils separated from the rest of the tuft. *b*, a portion of a loop showing nuclei a little flattened. *c*, tissue which connected the coils with each other. *d*, small portion of capillary pressed as much as possible to show thickness of wall at the point of reduplication. p. 166.

Fig. 201.

Minute artery and capillaries from a healthy brain. Human subject. × 215. p. 166.

Fig. 202.

Minute artery and capillaries from a case of white softening of the brain. Human subject. × 215.

100th of an inch ⌊⌋ × 130.

" " ⌊_____⌋ × 215.

" " ⌊_____⌋ × 700.

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DIPTHERIA.

CHAPTER V.

LYMPH, CHYLE, BLOOD, SALIVA, MILK, BILE.—*Examination of Blood.—New Researches on the Blood Corpuscles.—Blood in Disease.—Blood in Lower Animals.*—SERUM.—*Examination of Serous Fluids.—Fluid from Serous Cavities.—Fluid from Cysts.*—SPUTUM, VOMIT, FÆCES.—*Examination of Sputum.—Of Preserving Specimens of Sputum.—Extraneous Substances in Sputum.—Mucus.—Sputum in Bronchitis; Pneumonia; Phthisis; Tubercle; Fragments of Lung Tissue; Calcareous Substances.—Diptheria.—Entozoa and Vegetable Organisms in Sputum.—Other Structures met with in Sputum.—Examination of Vomit.—Examination of Matters passed by the Bowel.—Discharges from the Uterus and Vagina.—Detachment of Flakes and Firm Thick Layers of Epithelium from Mucous Surfaces.*—PUS.—TUBERCLE.—*Examination of Pus; Microscopical Characters.—New Observations on Pus—On the Poison or Virus of Contagious Diseases—Examination of Tubercle.*

LYMPH, CHYLE, BLOOD, SALIVA, MILK, BILE.

193. Lymph and Chyle.—A drop of lymph or chyle may be subjected to examination in a thin glass cell. Chyle can be obtained very readily from the thoracic duct or lacteals of an animal which has been fed with fatty matter for two or three hours before death (see page 75). The character of the corpuscles should be observed and their reaction with acetic acid studied.

There are masses of germinal matter both in lymph and in chyle, which are so extremely minute and transparent that they are passed over if the examination is conducted with ordinary powers, including the one twelfth of an inch object glass. Such particles are, however, of the highest importance, and well worthy of the most attentive examination. They are probably small portions of germinal or living matter which once formed part of a chyle or lymph corpuscle, but which have been detached, and are growing to form new corpuscles. It is remarkable that when separation has once taken place the

particles never again coalesce, although as long as the new corpuscle continues attached to the parent by the narrowest pedicle it may be drawn again into the general mass. In order to observe these points it is necessary to employ a $\frac{1}{25}$ or a $\frac{1}{50}$ of an inch object glass. By the use of these high powers not only do we gain the advantage of increased size, but objects which from their extreme tenuity are quite invisible to ordinary powers, magnifying as much as 700 diameters, are seen very distinctly with the aid of these highest objectives. These extremely delicate masses of living matter, not to be detected by ordinary examination, are the active agents concerned in the absorption of nutrient matters from without, and by their increase and multiplication alone, can new lymph and chyle be formed. The small quantity of fibrin present in these fluids is doubtless formed by the germinal matter only, pl. XXVIII, figs. 216, 218, 219. Perfectly pure lymph may sometimes be obtained for examination from a cutaneous lymphatic trunk, which opens upon the surface of a wound or ulcer. Such cases, however, are not commonly met with.

194. Examination of Blood.—In order to examine the blood, a small drop is placed upon a glass slide, and covered with thin glass, which is to be pressed down until a very thin, transparent, and almost colourless, stratum only remains, care being taken not to completely crush the corpuscles. If in this manner the individual globules cannot be seen distinctly, a little serum, or white of egg and water must be added; but it is better to avoid the addition of any fluid, if possible. Upon carefully focussing, the red globules will appear to present a dark centre and light circumference, or the reverse, according as the focus is altered, pl. XXVII, figs. 203, 204, and here and there a white corpuscle may be observed.

The white corpuscles are rather larger than the red, and have a granular appearance. Upon the addition of acetic acid, from one to three nucleus-like bodies make their appearance in the white corpuscles, and not unfrequently these may be seen without the addition of any reagents.

If a little strong syrup be added to a drop of blood, the corpuscles will become much flatter from exosmose of a part of their contents; while, on the other hand, if placed in water, they become spherical from endosmose, and swell up so as to be perfectly transparent and invisible. It is not difficult to make a solution of similar density to that of the corpuscle, in which they do not alter in form at all; and in this manner, as Dr. Rees expresses it, we may "take the specific gravity of a blood corpuscle."

Acetic acid causes the corpuscle to become more transparent and clear, and to swell up. After the application of this reagent, the

blood-corpuscle may be scarcely visible, but the material of which it is composed, is not dissolved. Strong hydrochloric and nitric acids do not dissolve the globules; by the latter reagent the outline is often rendered darker and thicker, while the entire globule is caused to shrink. Blood corpuscles are entirely soluble in ammonia and alkalies. They are rendered darker, and the walls corrugated, by the acid of the gastric juice; and, after remaining in acid urine for some time, a similar change occurs; hence the black colour of blood, which has been effused into the stomach, and the dark smoky hue of acid urine containing blood. This smoky hue is especially distinct in cases in which the blood has escaped from the uriniferous tubes, and has thus been gradually but very intimately mixed with the urine. Blood crystals, and the method of obtaining them, have been described. in § 167.

194.* New Researches on the Blood Corpuscles.—The facts above noted can be demonstrated by magnifying powers in ordinary use, but it is not too much to say that in consequence of recent investigations with much higher powers, our views concerning the nature of the blood corpuscle and the changes taking place in the blood have been completely altered. An almost entirely new field for elaborate and highly important physiological and pathological enquiry has been quite recently laid open. I propose to advert very briefly to some of the facts which seem to me of greatest importance, and which, if followed up, will certainly lead to the discovery of new lines of highly important investigation.

Of the red blood Corpuscles.—The red blood corpuscle of man and mammalia generally consists of a mass of soft viscid matter, perhaps of the consistence of treacle, composed of hæmatocrystallin. It is at least in certain states soluble in water, but is only dissolved by serum and the fluid part of the blood very slowly. The outer part of this matter is of firmer consistence than the interior, especially in the older corpuscles. When the latter are placed in water the more soluble matter is dissolved, leaving the harder external portion. By the action of many chemical reagents the outer part of the red blood corpuscles is condensed. These and other appearances have led observers generally to the conclusion that the red blood corpuscle was a cell containing fluid contents, and so firm has been the conviction that this was so, that the rupture of the "cell," and the escape of the contents have been spoken of as if they had actually occurred and had been seen. That the red blood corpuscle is not a cell is proved conclusively by the following facts:—

1. A red blood corpuscle may be divided into many smaller por-

tions, every one of which assumes the spherical or spheroidal form, and in many cases become stellate, pl. XXVII, fig. 205.

2. The mass of germinal matter in the case of the nucleated blood corpuscle of the frog and other vertebrates, or a portion of it, may pass right through the red viscid material of which the outer part of the corpuscle is composed without the rupture of any membrane, just as a solid particle might pass through treacle or molten pitch, pl. XXVII, fig. 208, *a*, *b*, *c*.

3. A red blood corpuscle from Guinea pig's blood assumes the crystalline form very readily, and without the addition of any reagent. The process may be watched under the microscope, and a single corpuscle seen to become a single crystal, or by the application of a gentle heat a corpuscle may be broken up into several smaller portions, every one of which becomes a tetrahedral crystal, pl. XXVII, figs. 209, 210.

4. Several red blood corpuscles under certain circumstances run together, forming a soft homogeneous viscid mass, in which nothing like cell walls or the remains of such structures can be seen, and which undergoes crystallization in every part without exhibiting indications of cell walls anywhere, fig. 206.

5. When water is added to blood corpuscles, they swell up just as a piece of jelly would swell up, but they do not burst as is generally stated. No doubt soluble matters are dissolved out, but as the water evaporates, the corpuscles assume their previous form, although they appear paler than before. Although many appearances may be urged in favour of the existence of a cell wall, the above facts and those learnt from studying the changes taking place during the development of the corpuscle, seem to be absolutely incompatible with such a view. Neither here nor elsewhere is the 'cell wall' a necessary or essential portion of the elementary part. A thing may arise from a thing which existed before it, grow, live, perform its offices, and increase its kind, without having a cell wall at any period of its existence, and cell walls may be easily made artificially; so that in spite of the importance hitherto attached to it, the 'cell wall' is of no real significance.

It is generally stated that the red blood corpuscles of an animal exhibit a certain definite size, but it will be found that they vary extremely, so that corpuscles exist of various dimensions. With the highest powers not only do we meet with extremely minute corpuscles, but many of these are so very transparent that they could not be seen at all under a lower power. Extremely transparent bodies are demonstrated under high powers, which would certainly be passed over by those in ordinary use. The reader is referred to pl. XXVIII, fig. 217,

in which the various corpuscles met with in healthy blood are represented. It is probable that these very small pale corpuscles are young blood corpuscles gradually undergoing change, and acquiring colour and the characters of the red corpuscles, as the colourless germinal or living matter of which they are at first composed, gradually becomes converted into the coloured formed material, fig. 211.

Red blood corpuscles often assume a stellate form, pl. XXVIII-IX, figs. 217, 222, which is not very easily explained. As this has been observed in certain cases of disease it has been regarded by some as a morbid change. Not only is it commonly observed in the case of corpuscles found in perfectly healthy blood, but these may be divided and subdivided into very small portions, every one of which exhibits the stellate appearance, pl. XXVII, fig. 205. Nor do I think that this can be due to changes occurring in germinal matter, for although masses of germinal matter do often assume a stellate form, the red blood corpuscles of the Guinea pig become stellate soon after their removal from the vessels, and certainly in some cases the sharp spine-like projections formed have been seen to become the angles of tetrahedral crystals. See pl. XXVII, fig. 210.

Of the White or Colourless or Living Blood Corpuscles. The general nature of the white blood corpuscles has been already referred to, and the student has been recommended to study the movements which take place in it during its life. It has been shown how protrusions occur which become detached, and thus from one living corpuscle several minute particles of living germinal matter may be derived. These may ultimately assume the characters of the ordinary full sized white corpuscles,—or passing into the current of the circulation, and being exposed to the influence of the respiratory and other processes may continue to grow, and at the same time change. The living germinal matter becomes gradually resolved into the red lifeless hæmato-crystallin, which accumulates, and probably into other substances, which escape. The hæmato-crystallin is probably diffused through the germinal matter, and this latter being perfectly transparent and colourless, cannot be distinguished. Shortly before death, however, a change occurs in these young corpuscles, the germinal matter moves away leaving the lifeless coloured material behind, pl. XXVII, fig. 207. As the corpuscle advances in age, more and more germinal matter becomes resolved into formed material, until at last the red corpuscle consists of the latter substance only. It is entirely dead and is then subjected to physical and chemical changes, being gradually disintegrated and dissolved, and converted into new compounds. In the nucleated red blood corpuscles of the frog, the germinal matter remains as the

nucleus, but even here corpuscles may be found which contain a mere speck of living matter only, pl. XXVIII, fig. 212, while others are almost entirely composed of it, being merely invested as it were with a very thin coating of the coloured matter, pl. XXVIII, fig. 211 *a*, *b*, *c*, *d*.

White blood corpuscles are no doubt derived from the lymph and chyle corpuscles by the formation of offsets or protrusions, and I think it probable that the masses of germinal matter which project into the interior of the capillary vessels may also give origin to them, pl. XXVI, figs. 195, 196, 197. I cannot too strongly recommend the advanced student to study these points which are of the highest importance in connection with many diseases, especially pyemia and the whole class of contagious diseases. It seems to me probable that living particles of contagium gaining entrance into the blood, affect the growth or modify the changes occurring in the young corpuscles, and thus lead to numerous secondary phenomena which are familiar to us. So also it seems possible that the influence these particles exert upon one generation of young corpuscles may affect succeeding ones for a longer or shorter period, and in this way perhaps may be explained the immunity of the individual to subsequent attacks of the same disease.

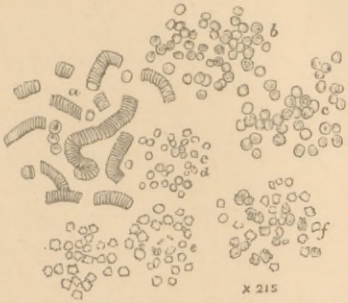
I have considered these points which are here only alluded to most cursorily in two papers, "on the Nature of the Red Blood Corpuscle," and "on the Germinal Matter of the Blood," read before the Microscopical Society, December 9th, 1863. The whole subject is fully discussed in a memoir of upwards of 160 pages, by Professor Arthur Boettcher, in a recent number of Virchow's Archiv, vol. xxxvi, p. 342. In this paper a full historical account of observations on the red blood corpuscle will be found, and the researches of various observers, including those published in the first of my papers, are very carefully criticised.

195. On Estimating the Number of Blood Corpuscles.—This operation may be effected roughly by placing a drop of blood upon a glass slide, and pressing very firmly upon it a small piece of thin glass so as to obtain the thinnest possible stratum for examination. Upon examining this with a quarter, an approximative idea of the number of corpuscles in a small area which has been carefully marked out, may be formed. If specimens of the blood of patients suffering from various diseases be examined in this way, the greatest differences in the number of the corpuscles will be observed. Vierordt has proposed a plan for determining the number of corpuscles in a given quantity of blood numerically, by the microscope, and Welcker has improved upon this. It is obvious in such very minute researches

Fig. 203.

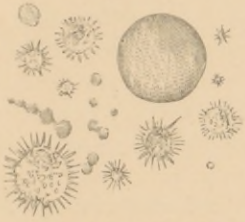
Blood corpuscles from healthy human blood. × 215. p. 168.

Fig. 204.



Human blood corpuscles. *a, b, c,* from the living body; *d, e, f,* from the urine. × 215. p. 168.

Fig. 205.

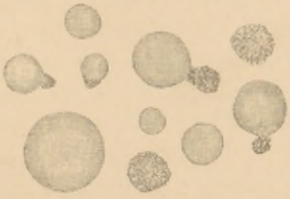


Human red blood corpuscles, dividing into spherical and stellate particles after pressure. × 1800. pp. 170, 171.

Fig. 206.

Blood crystals from the blood of the guinea-pig. × 700. pp. 127, 171.

Fig. 207.



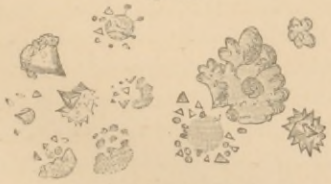
Colourless germinal matter separating from formed material of young human blood corpuscles. × 1800. p. 171

Fig. 208.

Portion of germinal matter tending to separate into smaller portions.

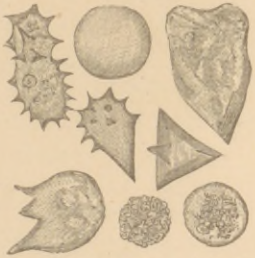
Portions of germinal matter which have divided into smaller portions, some of which have passed through the formed material into the surrounding fluid. p. 170.

Fig. 209.



Disintegration of red blood corpuscles of guinea-pig's blood, and formation of crystals, after application of a gentle heat. × 700. p. 170.

Fig. 210.



Formation of blood crystals from the red blood corpuscles of guinea pig's blood, shortly after removal from the body. No reagent added or heat applied. × 1800. p. 171.

1000th of an Inch ⌊⌋ × 215.

" " ⌊——⌋ × 700.

" " ⌊————————⌋ × 1800.

[To face page 172.

the slightest error becomes very great, when, from these data, the amount in a large quantity of blood is calculated. The operation is a very delicate one, and requires great care. As a full description of it would occupy much space, I think it better to refer those who desire to employ it, to the original paper, than to give a short summary of the plan which would be practically useless.*

196. Blood in Disease.—The best way of examining blood is to place a drop on a glass slide, cover it with thin glass, and at once submit it to microscopical examination, but where this is not possible, the blood may be collected in the fine capillary tubes now used for vaccine lymph. These tubes may be easily made by drawing out a piece of glass tube in the flame of a spirit lamp. The capillary tube may be broken into pieces about three inches in length. The drop of blood at once runs up the tube by capillary attraction. A space must, however, be left unfilled. Each end of the tube is then to be hermetically sealed, care being taking not to permit the heat to boil the blood, otherwise it will be driven from the tube by the sudden expansion of the vapour set free. To prevent this accident, the tube should not be filled to within $\frac{3}{4}$ of an inch of each end.

In looking at a drop of healthy blood, besides the red corpuscles, here and there a larger white or colourless corpuscle is seen. The relative number of these should be carefully noted, as in disease they are liable to increase enormously. In health there is one white corpuscle to about fifty red ones. The condition in which they are much increased in number is frequently associated with enlargement of the spleen, and lymphatic and mesenteric glands, and has been termed "Leukhemia;" or, more correctly, "Leucocythemia," or "white-cell blood disease," by Professor Bennett. In extreme cases, white or colourless corpuscles are almost as numerous as the red, and they appear much more so, because the red-blood corpuscles collect together in little piles, while the white remain separate and distinct, and occupy the intervals or spaces thus formed. The surrounding fluid sometimes contains granules, and vast numbers of extremely minute corpuscles may be discerned by the highest powers. Upon being treated with acetic acid, the cells swell up a little, become more transparent, and usually display one, two, or even more roundish bodies in the centre, much resembling those developed in the pus globule, by the action of the same reagent.

In some cases of cholera, several cells, much larger than the white corpuscle, have been found in the blood, although it is probable that

* Vierordt in "Vierordt's Archiv," Jahrg. II, Heft I. Dr. Welcker in "Archiv. des Vereins für gemeinschaftliche Arbeiten zur Förderung der Wissenschaftlichen Heilkunde," vol. i, page 161.

their nature is closely allied to these. In a case which I had an opportunity of examining, some years ago, many of these large cells contained oil globules, collected together in one part, leaving the remainder of the cell perfectly clear and transparent as if the endosmosis of fluid had occurred, pl. XXIX, fig. 221. I have also seen very large white blood corpuscles in cases of pyemia.

Sometimes blood corpuscles adhere together with unusual tenacity. Of this I met with a very unusual example in the year 1854. The case was that of a man aged twenty-six, who was suffering from kidney disease. The corpuscles in the defibrinated blood manifested so great a tendency to cohere, that they collected in small masses, looking like minute dots to the eye, floating in a clear serum, when a thin stratum of the blood was examined. By pressure they were made to separate, but soon adhered again. In this case, there certainly appeared to exist an *attraction* of the corpuscles for one another. It seems impossible to explain the circumstance by supposing any unusual alteration in the density of the serum and corpuscles, pl. XXIX, fig. 220.

The adhesion of the blood corpuscles above described is met with in many cases of cholera, but I think the following observation renders it probable that it has no special relation to that disease, but is due simply to the blood being deprived of much of its water. One day I took some Epsom salts which produced three very copious liquid stools. I examined a drop of blood from the finger, and found the corpuscles adhering exactly as represented in fig. 220. I then took three tumblers of warm water, and in less than an hour after the first observation was made, the blood corpuscles exhibited their ordinary characters forming the piles of disks, but not exhibiting the peculiar tendency to adhesion above referred to.

But the most interesting, and probably by far the most important of the changes yet observed in blood in disease, is the presence of a number of masses of germinal matter and products resulting from their death and decay, which are not present in the healthy blood, and there is reason for thinking that these particles have obtained entrance from without and made their way through the thin capillary walls and thus became mixed with the circulating fluid. By their multiplication in the capillaries circumscribed local congestions are caused and in this way peculiar 'eruptions' and 'rashes' result. In many cases the congestion ends in complete stagnation, followed by suppuration (boil, carbuncle pustule), and the death, destruction and removal of the portion of tissue affected; or it is followed by the escape from the blood and lymphatics of serum and small particles of germinal matter which multiply for a time in the substance of the cuticle, the superficial portion

Fig. 211.

Young red blood corpuscle not yet coloured. Frog. × 1800.

Young red corpuscle. Frog. Formation of coloured portion. × 1800.

Young red corpuscle. Part of coloured portion fully formed. × 1800.

Young red corpuscle, coloured portion and nucleus. × 700. p. 175.

Fig. 212.

Old red corpuscle. Frog. Nearly the whole of the germinal matter has been converted into colourless formed material. p. 175.

Fig. 213.

Division of very young corpuscles (white corpuscles) and formation of outer coloured portion

Fig. 214.

'Nucleus,' 'nucleolus,' and outer red formed material. p. 175.

Fig. 215.

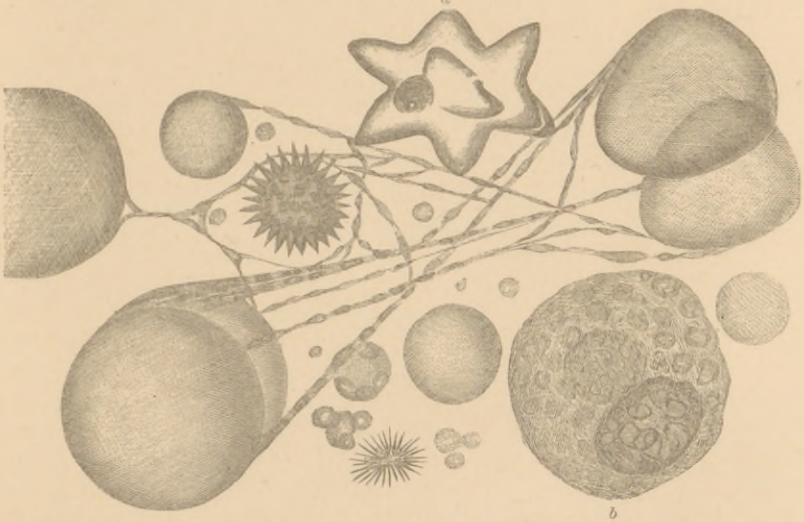
Movement of germinal matter towards surface.

Division of germinal matter or nucleus.

Fig. 216.

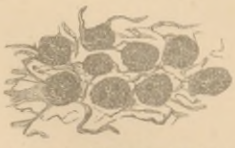
Portion of a large mass of fibrine from guinea-pig's blood the instant coagulation had occurred. × 1800.

Fig. 217.



Red and white corpuscles in blood from the finger. × 2800 linear. The large smooth circular bodies are the red corpuscles. Three very small red corpuscles are less than the $\frac{1}{3000}$ of an inch in diameter. The smallest particles are composed of matter like that of which the white blood corpuscle (*b*) consists. Threads of fibrine undergoing coagulation are observed between the corpuscles in the upper and lower part of the field. *a*. red corpuscle, exhibiting angular projections. Below it, and to the left, is another, with still more pointed processes. September, 1863. p. 171.

Fig. 218.



From a pale clot in the heart of a patient who died of exhaustion, showing white corpuscles and fibres of fibrine. × 700.

Fig. 219.

White blood corpuscle (human subject), with a thread of fibrine being formed from it. × 1800.

$\frac{1}{1000}$ of an inch × 700.

" " × 1800.

$\frac{1}{3000}$

" " × 2800.

[To face page 171.

of which is elevated (vesicle, bulla), the fluid and corpuscles drying up and forming with the altered cuticle and secretion of the sebaceous glands, a *scab* or *crust*, or a raw, moist surface, which does not readily heal, known as an *ulcer*, is formed beneath the detached layer of cuticle.

The particles of germinal matter above referred to, become obstructed in the capillaries, and although there may be vast numbers in the circulating fluid, we should not expect to find them in the mass of the blood. Nor is it likely that they would be readily detected in blood drawn from the capillaries themselves, for they would form little collections which would not readily escape, but would adhere to the capillaries, particles making their way through their walls, and growing and multiplying in the surrounding tissues. Hence in order to demonstrate these particles, we must most carefully examine the tissues themselves in the manner referred to in § 101, for without preparation, as is well known, not even the smaller vessels can be demonstrated. I have, however, succeeded by squeezing the blood *from* the capillaries towards an opening in a vein, in obtaining clots with numerous particles of germinal matter. The examination must be made very soon after death. By the death and decay of these particles of germinal matter numerous granules, many oil globules, and myelin particles result.

I have discussed this subject in my reports on the Cattle Plague and Cholera, but I select a few of the drawings which will, I think, enable the reader to understand the views which I have been led to adopt.

Drawings illustrating the above remarks will be found in pl. XXIX, figs. 222, 223, 224, taken from my report on the Cattle Plague. Fig. 225, shows how the masses of germinal matter belonging to the capillary walls increase in size in all fevers and inflammations, in consequence of being supplied with an increased proportion of pabulum. A further stage of the same process would be the formation of pus, involving the destruction of the affected capillaries and tissues in the immediate neighbourhood.

197. Blood of Lower Animals.—The blood of the lower animals, particularly of the frog, newt, and fish, should be examined when opportunities occur. The oval form of these corpuscles seems to be determined by the circumstances of the circulation, for the oval corpuscles (except the oldest, fig. 212), of the frog assume the spherical form if placed in glycerine and water, pl. XXVIII, fig. 211 *d*. The size of the colourless corpuscles in these different animals may be compared, and it is interesting to observe the relation which they bear in size and number to the red globules in them, as well as in man.

In the substance of some of the blood corpuscles of the spleen of

the dog, and of certain fish, as the perch, and other animals, two or three little yellowish crystals have been observed (Funke, Kölliker). Sometimes, in examining a clot of blood, which has been effused in the brain, or in other situations, and which has remained there for some time, red crystals of hæmatine may be found in connection with altered red blood corpuscles. The subject of blood crystallization has been considered in § 167.

The phenomena of the circulation of the blood are better studied in the foot of the frog, in the tail of the minnow or stickleback, or in the branchiæ of the young newt. Among mammalia, in the wing of the bat. See page 73.

198. Saliva.—The examination of saliva presents no difficulty. The fluid is perfectly transparent and viscid, but it holds in suspension, besides epithelium from the mouth, a number of small cells, for the most part of an oval or spherical form, which are probably derived from the ducts of the gland. These are about the 1-2000th of an inch in diameter, and are sometimes called "Salivary Corpuscles." In some cases they accumulate in great number, and closely resemble pus corpuscles. Some observers consider them to be altered epithelium from the cavity of the mouth, but this can hardly be the case, as they are often met with in the absence of any of the characteristic cells of scaly epithelium. They are found in great number in cases of salivation. In the somewhat viscid matter of which the salivary corpuscle is composed are multitudes of highly refracting particles in incessant motion. The nature of these particles is extremely doubtful. They look very like the germs of bacteria, and it is possible they may be of this nature. They should be examined under a $\frac{1}{25}$ or $\frac{1}{50}$. Occasionally the salivary ducts have been found to contain a considerable number of small, white, granular masses, which are perfectly spherical, and consist of cells filled with large oil globules, or they are perhaps mere collections of oil globules. Sometimes microscopic calculi are found. Epithelium from the mouth is represented in pl. XXX.

199. Examination of Milk.—The examination of milk presents no difficulties. All that is necessary is to place a drop upon a glass slide and cover it with a piece of thin glass, employing slight pressure so as to get a very thin stratum. The general characters of the oil globules, and the fact of their not running together, and forming larger globules when pressed, should be noticed, pl. XIX, fig. 136. This is prevented by the casein investment which surrounds each globule, and which may be demonstrated as follows. If the drop of milk be treated with a little acetic acid, the form of the globule is much altered, and if the acid be strong, the membrane will

be dissolved, and several will run together, forming a larger globule. Again it will be found that ether will not dissolve the oil globules of the milk unless a little carbonate of soda, or some other alkaline salts, capable of dissolving this membrane, be previously added, when the ether immediately effects the solution of the oily matter. This very instructive experiment may be performed in a test tube, or upon a glass slide, under the microscope; the reagents being most conveniently applied by using the little bulbs, § 138. In the figure some globules thus treated are seen running together.

The colostrum, or milk secreted first after delivery, will be found to contain many large cells, consisting of an investing membrane, filled with oil globules resembling those which are floating free in the surrounding fluid.

By microscopical examination, the most common adulterations of milk can be readily detected,—such, for instance, as chalk and flour (starch globules). It has been said that milk has been adulterated by the addition of sheep's or other animals' brains. Such cases must be very rare, as brains could not be mixed to make a fluid, either in appearance or taste, like milk. Fragments of vessels, nerve-tubes, and cells, would be readily detected upon microscopical examination. The only adulteration of milk which is worth consideration is perfectly harmless and consists of water, which is added in certain proportion, to what perhaps was originally skimmed milk. This most dishonest practice no doubt exists to a deplorable extent and ought to be prevented by legislation. Occasionally patients mix milk with urine, saliva, or tears in order to impose upon us. The oil globules with their envelopes of casein, the precipitation of casein by the addition of acetic acid, or when the fluid becomes acid, enable us to pronounce upon the nature of the fluid.

200. Examination of Bile.—The only insoluble substances met with in bile are epithelial cells of a columnar form, occasionally crystals of cholesterine, and very frequently minute dark yellow particles consisting of inspissated bile. Sometimes these are nearly spherical, almost like very minute calculi. The observer must remember that in examining the bile of many of the lower animals, especially the sheep, he may meet with the ova of entozoa, which sometimes pass into the bile in immense numbers. In the bile of fishes these are often very numerous; some of them have a very peculiar appearance, and have been mistaken for cells. Little solid particles and masses of epithelium often become the nuclei of gall stones. The mode of crystallizing bile is described in § 168.

Serum.

201. Examination of Serous Fluids.—Serous fluids may be

poured into a conical glass vessel, and allowed to stand until all the deposit has collected. A small quantity may then be removed by a pipette, in the usual way, and examined in the microscope. The microscopical characters of a serous fluid of doubtful origin, should be contrasted with those of ascitic fluid, the fluid of hydrocele, and serum from ovarian and other cysts. Portions of hydatids and claws of echinococci are sometimes met with in fluids removed from a cavity which contains, or communicates with, an hydatid cyst. The deposit should be carefully examined in the microscope, as the hooks are readily detected, and the nature of the case at once becomes evident. The deposit from a serous fluid removed from the chest of a girl, is represented in pl. XX, fig. 145. Albumen in a serous fluid can always be detected by the application of heat, or upon the addition of nitric acid.

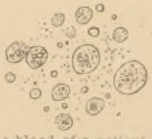
202. Fluid from Serous Cavities.—The clear serous fluid which collects sometimes to a great extent in the peritoneal cavity (ascites), will be found, if recently effused, to contain but traces of cells, or cell débris; but after the disease has been of long standing, the surface of the peritoneum becomes altered, and covered with a vast number of granular and almost spherical cells, varying very much in size, and not usually containing a distinct nucleus. A moderately-abundant deposit often takes place after the fluid has stood for some time. In other cases, which are of a more acute character, the fluid is found to be of a greenish or dirty-yellow colour,—opaque, with numerous flocculi and shreds of false membrane suspended in it, or attached to the surface of the peritoneum. In such a specimen, pus globules, with many of the cells above referred to, and fibrillated shreds of fibrin, would be found with other cells, which are darker in consequence of being filled with minute oil globules. The flocculi present a delicately fibrous appearance, with numerous cells entangled in the meshes formed by the interlacement of the fibres. Plates of cholesterine are sometimes found in ascitic fluid. The fluid which accumulates in hydrocele is usually perfectly clear, containing a few delicate cells, and, perhaps, a few free oil globules; spermatozoa are sometimes met with, and occasionally many plates of cholesterine are present.

203. Fluids from Cysts.—Upon contrasting the chemical and microscopical characters of the serous fluids just alluded to with those which are found within the cavities of cysts, a marked difference is always observed. As an example of a cystic fluid, ovarian serum may be instanced; but the fluid found in cysts occasionally met with in different parts of the body, as in the antrum, in the eyeball, thyroid gland, the mamma and

Fig. 220.

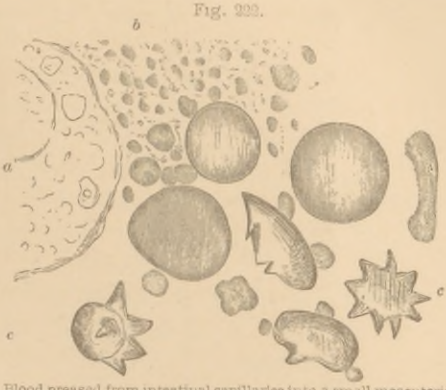
Blood corpuscles, adhering very intimately to each other; when pressed beneath the thin glass they separated, but soon became attached again. On attempting slight separation they became drawn out in a string-like form. × 215. p. 179.

Fig. 221.



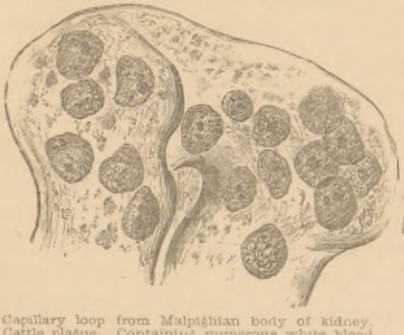
From the blood of a patient suffering from cholera. × 215. p. 174.

Fig. 222.



Blood pressed from intestinal capillaries into a small mesenteric vein. Cattle plague. *a*, part of white blood corpuscle in outline. *b* minute particles of germinal matter in immense number in all parts of the field. The smooth round bodies are young red corpuscles. The angular corpuscles *c*, are old and altered red blood corpuscles. × $\frac{1}{50}$th. p. 171.

Fig. 223.



Capillary loop from Malpighian body of kidney. Cattle plague. Containing numerous white blood corpuscles and many minute particles of germinal matter (contagium?) × 700. p. 150.

Fig. 224.

Capillary vessel from the surface of a villus, containing large masses of germinal matter. × 700. pp. 150, 166.

Fig. 225.

Capillary. Connective tissue. Cattle plague. The masses of germinal matter of the capillary are very much enlarged, and are dividing and subdividing to form new masses. × 700. p. 166.

Fig. 226.

Deposit from ovarian fluid. *c*, blood corpuscles rendered spherical by endosmosis.
× 215. p. 179.

1000th of an Inch ⌊⌋ × 215.
" " ⌊_____⌋ × 700.
" " ⌊_____⌋ × 2800.

[To face page 178

other organs, &c., will be found to present very similar characters.

The deposit of ovarian fluid consists usually of cells, free granular matter, oil globules, and perhaps blood corpuscles. Not unfrequently, many crystalline plates of cholesterine are observed in it. The cells are composed of at least two distinct forms :— 1. Small, delicate, transparent, and faintly granular cells, without the slightest appearance of a nucleus, some being somewhat larger, and others smaller, than a pus corpuscle. 2. Large cells, often as much as the thousandth of an inch in diameter, but varying in size, of a dark colour by transmitted, and white by reflected light. These, which have been termed "granular corpuscles," "compound granular cells," "inflammation globules," &c., are aggregations of minute oil globules in a cell form. They are almost constantly present in the fluids which are now under consideration, and have a structure apparently identical with that of cell-like bodies presenting similar characters, and found frequently in softening of the brain, pl. XIX, fig. 138,—sometimes in the coats of vessels undergoing fatty degeneration, in the sputum—especially in pneumonia in an advanced stage, in cystic tumours of the breast, in malignant growths, in the urine in certain cases, and in other fluids and solid structures in a state of degeneration. In all instances, the fatty matter abounds in cholesterine, which crystallizes out of the oily fat in which it was dissolved. I have seen cases in which the cholesterine crystallized after cells of this kind had for some time been preserved as permanent objects. Its presence can always be demonstrated by treating the cells with a little dilute alcohol and allowing the solution to evaporate spontaneously. The attention of the student is particularly directed to the occurrence of cells of this description in various morbid products.

Fig. 226, pl. XXIX, represents the appearance of the deposit from a specimen of serum obtained from a case of ovarian dropsy. In some rare cases ciliated epithelium is met with in the fluid of ovarian cysts. Fig. 187, pl. XXIV, was taken from a specimen I met with seven years ago. The cyst from which it was removed was originally developed from the ovary, and was not connected with the Fallopian tube.

Sputum.—Vomit.—Fæces.

It is proposed to give a short description of the microscopical appearances of the different varieties of sputum which come most

frequently under the observation of the practitioner,—the nature of which may affect the diagnosis of the case. It is now generally admitted that in some cases much is to be learned by a careful examination of the sputum in the microscope, and there are even a few instances in which the nature of morbid changes going on during life has been ascertained, and a decided prognosis justified at a very early period of the disease, when there were really no other symptoms to attract special attention, and but little was discoverable from a most careful investigation of the physical signs. It is, however, quite true that the nature of many cases is to be satisfactorily ascertained without resorting to a microscopical examination of the sputum, and there are some in which the microscope does not afford the slightest help. At the same time, every practitioner should be familiar with the microscopical characters of the principal varieties of sputum; for in the course of practice he will certainly now and then meet with an obscure case, in the diagnosis of which the microscope will afford him valuable aid.

The observer should make himself thoroughly familiar with the different forms of epithelium which occur in sputum, particularly the epithelium from the mouth and tongue, and he should remember that many small particles of food are often found entangled amongst the long hair-like epithelial growths detached from the conical or filiform papillæ.

In searching for any particular substance in sputum, the observer must not rest contented with the examination of one, two, or three specimens; but many portions, taken from different parts of the mass, should be examined. When fragments of pulmonary tissue are expected to be present, the examination should be conducted with great care, and a vast number of specimens should be placed under the microscope before any conclusion is arrived at, for small pieces may be scattered sparingly through the mass, and easily escape observation.

204. Examination of Sputum.—Some observers have recommended that the sputum should be thrown into water, so that certain pieces may be selected for examination; but I think, as a general rule, it is better to avoid the admixture of water, as it necessarily causes a physical alteration in many of the cells, and produces complete disintegration of some. Small pieces of sputum should be removed from the vessel with the aid of forceps and scissars, and placed upon a glass slide. It is better to remove at once two or three specimens from different parts of the sputum, and place them on the same glass slip for examination. As great difficulty is often experienced in removing portions, in consequence of the tenacious

character of the sputum, my friend Dr. Sansom has designed a pair of forceps which to some extent overcome this difficulty. These are represented in pl. III, fig. 19. The blades are slightly cup-shaped and the edges sharp, so that pieces of the viscid sputum can be easily cut off. Pieces of sputum will often require teasing out with needles upon the slide, and if, from the opacity of the specimen it is necessary to add a fluid, it is better to use a little glycerine and water, or white of egg. The specimen is to be covered with thin glass in the usual manner.

205. Of preserving Specimens of Sputum as Permanent Objects.—Specimens of sputum may be preserved in glycerine and water, and keep very well, but are rendered very transparent; the naphtha and creosote solution, dilute spirit, and water impregnated with arsenious acid are also employed for preserving sputum. The preservation of the recent characters of sputum is a matter of great difficulty. I have tried a great number of different preservative solutions, but have not succeeded in finding one which possesses all that is required. Many so completely alter the character of the cells, that they could not be recognized, while some have the effect of keeping the specimen very well for a time, but after the lapse of years it has undergone complete change. Dr. Andrew Clarke has strongly recommended certain solutions, the composition of which is given below. Upon the whole I find glycerine the best preservative medium.

Solutions for the preservation of sputum—

1. Spirit	1 ounce.
Creosote	30 minims.
Bichloride of mercury	1 grain.
Saturated camphor water ...	6 ounces.

Dissolve the bichloride in the water, then the creosote in the spirit; mix gradually, agitate, set aside for some days, and filter.

2. Arsenious acid and Goadby.

Make a boiling saturated solution of arsenious acid, when cool dilute with three parts of saturated camphor water. This forms the common A solution.

Take of this solution	1 part.
Take of Goadby's fluid	1 „
Take of saturated camphor water ...	1 „

Mix: allow the solution to stand for a week and filter once or twice. This fluid is very good, but it increases the fibrillation of mucin.

EXPLANATION OF PLATE XXX.

Fig. 227. From the dorsal surface of the tongue of a healthy man.
a. Oil globules.
b. Squamous epithelium.
c. Collections of vegetable growths.
d. Separated filaments of fungi.

Fig. 228. Epithelium from mucous membrane lining the cheeks.
a. Epithelial cells, with nuclei and nucleoli.
b. Sporules of fungi.

Fig. 229. Cells which have accumulated in the dilated extremity of the duct of a labial gland, the orifice of which was obstructed. These are, probably, imperfectly formed pus cells.

Fig. 230. The same, acted upon by acetic acid, showing the little bodies 'nuclei' in the centre, developed by the action of the acid.

Fig. 231. Cells contained in mucus, removed from the mucous membrane of the fauces of a man suffering from relaxed sore throat. The affection was very slight, and the specimen was removed on the first day.
a. Epithelial cells.
b. Small cells containing granular matter and oil globules, consisting partly of altered epithelium, partly of mere aggregations of oil globules surrounded with viscid matter, giving the appearance of a cell wall. A group of these are represented on the left, more highly magnified.

Fig: 227.

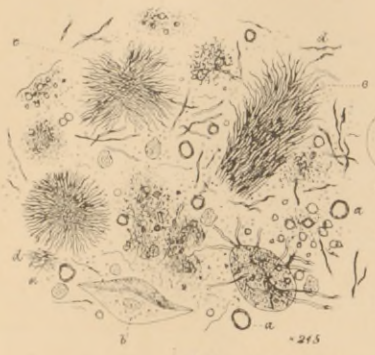


Fig 228.

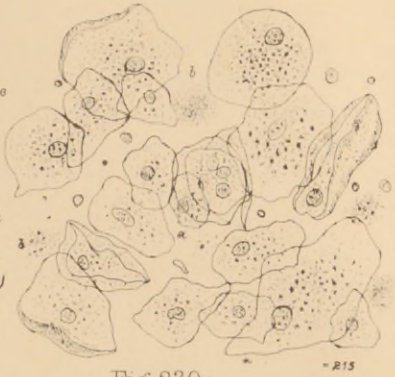
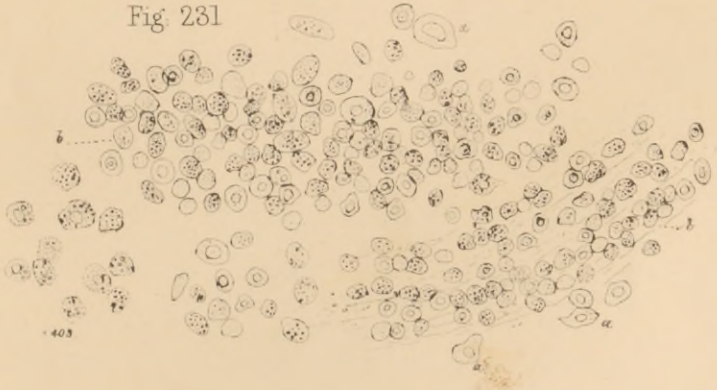


Fig: 229.

Fig: 230

Fig: 231



L.S.B.

1000 ths — ×403

1000 ths — ×215

Path. Lab 1854

Harrison & Sons, Lith. St. Martins Lane.

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3. Of the above ... ... 2 parts.
Of glycerine ... ... 1 „

Very good for thick specimens which are also opaque. Blood discs in the sputum remain distinct in this medium.

206. Extraneous Substances in Sputum.—As may be supposed, epithelium from the cavity of the mouth and air passages, with portions of any vegetable growths which are so commonly found in the mouth, pl. XXX, fig. 227, especially about the back of the tongue and in the matter secreted by the tonsils, with small fragments of any substances taken as food, are liable to be met with in sputum. Unless the observer is familiar with the appearances of all these structures, he will find himself beset with difficulties at every step, and will be liable to make the most ludicrous mistakes. In the first instance, he should be familiar with the characters of the epithelium from the cavities of the mouth and nose, tongue, trachea, and bronchial tubes, and with the cells in the mucus formed upon these portions of the mucous membrane. Next, he should place under the microscope small quantities of the different extraneous matters liable to be met with most frequently. The most important are the following: bread, wheat starch, potato starch, rice starch, testa of wheat, cells of potato and other vegetables taken as food, cotton, flax, and silk fibres, portions of feathers and hair, air bubbles, oil globules, portions of adipose tissue, as bacon, muscular fibre, white and yellow fibrous tissue, fragments of cartilage, bone, &c. Some of these are figured in pl. XXXII, and in pl. XXXIV, containing extraneous matters found in urine.

Of the Different Kinds of Sputum.

The anatomical elements met with in sputum vary much, and its characters are much influenced by the time which elapses prior to its expectoration.

207. Mucus, which is formed upon the fauces, and to a slight extent in the air tubes of healthy persons is clear and transparent. The viscid, indistinctly fibrillated material, to which its physical characters are due, entangles in its meshes cells of various forms and in different stages of growth; and in some specimens every transitional form of cell, from the large cell of squamous epithelium to the small faintly granular corpuscle, formerly termed *mucus corpuscle*, may be detected. (see pl. XXX, figs. 228, 231). Not unfrequently cells of columnar ciliated epithelium from the trachea or bronchial tubes are present. Fig. 236, pl. XXXI, represents the microscopical characters of a

specimen of transparent, frothy, viscid, and almost colourless bronchial sputum. Some of the cells which have been treated with acetic acid, are shown to the right of the figure. The clear mucus is precipitated by acetic acid, and numerous striæ make their appearance.

In *catarrh*, when this mucus is more abundant, besides the cells above alluded to, a number of round or oval masses are observed, which consist of aggregations of minute oil globules cohering together, and often appearing as if they were within a cell wall. Two or three of these are represented in the figure. They are often present in great number. Granular masses, varying much in size, but for the most part smaller than the last, are also met with. A vast number of granular cells, closely resembling pus corpuscles, are very common in most specimens of sputum, and it is not difficult to make out all the intermediate stages between the faintly granular cell which is rendered transparent upon the addition of acetic acid, exhibiting a nucleus, and the true pus corpuscle, in which this reagent developes two or three highly refracting bodies, a circumstance which distinguishes it from different forms of epithelial cells.

208. Sputum in Pneumonia.—The rust-coloured sputum of the early stages of pneumonia contains a number of the large spherical collections of minute oil globules (exudation corpuscles, or granular cells) together with a vast number of minute granular cells of a circular form which are developed in the exudation poured out into the air cells of the lung, with numerous blood corpuscles, for the most part separated from each other, to the presence of which the peculiar colour of the sputum is due. At a later stage, in bad cases, the quantity of blood increases, the mass is nearly fluid, and contains a vast number of disintegrated cells and much granular matter, with numerous altered and ragged blood corpuscles.

209. Sputum in Bronchitis.—The opaque yellow sputum of chronic bronchitis owes its peculiarities to the presence of pus corpuscles which are suspended in the viscid material. In these cases many forms of cell are often met with, and epithelium in all stages of growth. Granular matter and small oil globules are frequently present in considerable number. Collections of dark colouring matter, more or less globular, and much resembling the collections of minute oil globules above alluded to, are frequently observed. These are composed partly of blacks, introduced in respiration; but sometimes the dark colouring matter is formed in the air cells of the lung, and consists of dark coloured material derived from the blood, and not introduced from without. A large quantity of coal dust is found in the expectoration of men working in coal mines; and in the Sheffield dry grinders, metallic particles, which are inhaled,

and give rise to great irritation, and, not unfrequently, to death at an early age. These metallic particles are expectorated, and can be detected in the sputum. Dr. Hall, of Sheffield, has paid great attention to this fatal disease.*

The character of the pus corpuscles varies much in different specimens of sputum. Sometimes they are well formed, and exhibit their ordinary characters, but often they are fainter, not perfectly circular, perhaps with very irregular outlines, and partly disintegrated. In cases where the pus has been retained for some time in the air tubes, or in cavities after its formation, it is completely broken down, and no distinct corpuscles are to be distinguished.

210. Sputum in Phthisis.—The characters of sputum in phthisis are very variable, according to the stage of the disease, the amount of lung implicated, and the length of time the sputum has been retained in the cavity before its expectoration has occurred, and many other circumstances. No physician would attempt to diagnose a case from the examination of the sputum only, and the characters of the sputum are not so invariable as to enable us to determine with precision the particular stage of the disease. So far as I know, the only forms of sputum which would be considered by ordinary examination with the unaided eye to be characteristic of phthisis, are met with only in confirmed cases where there is almost invariably strong evidence of a different kind of the existence of the disease. The sputum often contains pus corpuscles, sometimes well formed, and in other instances apparently disintegrated, with much granular matter, and often minute oil globules, with a number of the cells above alluded to, and which are derived from the smaller bronchial tubes. In many cases, but not in all, the microscope certainly affords very important information.

The general character of tubercle corpuscles is represented in pl. XXXIII, fig. 250. They are seldom found in sputum unless mixed with a considerable quantity of granular matter, and in many cases, pus corpuscles are so numerous that it is difficult to discover the tubercle, while the latter is often disintegrated, so that it cannot be distinguished as a special deposit. The characters of tubercle are described in page 204.

Fragments of Lung Tissue.—It is, however, most important that the practitioner should be familiar with the characters of one structure sometimes met with in phthisical sputum, which has been cursorily alluded to already. The recognition of this is really a subject of the greatest practical importance. The microscopical

* "On the Pathology, Diagnosis, &c., of Thoracic Consumption," third edition.—Longman, 1856.

characters are distinct; the structure cannot be confounded with anything else met with in sputum, and the diagnosis to which the practitioner is led even at a very early period, before the patient or his friends have the slightest suspicion of serious disease, will be in almost every case in which the structure is observed, but too painfully correct. I allude to the very important observation of Professor Schroeder van der Kolk of the presence in the sputum of the elastic fibres of the pulmonary tissue at a very early period of the disease. This was noticed in the year 1846, and the value of the observation has since been amply confirmed by Dr. Theophilus Thompson, Dr. Hughes Bennett, of Edinburgh, Dr. Andrew Clarke, Professor Quekett, and myself. The elastic tissue is not prone to change. It can hardly be mistaken for any other structure, and it is detected with great facility, especially if the sputum be treated with acetic acid, which renders the other elements transparent, but has no action upon the elastic tissue. Its presence shows that disintegration of the walls of the air vesicles has actually commenced. In searching for this substance, several specimens from different parts of the sputum should be examined, and any little grayish masses should be particularly selected. Dr. Bennett mentions a case in which this elastic tissue was met with at a time when no other signs of phthisis were present. The sputum was examined by Dr. Bennett, Dr. Iliff, Professor Quekett, Mr. Rainey, and myself. All concurred in pronouncing the substance to be pulmonary tissue. After a time other symptoms of the affection manifested themselves, the physical signs of a cavity became distinct, and the patient died. The lung tissue represented in pl. XXXI, fig. 232, was found in the sputum of a case of phthisis of about a year's duration. Figs. 233, 234, and 235, are copies of fragments of pulmonary tissue found in sputum which contained a very large quantity. The amount of expectoration was very small amounting to not more than half a dozen pellets in twenty-four hours. The case was that of a stout lady of about fifty years of age, who had been suffering from cough, for about six weeks, consequent upon taking cold. There was slight dulness under one clavicle, but no marked symptoms of phthisis, in fact it was difficult to persuade the patient that there was anything the matter with her, and the diagnosis rested almost entirely on the fact of the presence of the pulmonary elastic tissue in the pellet of sputum which was subjected to examination.

In order to obtain fragments of lung tissue from sputum, Dr. Fenwick recommends that the sputum be liquefied by being boiled in a solution of soda, Med. Chir. Soc., June 26, 1866. The elastic tissue falls to the bottom if the mixture be placed in a

conical glass and may be removed with the pipette, p. 81, pl. V, fig. 27.

In some specimens of sputum there are numerous curved bands and streaks of mucus which somewhat resemble the elastic tissue; upon the addition of acetic acid no distinct fibres are to be made out, and the fibrillated appearance becomes less defined in consequence of the mucus shrinking from the action of the acid. The observer should not trust entirely to the appearance observed in sputum, until he has become familiar with the characters of the elastic tissue taken from the lung itself. Crystals of cholesterine are occasionally found in phthisical sputum, and granules of phosphate of lime are occasionally met with.

211. Diptheria.—There is nothing very distinctive in the exudation effused upon the surface of the mucous membrane of the fauces in cases of diptheria. It consists as is well known of a white soft membrane varying considerably in thickness. Under the microscope, this is found to be composed of a more or less transparent viscid substance about the consistence of mucus and exhibiting the striations and wavy lines always seen in this material. Sometimes the lines are so regular as to give to the specimen a delicately fibrous appearance. Entangled in this are found *a*, cells of scaly epithelium from the mouth; *b*, a number of small transparent granular, round, or oval particles, resembling those found in the mucous follicles of the fauces and in the deepest layers of epithelium. In some cases the membrane appears to consist almost entirely of ordinary epithelium, in others the small roundish cells predominate, while sometimes the mass appears very transparent and only contains a few of both forms of cells just described. The small cells pass into pus corpuscles and where the case is severe and the powers of the patient much reduced, the number of these pus-like cells is very great. It is, however, important to observe that the action of acetic acid upon these is different from its action upon well-formed corpuscles. One or two bodies with a well-defined dark outline but not perfectly circular are certainly displayed as in the case of the pus corpuscle, but the greater part of the cell seems to be dissolved by the acid, or rendered so very transparent as to be quite invisible. It is probable that if the production of such cells was to continue for a certain period of time, well-defined pus corpuscles would be developed.

In this condition then it would appear that the greater part of the epithelial layer is stripped off in a membranous form,—that this is increased in thickness by the rapid development of new cells having the characters above described upon the surface of the mucous membrane,—and that these new cells, corresponding to the deepest layer

of epithelium, lose more and more the epithelial character, and tend gradually to pass into pus corpuscles. It is true that in many cases sporules of fungi are met with, but many circumstances prove satisfactorily that they merely grow in the false membrane as in a nidus favourable to their development, and are not to be regarded as the cause of its production.

The description given above, results from observations made by myself upon specimens which have fallen under my notice. The two cases from which the drawings represented in figs. 237, 238, pl. XXXI, were made, occurred in the practice of Mr. Woody, of Tamworth, whose former assistant, Dr. Spratly, I have to thank for the specimens and careful notes of the cases.

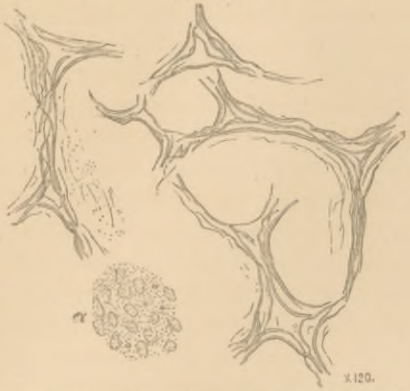
Fig. 237 was obtained from the fauces of a gentleman about forty, on the fourth day of the disease. *a.* Epithelial cells from the mucous membrane of the mouth. *b.* Portion of false membrane exhibiting a striated appearance and entangling numerous cells resembling pus corpuscles. *c.* Cells like pus corpuscles, showing nuclei very distinct. *d.* Another part of the false membrane stretched somewhat and entangling corpuscles rendered oval by the pressure. Fig. 238 was obtained from another case also on the fourth day. *e.* Granular cells more disintegrated than those represented at *c*, and not exhibiting nuclei. *f.* Blood corpuscles. *g.* A portion of the mass entangling granular cells acted upon by acetic acid.

Virchow considers that an exudation takes place into the substance of the mucous membrane itself, and that the tension so caused at length leads to ulceration, and there can be no doubt this is the case in very severe examples of the disease. That the mucous membrane itself is affected as well as the epithelial surface is rendered probable by the subsequent loss of sensibility in the nerve-fibres. In the fragments of false membrane which I have examined, I have failed to find any structures such as capillaries and areolar tissue which enter into the formation of mucous membrane.

The "exudation" is sometimes poured out principally from the orifices of the glands and caused to spread over the epithelial surface. In the case of a very thick and firm false membrane formed upon the surface of the tongue and pharynx of a pig, I found that the adventitious tissue which was a quarter of an inch in thickness could be raised somewhat without being torn. Processes could be traced from the deep surface a quarter of an inch in length into and to the very bottom of the glands of the mucous membrane.

212. Entozoa and Vegetable Organisms and Sputum.—Hydatids are

Fig. 232.



Fragments of lung tissue, from a case of phthisis of about a year's duration. *a*, mucus corpuscles and granular matter. p. 183.

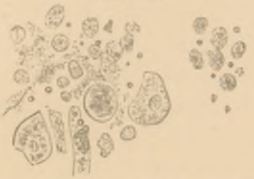
Fig. 233.

Fragments of air cells, with elastic tissue from sputum. From a case of phthisis, in which the physical signs were not at all marked. × 215. p. 186.

Fig. 234.

Fragments of pulmonary tissue, from sputum. × 215. p. 186.

Fig. 236.



Healthy bronchial sputum, showing mucus corpuscles, epithelium, and oil-globules. × 215. p. 183.

Fig. 235.

Fragments of lung tissue from sputum. × 215. p. 186.

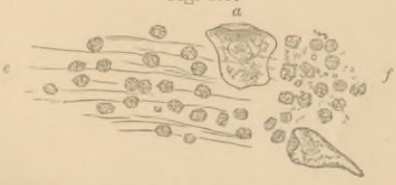
Fig. 237.

False membrane from a case of diphtheria on the fourth day. × 215. p. 188.

Fig. 239.

Fungi (Oidium) in various stages of growth, with epithelium of the mouth, expectorated by a patient in the last stage of phthisis. p. 189.

Fig. 238.



False membrane from another case of diphtheria, on the fourth day. × 215. p. 188.

1000th of an Inch ⌊_⌋ × 130.

" " ⌊__⌋ × 215.

[To face page 188.

sometimes expectorated in sputum. Occasionally they are developed in the lung itself; but in the great majority of instances they are formed in the liver,—an opening is gradually made through the diaphragm, and they make their way through the lung into a large bronchial tube. After the cyst has been completely emptied, the large wound gradually closes, and the patient may get quite well. Two or three cases of this kind have been in King's College hospital. One occurred, some time since, in the practice of Dr. Todd,* and I have had two or three under my own care more recently, which terminated in recovery. The characters of the cysts are sufficiently distinctive as a general rule; but if the sputum be well agitated with water and allowed to stand, the hooklets of the echinococci will sink to the bottom and may be removed with a pipette. The appearance of these is characteristic. See drawings in plates illustrating the characters of Entozoa. In many of these cases biliary acids may be detected in the sputum, and in a case under my care a short time ago, crystals of cholepyrrhin were found in large number.

Fungi are from time to time met with in sputum, but the distinctive characters of these will be briefly considered in the last chapter. Fig. 239, pl. XXXI, represents the characters of fungi from some apthous sores in the mouth of a patient in the last stage of phthisis. The specimen was sent to me by my friend Dr. Scott Alison.

213. Other Structures met with in Sputum.—*Blood Corpuscles* are occasionally met with in small numbers in all varieties of sputum; they may be derived from the gums or some part of the throat, and do not *necessarily* indicate the existence of serious mischief. Sometimes blood corpuscles in sputum are aggregated into small masses. Sporules of fungi *resembling* blood corpuscles are often met with in sputum.

Dark Granular, Cell-like Bodies.—In sputum in various conditions a number of dark cell-like masses are often found. In some cases the dark material consists merely of carbonaceous matter which has been inhaled; but in other instances it seems to be composed of a dark pigmentary material derived from some portion of the respiratory tract. This substance is doubtless formed from the blood, as it is found in various organs quite unconnected with respiration. It is exceedingly common in many of the lymphatic glands, especially in those near the bronchial tubes, and has been described by some observers under the head of *melanosis;* but there are many instances in which this dark material is deposited unconnected with cancer,

* "Medical Times and Gazette," 1852. See also Livois, Recherches sur les Echinocoques chez l'homme," &c.—Thèse, Paris, 1843.

and these have been included under the term "*spurious melanosis.*"

Calcareous Masses.—In cases of phthisis, gritty masses consisting of phosphate and carbonate of lime are sometimes expectorated. These are not unfrequently as large as a pea or larger. They result from the disintegration of tubercle, the organic portion of which has been removed by absorption, and it is not uncommon to meet with them in post-mortems, inclosed in a small fibrous cyst, surrounded by healthy lung. I have known them to be coughed up in several cases and think that their expectoration is generally indicative of a favourable change in the progress of the disease.

Fibrinous Casts of the large and small bronchial tubes are expectorated in certain cases, of which instances are recorded in all standard works on Medicine. Under the microscope they are seen to be composed of a striated material like fibrin with a number of small faintly granular corpuscles.

The following references will be useful to those who desire to make a special study of the microscopical characters of sputum:—

Wright, "The Pathology of Expectoration."—(Medical Times, 1844, 1845.)

Lebert, "Traité de la Phthisie," second edition, Paris, 1843.

Remak, "Diognostische und Pathogenetische Untersuchungen," Berlin, 1845. Deutsche Klinik, Sitzungsprotokoll der Gesellschaft für Wissenschaftl. Medecin in Berlin, vom 1 Juli, 1850.

Schroeder Van der Kolk, "Nederlandsch Lancet," 1846. "Sur la présence des Fibres Elastiques dans les Crachats des Pthisiques," Bruxelles, 1850. "On the Origin and Formation of Tubercles in the Lungs."—(Nederlandsch Lancet, 3rd series, 2nd Jaarg., No. I. en II.)

Hœfle, "Chemie und Mikroscop am Krankenbette." Erlangen, 1848.

Jacubowitsch, de Saliva, diss. Dorpat, 1848.

Virchow, "Verhandlungen der Physikal. Medicin. Gesellschaft in Würzburg," 2 Bd., Sitzung vom 4 Jan., 1851.

Dr. Black, "Association Journal," 1853.

Thierfelder, über Bronchitis crouposa, Archiv für Physiol. Heilkunde, 13 Jahrgang, 2 Heft. 1854.

Dr. H. Thompson, Lettsomian Lectures, 1854, "Lancet," February 11th, 1857.

Dr. Andrew Clarke, in "Transactions of the Pathological Society," Vol. vi, page 74.

Dr. Hughes Bennett, in "Edinburgh Monthly Journal," January,

1856, page 585. "Clinical Lectures on the Principles and Practice of Medicine," 1858.

Dr. J. C. Hall, "Hints on the Pathology, Diagnosis, Prevention and Treatment of Thoracic Consumption."—Longman, 1858.

Dr. Radclyffe Hall, "Medico-Chirurgical Review," vol. xv, page 477; vol. xvi, page 465; vol. xvii, page 449.

Dr. R. P. Cotton, "Fothergillian Prize Essay."

Dr. Th. Williams, Article "Respiration."—(Cyclopædia of Anatomy and Physiology.)

Dr. Anton Biermer, "Die Lehre vom Auswurf," Würzburg, 1855.

Detachment of Flakes of Epithelium from the Tongue.—A man was some years ago under my care who was suffering from the formation of what appeared to be a very thick false membrane on the side of the tongue. It was moderately adherent and proved to be in continuity with the deep layers of epithelium. It came off within one or two days of the man's admission into the Hospital leaving one or two superficial ulcers. It consisted principally of altered epithelium with granular cells, sporules of fungi, and débris (vol. i, p. 218).

Detachment of Flakes consisting of a thick layer of the Epithelium of the Æsophagus.—Portions of membrane are sometimes detached from the lining membrane of the gullet and rejected. Mr. Wood, of Shrewsbury sent me a very remarkable specimen of this some years ago. There was a distinct membranous tube several inches in length.

The following is an extract from Mr. Wood's note:—"I feel induced to trouble you with the enclosed, although I know so little about it. It was given to me by a medical friend in Shrewsbury. All I know is, that a lady patient of his was for a long time troubled with sickness which nothing would allay, and was reduced to extremities, when she vomited several pieces like the enclosed, but much longer, three inches in length. They appear membranous, but they are not, I believe, of a vegetable nature. On being burned, they give out the peculiar smell of animal tissue. I have never seen anything like this; the thicker portion feels like the membrane of diptherite, but the thin, firm membrane is very peculiar. Is it an exudation from the œsophagus? I have just received another portion seven inches long which appears to be a cast of the œsophagus, and when fresh was of a light skin colour."

Upon microscopical examination, it was found that Mr. Wood's conclusion as to the nature of these membranous masses was quite correct, they were composed of the firm and matted layers of squamous epithelium which form the lining of the œsophagus; several of the masses formed complete tubes. The case is especially interest-

EXPLANATION OF PLATE XXXII.

Fig. 240. Vomit from a healthy man, three hours after a meal, consisting of bread and bacon.

a. Oil globules, with crystalline fat. *b.* Starch granules, altered by baking, and partly digested. *c.* Epithelial cells, probably from the pharynx. *d.* Muscular fibres, scarcely altered. *e.* Muscular fibre, partly digested, showing a tendency to split into discs. *f.* Portion of muscular fibre, in great measure disintegrated by the process of digestion.

Fig. 241. Vomit from a female, aged 40, suffering from symptoms of cancer of the stomach, under the care of Dr. Eade, of Norwich. The specimen was not examined for twenty-four hours after it had been rejected. The disease probably commenced upon the surface of the mucous membrane.

a. Oil globules. *b.* Minute oval fungi. *c.* Vibriones. *d.* Pus cells. *e.* Cells from the surface of the ulcer. *f.* Cancer cells.* *g.* Altered biliary matter. *h.* False cells, formed by the aggregation of numerous small particles. *i.* Squamous epithelium—mouth.

Fig. 242. Vomit from a patient with dilated stomach who vomited sarcinæ,—in King's College Hospital.

a. Oil globules. *b.* Starch granules, altered by baking, and by maceration in the fluids of the mouth and stomach. *c.* Starch granules (some cracked), less altered than the preceding. *d.* Portion of the testa of wheat. *e.* Portion of vegetable fibre. *f.* Small oval fungi. *g.* Sarcinæ. *h.* Very small sarcinæ.

* One could not feel perfectly satisfied as to the cancerous nature of these cells, from the microscopical characters alone.

Fig. 240.

Fig. 241.

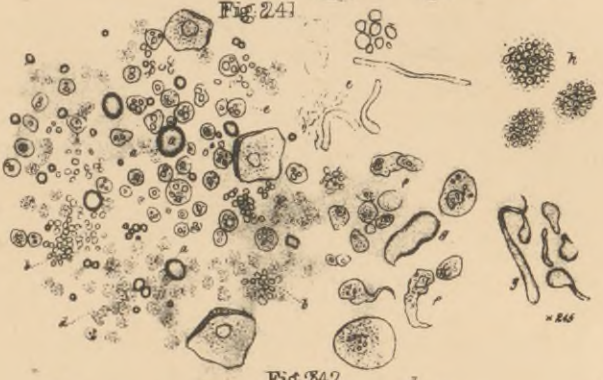


Fig. 242.

1000 ths. ×215

1857.

To face page 192.

ing as demonstrating the fact that a considerable thickness of an epithelial layer may be removed from many surfaces. Cases are referred to below in which large flakes were removed from the mucous membrane of the stomach, small intestines, uterus and vagina.

214. Examination of Vomit.—As vomit usually contains a vast number of substances often more or less isolated from each other, it becomes necessary to examine several specimens taken from different parts, in order to ascertain the general microscopical characters of the whole mass. Portions may be removed upon the point of a knife; by a pipette with a very wide opening, if the vomit be not very viscid; and with the aid of scissars and forceps, if it be very thick and ropy, as in the case of sputum.

It is desirable to examine vomited matters as soon as possible after their rejection, as many substances present undergo rapid alteration. Many of the remarks, made under the head of "Extraneous Matters in urine," § 227, are applicable to vomit; and unless the observer makes himself familiar with the appearance of different substances found in food, and those which are liable to obtain entrance accidentally, he is liable to make the most ludicrous mistakes in describing the object or drawing taken from it. A fragment of feather has been described as a lymphatic vessel, a portion of hair as a nerve tube, and other mistakes of the same kind have been made, in consequence of the observer not being acquainted with the characters of objects which he is liable to meet with in the course of such enquiries.

Vomit may be allowed to stand in a conical glass, and the deposit removed with the pipette. It may be placed on a glass slide, or in a thin glass cell, and covered with thin glass, or examined in the animalcule cage, p. 81, which is a most convenient little instrument for examining the deposits from fluids. It should be examined under a power of 200 diameters, but in this and other cases it is necessary to examine the specimen under a lower power in the first instance.

Vomit always contains fragments of vegetable and animal tissues, which have been taken as food, more or less altered by the processes of digestion. Starch globules are usually met with in great numbers; but if sufficient time has been allowed for the change to take place, the insoluble portions of the starch granules will alone remain.

Considerable attention has been given to the appearance presented by the uredo of wheat, as it occurs in vomit, and also in stools. In the time of the cholera, the undigested uredo found in the stools was looked upon as a fungus connected with the cause of this affection, but its true nature was pointed out by Mr. Busk.

Torulæ are very frequently present in considerable numbers in vomited matters; several other forms of vegetable fungi are not unfrequently met with, and vibriones are often very abundant. The characters of the two kinds of sarcina, met with in vomit, will be described in the last chapter. See also pl. XXXII, fig. 242, *g*, *h*. The vomit which contains this vegetable organism usually ferments for some time after its rejection, like yeast, but the sarcina is occasionally found in vomit which does not possess these characters. Besides the sarcina, numerous oval fungi are usually present.

The colour of the so-called "coffee-ground vomit" appears to be due to the presence of a dark-brown pigment in considerable quantity, forming small aggregations or minute granules which, probably, consist of the altered colouring matter of the blood. Often a considerable number of blood globules, somewhat changed in form, are present. In some specimens of cholera vomit, numerous flocculi, consisting partly of large cells of scaly epithelium, and partly of cylindrical epithelium from the intestines, have been found.

The clear fluid which is brought up in certain cases (Pyrosis or Waterbrash) contains only a little epithelium, and a few small oil globules.

The green vomit, depending upon the presence of bile, contains cylindrical epithelium (gall-ducts?), scaly epithelium, flakes and small masses of biliary colouring matter, often of a very bright colour, and fat globules.

In cases in which cancer of the stomach is suspected, the vomit should always be examined for cancer cells, pl. XXXII, fig. 241, although usually these will be so much broken down as not to be recognizable. The observer must be careful not to mistake cells of columnar epithelium for cancer cells.

Epithelium of the Stomach.—I have seen flakes of stomach epithelium rejected by vomiting. In a severe case of scarlet fever a thin membranous mass about 3 inches by 2 was rejected. It was found to consist entirely of epithelium. After the patient's death, the part of the surface of the mucous membrane from which it was detached, was discovered, and this, with the epithelial masses, were preserved permanently.

215. Examination of Matters passed by the Bowels.—The microscopical examination of the fæces is in certain cases of considerable importance. In dysentery, shreds of fibrinous matter, blood corpuscles, pus globules, and cylindrical as well as squamous epithelium, are sometimes present. Crystals of triple phosphate are also often met with.

Mucus casts are sometimes expelled from the large intestine, and

occasionally as complete tubes. Of this an interesting example was sent me by Dr. Borrett. Flakes, some of which are very firm, are common enough, especially after prolonged constipation. They consist of a firm mucus, in which the epithelial cells from the large bowel, and mucus corpuscles, are embedded.

The masses referred to above were tolerably firm, and some of them were evidently portions of a tube. They were passed by a child aged four, without giving rise to any urgent symptoms. On microscopical examination, the tissue was found to be composed of a very firm mucus, in which numerous cells of epithelium from the large intestines were embedded. The following notes of the case are extracted from Dr. Borrett's note :—"The casts of mucus and epithelium were passed by a little girl after some weeks of pain in the belly. My fears were that some foreign body had been swallowed, a button having once been passed up the nostril, and not recovered. We always had a difficulty in getting the little girl to sit down, and relief of bowels always caused more or less pain." "The substance came away after a strong dose of senna tea, which caused great griping; it had been found that senna always caused distress, and castor oil was the aperient used afterwards. There was increased sensibility of the canal which made senna a bad aperient. The mucus and epithelium cast of bowels was passed in Feb., 1860; since which time the child has enjoyed good health; she never makes any complaint of pain in the bowels; the appetite is large; and the general condition of the child excellent."

In typhus stools, crystals of triple phosphate are frequently present in great number; altered blood, and vast numbers of vibriones, with different kinds of vegetable fungi, are not uncommonly found.

The bodies represented in pl. XXXIII, fig. 243, were obtained from the liquid stools of a girl aged eighteen, who was suffering from cough and fever. Tho oval masses are probably fragments of a clot of blood. The specimen was sent to me in 1858 by Dr. R. E. Thompson.*

The stools of cholera patients are remarkable for the large quantity of cylindrical epithelium they frequently contain. In many instances the white flocculi are almost entirely composed of it. Sheaths of the villi are often found in great numbers quite entire. Some observers have failed to discover these sheaths, but I met with them myself in one of the first cases I ever saw, and I have seen them several times. In the majority of cases, however, they are not

* "Archives of Medicine," No. II, page 141.

present. Undigested muscular fibre exhibiting the transverse striæ very beautifully, large crystals of triple phosphate and fragments of substances taken as food, are also generally met with.

Masses of vegetable confervoid growths have occasionally been passed by the bowels, but such cases are not common; one is mentioned by Dr. Farre, and another by Professor Bennett.

Professor Quekett and Mr. Brooke have met with some elastic fibres in the fæces, exhibiting the transverse striæ, which are normal in the fibres of the ligamentum nuchæ of the giraffe. The transverse division depended probably upon incipient decomposition. The division is sometimes so distinct and complete as to have led to these fibres being mistaken for confervoid growths.*

It is often desirable to know if biliary matters are present in the fæces. It does not necessarily follow that if the stools be pale all traces of bile acids and their products are absent. The test for biliary acids is given on page 124.

Living things in the Stools.—I have found numerous living acari in matters passed by the bowels, but did not determine the species, nor could I ascertain positively whether they had passed alive from the bowel or had merely fallen into the dejection afterwards. I have found different kinds of maggots, the larvæ of various blow flies, in the stools, and the evidence that these will pass through the whole length of the alimentary canal in a living state is quite conclusive. See cases by Dr. Brinton and Mr. Blood, in the "Archives of Medicine," vol. iii, page 133.

216. Discharges from the Uterus and Vagina.—The character of these discharges varies very much. In subjecting them to microscopical examination, it is better to avoid the addition of water or other fluid if possible.

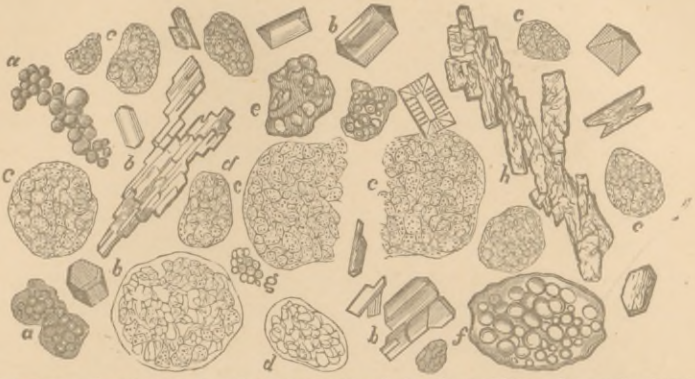
In uterine and vaginal discharges, the following substances are not unfrequently met with. Epithelium of the vagina, pus globules, blood corpuscles, small transparent oval or circular granular cells, usually occurring in abundance in the mucus about the os and cervix uteri, and small oil globules.†

A considerable thickness of the epithelial layer of the vagina, and according to some observers, also that of the uterus, is sometimes shed in the form of a membranous cast or mould. I have seen such epithelial casts or moulds from the rectum, œsophagus, and from

* "Principles of Human Physiology," Dr. Carpenter, fourth edition, page 438, note.

† Upon the microscopical characters of Leucorrhæal discharges, the Memoir of Dr. Tyler Smith, in vol. xxxv of the "Medico-Chirurgical Transactions," should be consulted.

Fig. 243.



a. rounded masses of earthy matter, probably carbonate and phosphate of lime. *b*, crystals of triple or ammoniaco-magnesian phosphate. *c*, oval masses, probably fragments of a clot. In one, to the left of the figure, the outline of the blood corpuscles is more distinct than in most, and in *d* the individual corpuscles can be seen. *e*, dark amorphous masses, probably derived from the food. *f*, ovum of an entozoon, probably an ascaris. *g*, small collection of blood corpuscles. × 215. p. 195.

Fig. 244.

Epithelial cast or mould of the vagina (?), but supposed by Dr. Tilt to come from the uterus. Natural size. p. 197.

Fig. 245.

Formation of pus from germinal matter of epithelial cells. × 215. pp. 192, 200.

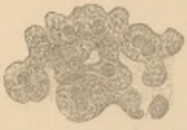
Fig. 246.

Pus corpuscles, under the action of acetic acid. × 215. p. 199.

Fig. 247.

Pus corpuscles. *a*, some cells acted upon by acetic acid. × 215. p. 199.

Fig. 248.



Pus corpuscles, showing protuberances. × 700. p. 201.

Fig. 249.

Multiplication of pus corpuscles by detachment of protruding portions from each corpuscle. × 215. p. 201.

Fig. 250.

Tubercle corpuscles from a tubercle in the lung. × 215.

Fig. 251.

Tubercle corpuscles from the interior of the eye of a child aged eight. Removed by Mr. Hulme. × 215. p. 201.

1000th of an Inch ⌊⌋ × 215.

[To face page 196.

the stomach. They correspond to the layers of cuticle which are detached from different parts of the cutaneous surface after scarlatina.

Dr. Arthur Farre has recorded some interesting cases of "Exfoliation of the Epithelial coat of the Vagina," in vol. i of my "Archives." The appearance of the specimens is represented in pl. XII of the "Archives of Medicine." Dr. Farre remarks that the act of exfoliation is repeated at intervals. The casts described by him are interesting in another point of view, as showing the real form of the vagina when in its ordinary empty and collapsed condition. (See "Archives," vol. i, p. 71.) Dr. Tilt has also described some interesting cases of the same kind. His opinion is, that some of these cases come from the uterus, while others are formed, as Dr. Farre stated, in the vagina. The beautiful specimen figured in pl. XXXIII, fig. 244, is one of those examined by Dr. Tilt, and considered by him to come from the uterus, although the characters of the epithelium of which it was composed, agree more closely with those of the vaginal cells. (See "Archives," vol. iii, p. 26.)

Leucorrhœa.—In this condition very many imperfect cells of vaginal epithelium are formed upon the surface of the mucous membrane, as well as pus corpuscles. Many pus corpuscles originate in the cells of vaginal epithelium, even after the epithelial cells have assumed their distinctive form, but many of the younger cells of vaginal epithelium, and those in the follicles of the mucous membrane, divide and subdivide, giving rise at length to multitudes of the spherical granular cells we know as "pus corpuscles," which divide and subdivide very rapidly if freely supplied with nutrient matter.

In cases of cancer of the uterus, we should expect to meet with cancer cells in the discharge, but these are often so broken down as not to be distinguishable; still, when this condition is suspected, the discharge, and also the urine, should be subjected to very careful and repeated microscopical examination. In this investigation, the resemblance of the cells of columnar epithelium from the ureter, to spindle-shaped cancer cells, must be borne in mind, and the student must be careful not to mistake the former for the latter. In many cases it is not difficult to remove a little of the softened cancerous matter upon the extremity of the sponge used in vaginal examinations, when there is a much better chance of meeting with entire cancer cells than in the urine.

It is not uncommon to detect cells containing much dark granular matter extremely like cancer cells in the urine. In some cases I have found that the dark granules consisted of particles of urate of soda, but in others they were composed of pigmentary matter. Some of these cases are extremely difficult of diagnosis.

Pus.—Tubercle.

217. Examination of Pus.—The microscopical examination of pus is easily performed. When found in the secretions, the practitioner must not draw a too hasty conclusion with reference to the nature of the case. Small quantities of pus may be present in certain secretions without the existence of any serious disease.

Pus corpuscles become smaller on being placed in saline solutions of greater specific gravity than the serum in which they float, in consequence of exosmose of part of their contents. The corpuscles of pus are destroyed by the action of caustic alkalies, and converted into a thick glairy mass, which cannot be poured from the vessel containing it, in drops. Upon examining this glairy mass in the microscope, only a few granules can be observed. Ammonia acts very slowly upon pus corpuscles, while the white and red blood corpuscles are instantly dissolved by it.

Water containing a trace of iodine in solution causes the pus globule to swell, and displays the central mass. The most characteristic reaction, however, is produced by the addition of acetic acid. This reagent, if not very strong, causes the corpuscle to swell, so that it may become nearly twice its previous diameter; the outline of the cell being very thin, but clear and distinct, and from one to four little bodies are developed in the centre (figs. 246, 247*a*, pl. XXXIII). These have a dark outline, are of rather an irregular form, highly refracting, but do not appear to be soluble in ether.

Occasionally I have found pus cells in which the central contents were very dark, and slightly separated from the cell wall, fig. 246. Upon treating these with acetic acid, the same reaction ensued (*a*). It appeared as if the acid caused the central mass to contract, probably after dissolving part of its constituents. The central bodies have been termed nuclei, but they cannot be looked upon in the same light as the nuclei of cells generally.

218. Microscopical Characters of the Pus Globule, and of Detecting it.—I must here offer a few very brief observations upon detecting the pus corpuscle, and the inferences to be drawn from its presence.

When a small quantity of pus is placed between glasses, and examined with a power of about two hundred diameters, numerous granular cells, larger than a blood globule, but with a circular outline and finely tuberculated surface, are noticed. The serum in which these cells float usually contains a few free fat globules. The cells

above referred to have been considered as characteristic of "pus," and much trouble was taken in the earlier days of microscopical research to assign definite characters to them, by which they might be distinguished from the so-called "mucus corpuscle," and other cells, which they much resemble. Such a distinction, however, cannot invariably be made, for, in the first place, cells may be obtained which present various stages, apparently intermediate between an ordinary epithelial cell and a pus globule; secondly, cells agreeing in their microscopical characters with the pus globule, are not unfrequently formed upon the surface of a mucous membrane, without its functions being seriously impaired, and certainly without the occurrence of those preliminary changes which usually precede the formation of pus; and, thirdly, cells are found in the lymph, in the blood, in the lymphatic glands, in the serous fluid in the interior of certain cysts, and in many other situations, which in their size, form, and general appearance, so much resemble the globules found in true pus, that it is quite impossible to assign characters by which they may be distinguished. The figures of these cells, as they appeared before and after treatment by acetic acid, often could not be distinguished from the figures of pus cells, treated in a similar manner, given by the same authors. The so-called "mucus corpuscle" is nothing more than an imperfectly formed epithelial cell, which is entangled in the transparent viscid mucus secreted by the mucous membrane. In inflammation of the bronchial mucous membrane we have an excellent opportunity of demonstrating the transitional stages through which a mucus-forming surface passes when it gives origin to pus.

Cases occur in which it appears almost useless to attempt to decide as to the presence or absence of pus, if only a few globules are to be found (nor do I think that if such were possible, it would be of any advantage), because no characters by which the globules can be distinguished individually have been laid down. At the same time it must not be supposed that the diagnosis of pus is a matter of secondary importance; and all that is intended in introducing these observations is to impress upon the student the importance of not stating that pus has been found in any particular locality, or in any particular fluid, merely because a few cells having many of the characters of a pus globule have been observed. To assert that "pus had been found in the blood," or that "the casts of the uriniferous tubes contained pus," would lead to a very different inference from that which would be derived from the observation that "cells having all the characters of pus globules had been found in the blood," or that the "casts of the tubes contained cells resembling those of pus."

The former would be true in extremely few cases; the latter in a vast number that fall under the observation of every practitioner. If, however, we find a considerable number of globules under the field of the microscope, of nearly uniform size, agreeing in general characters with the pus corpuscle, and upon the addition of acetic acid exhibiting the characteristic reaction, we shall seldom be wrong in calling them pus cells.

In examining the blood in cases in which the white corpuscles are enormously increased in number, there can be no difficulty in deciding, since we have every reason to believe that pus globules could not possibly exist in the blood under the same circumstances.

219. New Observations on the Pus Corpuscle.—The origin of the pus corpuscle has been already referred to in p. 151-2. The researches upon which the conclusions there briefly expressed, are based, have proved, I think, as I showed in the first course of lectures which I gave at the Royal College of Physicians, 1861, that the pus corpuscle is not formed by the breaking up of the tissue, and the aggregation of lifeless particles resulting therefrom. Nor is it produced by the precipitation of particles from a clear exudation and their subsequent aggregation to form masses as Dr. Bennet of Edinburgh supposes. Pus, as has been already stated, is a form of living germinal matter, and has descended continuously from the normal germinal matter of the body. Virchow has been led to conclude that pus is formed in connective tissue corpuscles and in epithelial cells only. But there is little doubt that pus may be derived from any germinal matter in the body. The white blood corpuscle, the minute masses of germinal matter which I have described as existing in the blood, lymph corpuscles, chyle corpuscles, the masses of germinal matter in the spleen and other ductless glands, those found in connection with the walls of capillaries, germinal matter of nerve, muscle and other tissues of the body may give rise to pus if placed under conditions in which they are too freely supplied with pabulum.

On the Changes occurring in ordinary living Pus.—I propose now to bring forward evidence which seems to me conclusive as to the mode of growth and multiplication of pus corpuscles, and which, I think, goes far to show how living particles, so minute that they may be transferred considerable distances without loss of vitality, may be produced.

There is certainly no true cell-wall in the case of ordinary pus, and this is proved by the fact that protrusions of the matter of which pus corpuscles consist, may occur upon every part of the surface, and not only so, but some of these protruded portions, after moving a considerable distance away from the mass, become disconnected from it, and thus new pus corpuscles are produced. It is in

this way that the very rapid multiplication of pus corpuscles is effected. In pus from the bladder, movements even more active than those in the mucus corpuscle are very easily observed, and when fresh in consequence of the alterations in form, not a single *spherical* corpuscle can be found. See fig. 44, pl. VII, representing some of the many different forms of pus corpuscles present in a very small quantity of pus. Every corpuscle exhibits a great number of these protrusions, and every protrusion might be detached and form a free pus corpuscle. In warm weather, I have known the movements continue in pus corpuscles in urine containing little of the ordinary urinary constituents, for forty-eight hours or more after the urine had left the bladder. The very phenomena which take place upon the surface of the mucous membrane of the bladder may in fact be watched for hours under the microscope, and there are few things more beautiful or more instructive. When the corpuscles die,—and their death occurs when they are placed in any fluid which is not adapted for their nutrition, the movements above described cease, and they invariably assume the spherical form.

Not only may active movements be observed in the masses of germinal matter above referred to, which have resulted from healthy germinal matter being supplied with a greater amount of nutrient pabulum than under normal circumstances, but they may be seen to occur in the white blood corpuscles, lymph and chyle corpuscles, as well as the connective tissue corpuscles, and the nuclei of various cells, and there is reason to believe, with greater or less activity, in every kind of living germinal matter in nature.* Such movements are not peculiar to the amœba, although from the circumstance that they were first observed in this creature, they have been termed *amœbiform*. Some writers appear to have considered that there was some special relation between all such moving masses of matter and amœbæ. The movements of the amœba, like the movements of pus, mucus, &c., are *vital* movements. The conditions required for the maintenance of life being more complex in the case of some forms of germinal matter than in others, we should conclude that such movements would only continue for a considerable period of time in

* It is probable that careful observations upon this transparent living moving material will teach us much concerning the nature of life. I think that this subject merits far more attention than it has hitherto received, not only from physicists, chemists, and physiologists, but from philosophers. I do not think that what will be learned from the study will favour the notions now most popular, but that is no reason why it should any longer be wholly neglected by those who profess to carry their enquiries to the utmost possible limits. Is it possible that some of those who profess to be most liberal in science are fearful lest enquiry should be pursued a little further than happens to be favourable to their particular view?

particles after their removal from their natural habitat, in the lowest and most degraded forms. This is actually the case, just as some creatures are capable of supporting life under a great variety of conditions, although comparatively slight alterations would be fatal to others.

A mass of any soft, living, germinal matter, when suspended in fluid in active movement invariably assumes the spherical form, and retains it for a short time after the movement has ceased, but if placed under favourable conditions it absorbs nutriment and soon exhibits *vital movements*, grows, and multiplies. The amœba in water, the white blood corpuscles in the liquor sanguinis, are both spherical while the surrounding fluid is in active movement, but after they have been at rest for a short time they exhibit their characteristic and very wonderful movements.

Other changes may also occur in the pus corpuscle; supposing it to be subjected to influences unfavourable to this rapid growth, the material upon the surface may be precipitated, and thus a very thin layer of semi-transparent insoluble material may be formed, which is rightly termed "*cell wall.*" Changes may then take place in the mass of the pus corpuscle itself; it may be resolved into oil globules, and the many alterations which are familiar to observers may be readily noticed in pus corpuscles which are subjected to disintegrating processes or to the influence of fluids not adapted to their nutrition.

Many kinds of pus have been described according to the different localities in which it has been found, and the different conditions under which it has been produced; but in all cases pus possesses certain general characters which show conclusively that it is living germinal matter. It is not possible to distinguish many pus corpuscles from lymph corpuscles, white blood corpuscles, and many other masses of germinal matter; indeed if the developing brain of an embryo be examined at an early period, it will be found that this important structure consists of nothing more than a number of spherical cells, which could not, by any means we are yet acquainted with, be distinguished from many forms of pus corpuscles, pl. XX, fig. 155. If we carefully reflect upon many observed facts, we shall be compelled to admit that masses of germinal matter which resemble one another in every character we can ascertain, differ nevertheless remarkably in *power*, as is proved by the results of their living. Few recent writers seem to have fully recognised the remarkable truth that living things may agree in physical and chemical characters, but differ widely in power; that wide difference in vital power may be associated even with similarity of composition. It need scarcely be said that physical and chemical properties do not determine the *form* living matter is to assume.

Properties and Powers of Normal Germinal Matter, and of the Pus descended from it.—I will next venture to offer some remarks upon the properties or powers of germinal matter. Although much of what I shall say will necessarily be rather speculative, the interest of the matter seems to me so great that I cannot pass it entirely over. The germinal matter of tissue, being supplied with an increased quantity of pabulum, may give rise to pus, as I have stated, but pus differs in *power* from the germinal matter from which it was derived. It cannot, as far as we know, acquire the properties which the original germinal matter possessed. My meaning will be rendered clearer if I adduce an example. The germinal matter of cuticular epithelium may give rise to the peculiar hard material of which the so-called "walls" of the epithelial cell consist, and this same germinal matter of epithelium, if freely supplied with pabulum, may give rise to pus. It seems to me, therefore, that germinal matter may *lose* formative power, and become degraded, and that it cannot acquire it or regain it when lost. There is, as it were, no return to a high position for living matter which has once suffered degradation, nor can degraded germinal matter produce descendants with exalted power.

It must not, however, be supposed that degradation in formative power implies *diminished vitality*. It is a mistake to conclude, as some have done, that disease is necessarily associated with diminished vitality. If, in speaking of the various degrees of vital activity, we refer to the rate of increase of germinal matter, we have in most diseases *increased vital activity*. In inflammation, as compared with health, there is greatly increased vital activity; that is, more lifeless matter becomes *living* during a corresponding period of time.

It would seem as if the formative or developmental endowments of germinal matter were diminished or completely destroyed by its rapid multiplication, so that a mass of germinal matter, which in the course of a considerable time undergoing comparatively slow change, would give rise to descendants which might be concerned in the development of the highest and most complex tissues, if placed under conditions favourable to its too rapid growth would absorb much more nutrient matter in a given time, and produce descendants much more quickly. But although this rapid multiplication might continue, not one of the resulting masses would give rise to the formation of characteristic normal tissue. Too rapid increase is associated with degradation in power, and in man and the higher animals, and plants, if textures grow too quickly, the perfection of the tissues formed is marred, and the period of their endurance is of necessity reduced.

Ordinary pus, then, may readily be produced if the nutrition of

the germinal matter of a normal tissue be modified and increased. Under certain specific conditions which we are not yet acquainted with, pus with peculiar and specific properties or powers, is formed, and this exhibits a far greater vital activity and is less easily destroyed than the first.

220. On the Poison or Virus of Contagious Diseases.—The foregoing observations are particularly interesting in connection with the discussion concerning the nature of the materies morbi or virus of contagious diseases. Just as a change in the conditions under which the normal germinal matter of the body lives, will affect the rate of its multiplication, and its properties and powers, so that from it may proceed the germinal matter known as pus, which grows and multiplies with the greatest rapidity, and may even be removed considerable distances from the seat of its production without its vitality being destroyed,—so I think under conditions which have not yet been investigated, the rapid increase of certain forms of germinal matter of the body, perhaps of the living particles existing in the blood, may result in the production of particles with a power of resisting the influence of external conditions far greater than that of pus, and a power of multiplication when placed under certain special conditions, to which that of the pus corpuscle would appear slow. I have discussed this part of the question in my Report on the Cattle Plague.

The various facts and arguments advanced in my report render it, I think, probable that the materies morbi or contagium of contagious diseases, like pus, is generated in the organism under certain special conditions. Like pus, I think it has originally descended from the germinal matter of the organism. So virulent is the poison, and such is its power of living under varying conditions, that having once sprung into existence, it is almost impossible to extirpate it. If, however, it were possible to destroy all the existing particles of any specific form of contagious germinal matter, it is reasonable to conclude that no new living matter with the same peculiar properties or powers would be reproduced, unless the very same complex conditions which were present at its origin, recurred.

221. Tubercle.—Specimens of tubercle should be taken from the lung itself. Not unfrequently tubercle is expectorated in the sputum, but it is so mixed with pus and other substances, and it is so much changed, that its characters are not often to be readily distinguished. When examined under the microscope, tubercle is seen to consist of a great number of small particles, for the most part of an oval form. They vary somewhat in size and form, are evidently solid, and have a granular appearance. The great majority of them contain nothing like a nucleus. They have been described as free nuclei, but I have

never been able to satisfy myself that this view of their nature is correct. They become indistinct when immersed in glycerine, and are rendered transparent by acetic acid. Much granular matter and many minute oil globules are usually present. Tubercle corpuscles are about the 1-2000th of an inch in their long diameter. Pus corpuscles and many of the cells described under "Sputum," are usually present with tubercle. Tubercle corpuscles cannot be regarded as the essential characteristic elements of this substance, for they are not always to be made out in structures which are evidently tubercular. Tubercle when first formed consists of germinal or living matter, but that which is usually termed tubercle consists of the products resulting from the death of these. By the further disintegration and breaking up of the tubercle corpuscles a variety of appearances result. Very different opinions as to the nature of the tubercle corpuscle are held by various authorities. Schroeder van der Kolk considers that tubercle results from a change taking place in the ordinary epithelium of the pulmonary air cells, and this opinion is entertained in a more or less modified form by a great number of observers.* Of the existence, however, of this epithelium in health there is much difference of opinion. In some cases, where the disintegration of the lung tissue has not proceeded to a very great extent, turbercle corpuscles may be detected in the sputum.

For the opportunity of examining many interesting specimens of sputum in phthisis, I have to thank many friends, especially Dr. Scott Alison, of the Consumptive Hospital.

It is extremely difficult to decide with any certainty the mode of origin of tubercle, and the facts at present accepted, really permit much difference of opinion. It is probable that tubercle results either from the multiplication of masses of germinal matter which have passed through the capillary walls from the blood or is developed from the masses of germinal matter usually termed nuclei in connection with the capillary walls. In the case of tubercle which was very rapidly developed upon the surface of the *pia mater* in a man of tubercular constitution, I proved most distinctly that the "tubercles" were connected with the vascular walls, and that if the "nuclei" had not given origin to them, they were certainly implicated. My own opinion is that these "nuclei" gave origin to the tubercle corpuscles in consequence probably of receiving from the blood peculiar nutrient matter. In the lung I have seen appearances which point to a similar conclusion.

* On this subject consult the papers of Dr. Radclyffe Hall, Dr. Thompson, Dr. Andrew Clarke, and others, referred to in the note on page 283.

CHAPTER VI.

ON URINE, URINARY DEPOSITS, AND CALCULI.—*Collecting Urine for Microscopical Examination.—On Examining Urinary Deposits in the Microscope.—Magnifying Powers.—Chemical Examination of Urinary Deposits.*—EXTRANEOUS SUBSTANCES MET WITH IN URINE.—OF URINARY DEPOSITS.—*Mucus.—Vibriones.—Torulæ.—Penicilium Glaucum.—Sugar Fungus.—Epithelium.—Spermatozoa.—Casts of the Uriniferous Tubes; of Medium Diameter; of Considerable Diameter; of Small Diameter.—Fat Cells.—Conditions in which Fatty Matter occurs in Urine.—Pus.—Earthy Phosphates.—Urates.—Uric Acid.—Oxalate of Lime.—Dumb-bells.—Triple Phosphate.—Cystine.—Carbonate of Lime.—Blood Corpuscles.—Large Organic Globules.—Small Organic Globules.*—URINARY CALCULI.—*Formation of Calculi.*—ON THE PRESERVATION OF URINARY DEPOSITS; *in the Dry Way; in Canada Balsam; in Aqueous Solutions.*

IT is not compatible with the object of this work to do more than give a very short summary of the microscopical characters of the principal urinary deposits, and describe the mode of collecting them and the plans adapted for their preservation. The microscopical and chemical characters of the urinary constituents in health and disease, have been fully described in my other work, to which the reader is referred for more complete information.* In the present chapter, drawings only of those deposits which more frequently come under the notice of the practitioner will be given.

The microscopical examination of the urine has of late years become a subject of such great importance, and the advantages derived from it so generally admitted, that I need scarcely dwell upon its value. Within the last fifteen or twenty years, the investigation of urinary deposits has been so much simplified by the use of the microscope in conjunction with chemical analysis, that the nature of the greater number of depo-

* "Illustrations of Urine, Urinary Deposits, and Calculi," third edition, 1868.

sits has been correctly ascertained. The investigations of Dr. Prout, followed by those of Drs. Golding Bird, Jones, Christison, Owen Rees, Johnson, and many others, have shown the importance of the examination of the urine, and the advantages derived from it in the diagnosis and treatment of urinary diseases.

By frequent examination of different specimens of urine, and reference to the drawings, the student will soon become familiar with most of the deposits he is likely to meet with. At first, however, he must be prepared to encounter serious difficulties, the nature of some of which it is desirable to consider here.

In some specimens of urine which he examines, he will perhaps be surprised to find no deposit whatever, whilst in examining others, the whole field of the microscope appears to be occupied by substances of various shapes and colours, the nature of which he is unable to ascertain by reference to works on the subject. Many of the bodies whose presence gives rise to this difficulty, have obtained entrance into the urine accidentally, and these are often mistaken by the student. Portions of hair have been regarded as casts of the renal tubes, starch granules as cells ; and other substances of extraneous origin, such as small portions of woody fibre, pieces of feathers, wool, cotton, &c., often take the form of some of the urinary deposits, and to a certain extent resemble the drawings of them in their general appearance, so as to mislead the student in his inferences, and retard his progress in the investigation.

In this portion of the work, the principle followed throughout, namely, that of supposing the student actually engaged in working at that part of the subject under discussion, has been adhered to as far as practicable.

222. Collecting Urine for Microscopical Examination.—Urine, which is to be submitted to examination, should be collected in considerable quantity, in order to obtain sufficient of the deposit for microscopical investigation. In many instances the amount of sediment, even from a pint of urine, is so small that, without great care in collecting, it may be altogether passed over. The bulk of deposit from a measured quantity of urine should always be roughly noted. The space occupied by it may be compared with the total bulk of the liquid, and we may say the deposit occupies a fifth, a fourth, half the bulk of the urine, &c. It is also very important that the total quantity of urine passed in the twenty-four hours should be noted.

Bottles used for carrying specimens of urine should be made of white glass, with tolerably wide mouths, and capable of holding at least four ounces ; but, if the sediment only of the urine is required, the clear supernatant fluid may be poured off, after the urine has

stood in the receptacle for several hours, and the deposit may then be poured into small bottles of an ounce capacity, or even less. The only objection to this latter mode of collecting urine is, that no idea of the *amount* of sediment belonging to a given quantity of urine can be formed. The bottles may be arranged in a case capable of containing two, four, or six.

223. Importance of Examining the Urine soon after it has been passed, and also at a later period.—In all cases the urine should, if possible, be examined within a few hours after its secretion, and, in many instances, it is important to institute a second examination after it has been allowed to stand for twenty-four hours or longer. Some specimens of urine pass into decomposition within a very short time after they have escaped from the bladder; or the urine may even be drawn from the bladder actually decomposed. Under these circumstances we shall probably find the secretion highly alkaline, with a strongly ammoniacal odour, and containing numerous crystals of triple phosphate, with granules of earthy phosphate; and upon carefully focussing, multitudes of vibriones will be noticed. In other instances, the urine does not appear to undergo decomposition for a considerable period, and may be found clear, and without any deposit for a day or two, or even longer, after it has been passed. In those cases in which *uric acid* or *oxalate of lime* is present, we shall find that the deposit increases in quantity after the urine has stood still in the glass for some time. These salts are frequently not discoverable in urine immediately after it is passed, but make their appearance in the course of a few hours. The deposition of uric acid seems to depend upon a kind of acid fermentation, which has been the subject of investigation by Scherer.

In order to obtain sufficient of the deposit from a specimen of urine for microscopical examination, we must place a certain quantity of the fluid in a conical glass, in which it must be permitted to remain for a sufficient time to allow the deposit to subside into the lower part. It is then removed in the pipette (§ 106).

224. Magnifying Powers required in the Examination of the Urine.—Urinary deposits require different magnifying powers for their examination, those which are most frequently used being the inch and the quarter of an inch. The former magnifies about 40 diameters (× 40), the latter from 200 to 220 (× 200, × 220). Large crystals of uric acid may often be readily distinguished by the former, but crystals of this substance are sometimes so minute that it is absolutely necessary to use higher powers. Octohedra of oxalate of lime are frequently so small that they cannot be seen with any power lower than a quarter; and, in order to bring out the form of

the crystals, even higher magnifying powers than this are sometimes necessary. Spermatozoa may be seen with a quarter, but they then appear very minute. In these cases, an eighth of an inch object-glass, which magnifies at least 400 diameters (× 400), will be of advantage, but I recommend the student to purchase a one-twelfth magnifying about 700 diameters, if he obtains any power higher than a quarter. The casts of the uriniferous tubes, epithelium, and the great majority of urinary deposits can, however, be very satisfactorily demonstrated with a quarter of an inch object-glass. The student should always bear in mind that it is very important to become thoroughly expert in the use of the lower powers before he attempts to work with higher ones.

In some cases, it will be well to subject the deposit to examination in various fluids, such as water, spirit, mucilage, turpentine, Canada balsam, &c., § 74.

225. Importance of the Chemical Examination of Urinary Deposits.—In the investigation of those deposits which are prone to assume very various and widely-different forms, such as uric acid, it will sometimes be necessary to apply some simple chemical tests, before the nature of the substance under examination can be positively determined.

Suppose, for instance, a deposit which is found, upon microscopical examination, not to possess any characteristic form, be suspected to consist of uric acid, or of an alkaline urate, we have only to add a drop of solution of potash, which would dissolve it, and then excess of acetic acid, when the crystals of uric acid will be deposited after some time in their well-known rhomboidal form; or any other chemical tests which should be considered necessary, § 129 et seq., may be applied. See tables in "Urine, Urinary Deposits, and Calculi."

When it is necessary to resort to chemical reagents, a drop of the test solution is to be added to the deposit which is placed in the cell, or upon the glass slide. If necessary, heat may be applied to the slip of glass by a spirit-lamp, and, with a little practice, the student will soon be able to perform a qualitative analysis of a few drops of urine, or of a very small portion of a deposit. See chapter III.

Reference may be made to the following works :— Prof. Bowman's "Manual of Medical Chemistry," by Prof. Bloxam. "Illustrations of Urine, Urinary Deposits, and Calculi." Miller's "Elements of Chemistry," vol. iii. Neubauer and Vogel, translated for the Sydenham Society.

226. Examination of the Deposit in the Microscope.—The drop of urine with the deposit, removed by the pipette, being now inclosed in one or other form of cell, §§ 109, 110, various parts of the speci-

men are to be brought into the field of the microscope. It is better to examine the object as regularly as possible, commencing on one side, and moving it up and down, until the whole has been traversed. After one specimen has been examined, and the nature of its contents noted, another may be treated in the same way. Specimens should be taken from the deposit at different levels; for while some deposits soon sink to the bottom, others are buoyed up, as it were, either by the small quantity of mucus which the urine contains, as is the case with small crystals of oxalate of lime, or by the flocculent nature of the deposit itself.

As each part of the deposit is brought into the field of the microscope, the student should endeavour to recognize every object as it passes before his eye. This, however, he will find to be for some time a matter of considerable difficulty, arising partly from the great number of deposits which commonly occur together, partly from the very various forms which many of these substances are liable to assume, but chiefly, I believe, from the great number of substances of accidental presence which are found in almost every specimen of urine submitted to examination; more especially in urine obtained rom the wards of a hospital, upon which the first microscopical observations are usually made.

227. Matters of Extraneous Origin frequently met with in Urine.—The substances named in the following list are among those which are very constantly met with amongst urinary deposits, and their general characters are represented in pl. XXXIV, figs. 252, 253, 254. Fragments of human hair: cat's hair: hair of different colours from blankets: portions of feathers: fibres of worsted, and fibres of cotton of various colours: fibres of flax: potato starch, rice starch, wheat starch, bread crumbs: fragments of tea leaves, or separated spiral vessels and cellular tissue: fibres of coniferous or other wood swept off the floor: particles of sand: oily matter, in distinct globules, arising from the use of an oiled catheter, or from the accidental presence of milk or butter.

Besides the above, there are many other things met with less frequently, as for instance, fragments of silk, mustard flour, cheese, small portions of the skin of potato, or of different kinds of fruit, and some others which will occur to the mind of every one. With the microscopical characters of these bodies, the student should make himself perfectly familiar as soon as possible; and, as they can be obtained without the slightest difficulty, there is no excuse for ignorance of the general characters of these common things. If he is not able to recognize the ordinary extraneous matters, the student will frequently find himself in considerable difficulty, and his ignorance

will lead him to make the most ludicrous mistakes. The origin of most of these substances is so obvious that it need not be stated, but it should be remembered that many of them become slightly altered by standing for some time in the urine.

Fibres of Deal from the Floor.—The only matter of extraneous origin which requires to be particularly noticed, is one which may very easily be mistaken, and, indeed, frequently has been mistaken for tube casts. The substance to which I refer consists of the delicate fibres of coniferous wood which are swept off the deal floor, and thus get into the urine, pl. XXXIV, fig. 253. The fibres become soft and swollen by soaking, and sometimes look much like casts. The round pores which they contain somewhat resemble epithelial cells. These bodies, of course, will only be met with when the floor is of deal and often swept. I have found them in very many specimens of urine obtained from King's College Hospital.

It is impossible, as a general rule, to prevent the chance of matters falling accidentally into the urine. In wards of hospitals, where the floors are constantly swept, the disadvantage is greatly increased. Much inconvenience arising from the presence of extraneous matters would be prevented if each vessel were provided with a light simple cover. For further remarks on the subject of extraneous matters in the urine, the reader is referred to a paper "On the Characters of Extraneous Matters," in the Microscopical Journal, No. II, and to the plates in my work "On the Urine."

Substances of various kinds are not unfrequently added to the urine for the purpose of deceiving the practitioner. With this view, hysterical patients sometimes try to impose upon, and excite the commiseration of the physician by adding flour, sand, brickdust, and other powders to the urine. Milk is very commonly added. Such a specimen is very easily distinguished from the chylous urine by the presence of the numerous oil globules.

In one case which came under the notice of my friend Dr. Stewart, jeweller's rouge (peroxide of iron) had been added to the urine. The man had been to several of the metropolitan hospitals and had imposed upon the physicians, but at last Dr. Stewart was able to ascertain the nature of the peculiar red brown deposit. Microscopical Journal, No. II, p. 93.

Dr. Beigel brought me, not long since, a specimen of urine with a bulky light brown deposit which was found to consist entirely of yeast which had been added to the urine.

Of Urinary Deposits.

228. Arrangement of Urinary Deposits.—The following arrangement of urinary deposits is based simply upon the appearance which the deposit assumes when examined by the unaided eye. Although such an arrangement is purely artificial, it will serve to associate, in the student's mind, the general appearances which different deposits usually present, with their microscopical characters. The proposed arrangement has no reference to their chemical nature, microscopical characters, origin, or to their importance in diagnosis. That it has some practical advantages, will, I think, be admitted; but it is not to be considered in the light of a scientific classification.

Upon taking a superficial glance at the more common forms of urinary deposits, it will be noticed that while some are transparent, light, and flocculent, others present the converse of these characters; on the other hand, there are several granular or crystalline substances which form a small dense sediment which sinks to the bottom of the vessel, leaving a perfectly clear supernatant fluid. Deposits will, therefore, be divided into three classes, according to the general characters which they exhibit to the unaided eye.

1. Light and Flocculent Deposits, usually Transparent, and occupying considerable volume.—Mucus, with epithelium of different characters, spermatozoa, vibriones, certain forms of fungi, various forms of casts of the uriniferous tubes, and certain matters of extraneous origin.

2. Dense and Opaque Deposits, occupying considerable bulk.—Urate of soda, pus, phosphates, aud certain matters of extraneous origin.

3. Granular or Crystalline Deposits, occupying a small bulk sinking to the bottom, or deposited upon the sides of the vessel.—Uric acid, oxalate of lime, small quantities of triple phosphate, cystine, carbonate of lime, blood corpuscles, &c., with matters of extraneous origin.

First Class of Urinary Deposits.

229. Mucus.—If healthy urine be allowed to stand for a few hours after it has been passed, a bulky, flocculent, and very transparent cloud will be deposited towards the lower part. Upon examining this in the microscope, a few delicately-granular cells, rather larger than a blood corpuscle, will be observed sparingly scattered through a clear and perfectly transparent substance, in which only a few minute granular points can be detected. Mucus is, in fact, the débris from

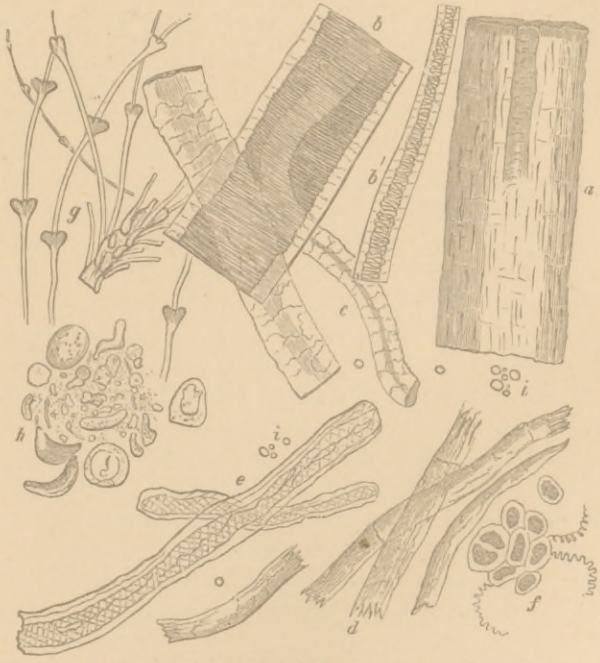
Fig. 252.

Globules of potato starch, as they appear when examined in water. × 215. p. 210.

Fig. 253.

Small fragments of deal wood swept from the floor. They may very easily be mistaken for casts, and the 'pores,' characteristic of coniferous wood, are not unlike epithelial cells. p. 211.

Fig. 254.



a, fragment of human hair. *b*, cat's hair. *c*, hair from blanket. *d*, fibres of flax. *e*, fibres of cotton. These, as well as worsted fibres, are often coloured. *f*, fragments of tea leaves, showing cells and spiral vessels. *g*, portions of feather. *h*, bread crumbs, showing wheat starch partly altered by baking and maceration. *i*, free oil-globules, consisting of small particles of butter. All × 215. p. 210.

1000th of an Inch ⌊⌋ × 215.

[To face page 212.

the epithelial surface. A few cells of epithelium from the bladder, or from some other part of the urinary mucous membrane, are not unfrequently met with. Nothing more is observed in examining healthy mucus in urine. In some diseases, however, this mucus increases in quantity, and forms a thick transparent deposit, containing numerous cells similar to those above referred to, with much epithelium, the character of which depends upon the particular part of the mucous membrane affected; fig. 255, pl. XXXV, represents the general appearance of mucus found in urine. In the upper part of the figure is represented a cell of bladder epithelium.

The mucus which is deposited from many specimens of urine, often contains a great number of octohedral crystals of oxalate of lime, frequently so very minute as to appear under a power of 200 diameters, like a number of dark square-shaped spots. Their crystalline form may be demonstrated by the use of a higher power, but they may be recognized with certainty with a little practice, as their square shape presents a characteristic appearance which soon becomes familiar to the eye. They are insoluble in a solution of potash, and also in strong acetic acid. These crystals are commonly not deposited until after the urine has left the bladder, and if it be allowed to stand for a longer period, they frequently undergo a great increase in size. Upon examination, fragments of hair, small portions of cotton fibre, and other substances of accidental presence, are not unfrequently found to be encrusted with these minute crystals. Oxalate of lime is often deposited in the urine of persons in good health.

A very thick, glairy, gelatinous deposit, which is frequently found in the urine in cases of disease of the bladder, must not be mistaken for mucus. This consists of pus altered by the action of carbonate of ammonia, which has been set free in consequence of the decomposition of the urea by the mucus or some other animal matter acting upon it as a ferment, § 230, after it has left the bladder. In some cases this change commences in the bladder itself, and the expulsion of the viscid glairy mass often occasions great pain, and it is sometimes very difficult to remove. Urine of this kind exhibits a highly alkaline reaction, evolves an ammoniacal odour, and frequently contains a considerable deposit of crystals of the triple or ammoniaco-magnesian phosphate, with granules of phosphate of lime. Liquor ammonia and potash exert a similar change upon pus out of the body.

230. Vibriones.—After mucus has been allowed to stand for some time in urine, numerous vibriones are developed in it. These vegetable organisms are seen as minute lines under the microscope, but they undergo very active movements; the longer ones twisting

about in a serpentine manner. They are sometimes developed in urine before it has left the bladder, and always occur in decomposing urine. Fig. 256 *b*, pl. XXXV, represents the appearance of some of the commonest vibriones met with in urine. The "Trichomonas Vaginæ," discovered by Donné, is said to be found sometimes in the urine of women suffering from leucorrhœa.

231. Torulæ.—Certain forms of vegetable fungi or torulæ are developed in urine after it has been standing some time. The period which elapses before the appearance of the fungi, and the particular species or the special form assumed by the species which is developed, varies much in different specimens of urine, and in different cases of disease. In diabetes, torulæ are often developed in quantity very soon (within a few hours) after the urine has been passed; and their growth at this early period leads the observer to suspect the presence of sugar, which must be confirmed by the application of chemical tests. See "Urine, Urinary Deposits, and Calculi."

Fig. 256 *a*, pl. XXXV, represents sporules of fungi of three different characters. Figs. 257, 260, and 261 show the appearance of fungi often developed in urine. All these were found in acid urine, and uric acid was present in the specimen which contained the fungi represented in the two lower drawings.

223. Penicilium Glaucum. Sugar Fungus.—Dr. Hassall has communicated a most interesting paper upon the development of torulæ in the urine, to the Medico-Chirurgical Society, which will be found in the volume of Transactions for 1853. Dr. Hassall has arrived at the conclusion that there is a species of fungus which is developed in specimens of urine, containing even very minute traces of sugar, which may be looked upon as characteristic of the presence of this substance, as it occurs in no other condition of the urine. This is the sugar fungus, which is represented in different stages of growth in fig. 263, after Hassall, and in figs. 264, 265. The sugar fungus in diabetic urine is identical with the yeast plant. The sporule state is represented in the upper part of the figure, and at *a* is shown the thallus of the sugar fungus. The fructification of this fungus is represented in fig. 259.

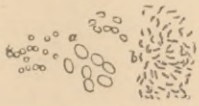
Besides the sugar fungus, however, there is another species which is very commonly met with in acid urine containing albumen, if exposed to the air. This is the *Penicilium glaucum*. This species is represented in different stages of growth in figs. 257, 258, 260, 261. Its fructification, which is very different from that of the sugar fungus, is shown in fig. 258.

The microscopical characters of the fungi in different specimens

Fig. 255.

Vesical mucus, found in urine. At the upper part of the figure a bladder epithelial cell is represented. × 215.

Fig. 256.



Vegetable organisms met with in urine. *a*, different forms of fungi. *b*, vibriones. × 215.

Fig. 257.

Penicillium glaucum, from acid urine.

Fig. 258.

Fructification of penicillium glaucum.

Fig. 259.

Fructification of yeast fungus.

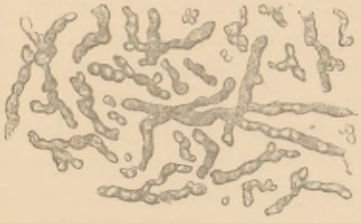
Fig. 260.

Penicillium glaucum. × 215.

Fig. 261.

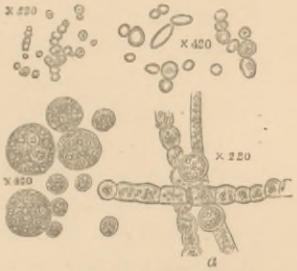
Penicillium glaucum, from acid urine. × 215.

Fig. 262.



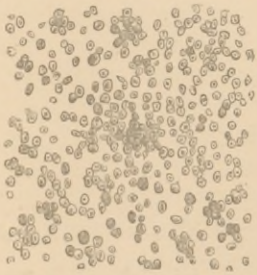
Penicillium glaucum, found in diabetic urine four days after it was passed. × 215.

Fig. 263.



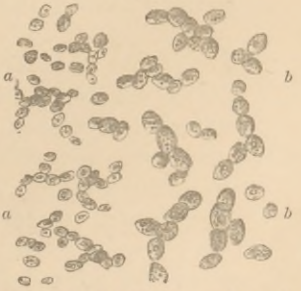
The sugar fungus, from diabetic urine.

Fig. 264.



Yeast torulæ, from beer. × 215.

Fig. 265.



Yeast added to diabetic urine, and allowed to stand in a warm place forty-eight hours. Showing growth of the torula. *a*, × 215. *b*, × 400.

1000th of an Inch ⌊___⌋ × 215.

" " ⌊_____⌋ × 400.

[To face page 214.

of urine vary considerably; but these differences depend not upon the existence of several distinct species of plants, but rather upon the stage of development which the fungus has reached, and the conditions present during its growth. In one specimen of urine, the growth of the fungus may be arrested at the sporule stage, figs. 256, 263, 264, 265; in another not until a thallus, figs. 260, 261, 263, is formed, and in a third it goes on until aeriel fructification takes place, and new spores are developed. The degree of acidity of the urine, and the length of time during which it has been exposed to the air, appear to determine, in great measure, the stage of development which the fungus attains.

The penicilium glaucum, as well as the sugar fungus, may be met with in saccharine urine, because all the necessary conditions for its development may exist, namely, exposure to air, an acid liquid, a little phosphate, and a certain quantity of nitrogenous matter; but the sugar fungus is found only in those specimens of urine in which to these three conditions is added a fourth, viz., the presence of sugar.

Sarcinæ.—These vegetable organisms, not uncommon in the matters rejected in certain cases of obstinate vomiting, are occasionally met with in urine. The specimens occurring in this fluid are usually more minute than those obtained from vomit. The characters of sarcinæ are described in chapter VIII.

233. Epithelium of the Genito-urinary Passages.—The forms of epithelium which may occur in urine are very numerous, as the characters of the cells differ very much in different parts of the genito-urinary mucous membrane.

The specimens represented in figs. 266 to 269, pl. XXXVI, were carefully removed from the mucous membrane of the urinary passages of a healthy male subject, with the exception of a few cells which were found in urine. Epithelium from the vagina and bladder is represented in the same plate.

Kidney.—Convoluted Portion of the Tubes.—The epithelium is of the variety termed glandular, or secreting epithelium, and forms a single thick layer of cells upon the basement membrane. The characters of this variety of epithelium have been described in page 157.

Straight Portion.—The epithelium is flatter, and approaches more nearly to the scaly variety. It forms a thin layer on the surface of the basement membrane.

Pelvis of the Kidney.—The epithelium consists of flat thin scales, which are united together at the edges without overlapping each other. This is termed tessellated epithelium, fig. 267.

Ureter.—The epithelium is very abundant, and of the columnar

or cylindrical form. The nucleus is usually large and distinct, fig. 268.

Bladder.—The epithelium of the bladder differs much in different parts. In the fundus there is much columnar epithelium mixed with the large oval cells figured in 271 ;—whereas, in that part termed the trigone, the large flattened cells, with a very distinct nucleus and nucleolus are most abundant. The columnar epithelium, *b*, fig. 181, appears to line the mucous follicles, while the scaly variety lies on the surface of the mucous membrane between them.

Urethra.—The epithelial cells of the urethra, fig. 269, are, for the most part, of the columnar form, but mixed with this there is also a good deal of scaly epithelium. Towards the orifice, the epithelium is almost entirely of the scaly variety.

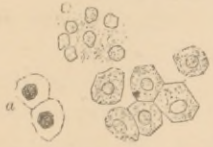
Vagina.—The large cells of scaly epithelium, so commonly met with in the urine of females, and derived from the vagina, are represented in fig. 270. They vary, however, much in size and form, and are sometimes very irregular in shape, with uneven ragged edges.

234. Spermatozoa.—The urine should be examined for spermatozoa soon after it has been passed, but they are not so rapidly destroyed as has been supposed. They may be detected with a power of about 200 diameters, figs. 272, 273, if the eye is familiar with their appearance ; but to demonstrate them to persons who have not seen them before, it is better to employ a power of from 300 to 700 diameters.

The detection of spermatozoa in the vaginal mucus in cases of suspected rape, is of immense importance. This is one of the cases in which the practical utility of the microscope is quite unquestioned. The mucus may even be dried and remoistened without destroying the forms of the spermatozoa. For cases see "Archives of Medicine," vol. I, pages 48 and 139; see also my work on "Urine, Urinary Deposits, and Calculi."

The occasional presence of spermatozoa in the urine is not inconsistent with perfect health. It is only when their appearance is constant and accompanied with other more important symptoms that the practitioner is justified in interfering. We must always exercise the greatest caution in these cases, for the mere allusion to spermatorrhœa has done more harm to the patient's mind, that can be counterbalanced by the good produced by medical treatment. The occasional presence of spermatozoa in urine must not be looked upon, in itself, as evidence of the existence of that condition, to which the term *spermatorrhœa* has been applied,—a word which I am sorry to put into print at all ; for I doubt if any one word has been productive of more unutterable misery than this. Instead of making use of it,

Fig. 266.



Epithelium from the convoluted portion of the uriniferous tube. *a*, treated with acetic acid.

Fig. 267.

Epithelium from the pelvis of the human kidney.

Fig. 268.

Epithelium from the ureter.

Fig. 269.

Epithelium from the urethra. × 215. p. 215.

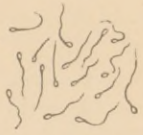
Fig. 270.

Epithelium from the vagina. p. 216.

Fig. 271.

Epithelium from the bladder. p. 216.

Fig. 272.

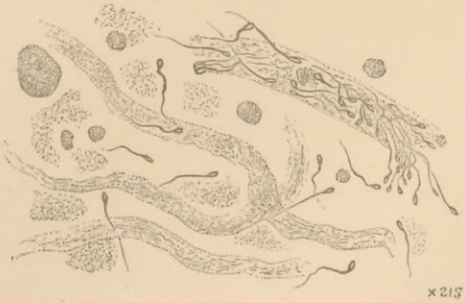


Spermatozoa from urine. × 215. p. 216.

Fig. 274.

Filaments of a vegetable nature resembling spermatozoa. × 403. p. 217.

Fig. 273.



'Cast' of the seminal tubes. Spermatozoa embedded in them. From an old man upwards of 80 years of age. p. 216.

1000th of an Inch ⌊___⌋ × 215.

" " ⌊_____⌋ × 400.

[To face page 216.

we should be more correct if we said that "the patient was suffering from such and such symptoms associated with the presence of spermatozoa in the urine." In the majority of cases in which this ill-chosen word is used, it excites the most terrible alarm in the patient's mind, from which, perhaps, he does not recover for some time,—his notions of the condition having been derived from studying the detestable pamplets sent round by quacks to catch unwary dupes. In the sense in which it is used by many practitioners, it only means that spermatozoa have been found in the patient's urine, as indeed they occasionally are in the urine of almost every healthy man.

The only bodies at all liable to be mistaken for spermatozoa that I have ever seen, are a form of vegetable growth which I have only once met with, in a specimen of urine kindly sent to me by my friend Mr. Masters, of Peckham Rye. Very careful notes of the case were taken by Mr. C. Roberts, of St. George's Hospital. Some of the bodies in question very closely resembled spermatozoa, but their true nature was ascertained by noticing the characters of many other specimens of the vegetable growth. These are figured in pl. XXXVI, fig. 274. See "Archives of Medicine," vol. I.

235. Trichomonas Vaginæ.—Donné observed some rounded cells with vibratile filaments projecting from them in the urine of females suffering from leucorrhœa, and considered them to be animalcules. The name, *Trichomonas Vaginæ*, was applied to them, but subsequent authorities have not been able to confirm M. Donné's observation. Gluge, Valentin, Siebold, and Vogel, consider the so-called *trichomonas vaginæ* to be merely a cell of ciliated epithelium from the uterus. Kölliker and Scanzoni have, however, found the trichomonas in the vaginal mucus, both of impregnated and unimpregnated women. (Scanzoni "Beiträge zur Geburtskunde," Band II.) I have never seen cells in any cases at all resembling M. Donné's figure.

Casts of the Uriniferous Tubes.

This is to the practitioner a most important and interesting class of urinary deposits, and one to which, until lately, very little attention has been paid. The microscopical characters of casts, in different forms of kidney disease, particularly with reference to the diagnosis of pathological changes taking place in the organ, have been investigated chiefly by Dr. George Johnson, to whose observations we are indebted for almost all that we know upon this subject.*

The microscopical characters of the forms of casts most commonly met with will alone be referred to here; and for a full

* "On Diseases of the Kidney," 1852.

description of the characters of the urine in which they occur, and their pathological interpretation, I must refer to my work on the Urine.

No conclusion can be based upon the presence of one or two casts of a particular kind, but it is to the general characters of the deposit we must direct our attention. Thus we may find in the deposit from the urine in acute cases which completely, and may be very rapidly, recover, one or two cells containing oil, and one or two casts containing a few oil globules. Now, we must not, from the presence of these, be led into the error of concluding that the case is one of fatty degeneration of the kidney; but if there were *numerous* cells and casts containing oil, and these occurred from day to day, such an inference might be justifiable. Nor must we expect to find in one case *epithelial casts* only, in another *granular casts*, in a third *fatty casts*, in a fourth none but *large waxy casts*, and so on; but we must be prepared to meet with several varieties in one case, and must ground our opinion, in great measure, upon the relative number of specimens of any particular kind of cast, and upon the circumstance of other deposits being associated with the casts. For instance, the presence of uric acid crystals and blood corpuscles would render it very probable that the case was acute, and of short duration. The absence of these deposits, and the presence of a number of granular or perfectly transparent casts, which can only be seen when the greater part of the light is cut off from the field of the microscope, or the existence of a number of oil casts, render it certain that the case is chronic. The former would indicate that the kidney was becoming small and contracted, while the latter variety of casts occur when it is often of large size and fatty. Such examples might be multiplied. When we consider how very numerous the secreting tubes of the kidney are, we cannot feel surprised that a different condition should exist in different tubes at the same time,—and from careful post mortem examinations, we know that very different morbid appearances are often seen in different parts of the cortical portion of one kidney. It is not difficult, therefore, to account for the fact of the presence of casts differing much in their diameter and characters in the same specimen of urine.

A *cast* consists of a mould of a uriniferous tube, and is composed of some transparent material which is formed in, or poured out into, the canal, and there rendered firm, entangling in its meshes whatever may be in the tube at the time of its effusion. The cast varies in diameter with that of the central canal; but probably, after its formation it contracts slightly, and in consequence, it is readily washed out of the tube and escapes into the urine. The diameter of the cast is determined in great measure by the width of the canal of the uriniferous

tube which varies according to the state of the epithelium. If the epithelial layer lining the tube be of its ordinary thickness, we shall have a cast of medium size. If the cells be enlarged, and adhere firmly to the basement membrane, the cast will be fine and narrow; while, on the other hand, if the tube be entirely stripped of epithelium, the basement membrane alone remaining, the diameter of the cast will be considerable. In describing the different varieties of casts, it will be convenient to divide them into three classes, according to their diameter. 1, *Casts of medium diameter;* 2, *Casts of considerable diameter;* and 3, *Casts of small diameter.*

Drawings of the various forms of casts, and a description of their characters, and the mode of their formation, will be found in my work on "Urine, Urinary Deposits, and Calculi," but a few of the typical forms have been introduced in pl. XXXVII of this book. The manner in which casts are formed is described in the same work.

236.—1. Casts of Medium Diameter, *about the* 1-700*th of an inch.* 'Epithelial casts' consist of moulds of the tubes in which cells of epithelium are entangled. Some of the cells may be entire, while others are disintegrated, pl. XXXVII, fig. 274. Some casts contain only granular matter, figs. 274*b*, 278, and epithelial débris. More rarely casts are met with which contain blood or pus globules. In some instances, entangled in the cast, are numerous oil globules, readily distinguished by their highly refracting nature, with or without cells of epithelium, larger than natural, and gorged with oil, fig. 275.

Once I have met with casts of medium diameter, containing well-formed dumb-bell crystals of oxalate of lime. These casts were found in the urine of a patient suffering from cholera. In the same specimen, also, several octohedra of oxalate of lime were present, but these latter were not entangled in the casts, showing that the octahedra were formed after the casts had passed from the kidney. See also "Urine, Urinary Deposits, and Calculi."

Occasionally, specimens of urine are met with which contain an abundant flocculent deposit, consisting entirely of casts gorged with cells closely resembling pus corpuscles and free cells of the same character. Such cases are frequently of an acute character, and may terminate fatally in a short time (three or four weeks), but this is not invariably the case. I have known several children in whose urine these casts and cells were most abundant, recover completely, and I have known one instance in which such cells continued present for upwards of six months. We must hesitate, therefore, before expressing a very unfavourable opinion in these cases, and ought never to ground our prognosis upon the characters of the urine only.

237.—II. Casts of Considerable Diameter, *about the* 1-500*th of an inch.*—"Large waxy casts" are perfectly transparent, and have a glistening aspect, somewhat resembling in appearance the surface of wax as it cools after having been melted. Casts of considerable diameter also occur, of a granular character, and one portion of a cast is often granular while the other is transparent, and containing perhaps a few epithelial cells. Large waxy casts are seen in fig. 276; at *a* is represented a large cast, perfectly transparent. Two of the casts in the figure, and the one depicted at *a*, fig. 277, appear to be composed of a material in the interior, differing from that which forms the circumference of the cast—an appearance which I have in several instances observed. In some cases it is probable that these casts of large diameter are formed in the wide part of the straight portion of the uriniferous tube where this is very wide. Often it is evident that the material is deposited in successive layers, as in fig. 277, *a*. Although in some cases the convoluted portion of the uriniferous tube is wide enough to admit of the formation of one of these large waxy casts, I have never seen an instance where the tubes leading from the cortical to the medullary portion of the kidney were wide enough to permit them to pass through. I think, therefore, that much of the material must have been deposited as the cast, at first very narrow, passed towards the lower portion of the uriniferous tube.

238.—III. Casts of Small Diameter, *about the* 1-1000*th of an inch.*—'Small waxy casts' are formed in cases in which the epithelium manifests no tendency to desquamate (*non-desquamative nephritis*). The diameter of the cast is, therefore, that of the central canal only, fig. 278; and, not unfrequently, we meet with casts of less than 1000th of an inch in diameter, having a perfectly smooth and glistening surface, and without the slightest trace of granular matter. These appear perfectly hyaloid, and, in the microscope, present the same general appearance as a piece of the elastic lamina of the cornea.

239. Fat Cells.—Besides the occurrence of fatty matter in casts, and in cells entangled in casts, it is very commonly met with in cells in the urine without the presence of casts. These are altered epithelial cells of the kidney, enlarged and gorged with oil, figs. 275, 279. Sometimes they contain a few oil globules, which are well defined, and are seen to be distinct from each other; while, in other instances, the globules are very minute, and so crowded together, that the cell appears perfectly opaque and dark, resembling the so-called inflammatory globules or exudation corpuscles. Occasionally, cells containing oil globules may be derived from some other part of the mucous surface of the urinary passages. Fig. 280, pl. XXXVIII, represents the appearance of some epithelial cells, and collections of oil globules

taken from the membranous portion of the urethra. These could hardly be mistaken for the cells and casts met with in the urine in cases of fatty degeneration of the kidney; but at the same time it is important to bear in mind that cells containing oil globules are occasionally met with in cases where the kidney is not diseased.

240. Conditions in which Fatty Matter may be met with in Urine.—Of late, much attention has been paid to the presence of fatty matter in the urine, and it may be of advantage to refer to the various states in which it may be met with in this secretion. 1. Fatty matter may occur in the urine as distinct and separate globules, resembling those which are produced by intimately mixing oil with water by the aid of mucilage, &c., pl. XXXVIII, fig. 279, *b*. When fatty matter occurs in this state only in urine, it has most probably been mixed with the urine after the secretion has left the bladder. It may have dropped into the urine accidentally, or it may have been intentionally introduced for the purpose of deceiving us, or the secretion may have been drawn off with an oiled catheter.

2. Fatty matter occurs in the urine in the form of globules, inclosed within a cell wall, or in casts, as referred to in p. 218. The composition of the fat in these cases is very interesting. I have shown that it contains much cholesterine dissolved in a more fluid fat, from which it may be readily separated in a crystalline form. From the fatty matter contained in cells obtained from morbid structures in other parts of the body, I have also been able to extract cholesterine; and also from some organs in a state of fatty degeneration. See "Archives of Medicine," Vol. I, page 8, and my work on Urine, Urinary Deposits and Calculi.

3. In some of the rare instances which occur from time to time of the so-called "chylous urine," the fatty matter is suspended in a state of exceedingly minute division. In a specimen of chylous urine, for which I have to thank my friend Mr. Cubitt, of Stroud, there existed nearly thirteen grains of fatty matter in a thousand of urine. I could not detect any oil globules. The whole of this large quantity of fatty matter was in that extremely minute state of division, which is termed "molecular," in which condition the fatty matter exists in chyle. Upon microscopical examination, the field was seen to be covered with minute molecules, like small dots, vibrating with a quivering motion, about each other. In this specimen there were also a few delicately granular cells present. The appearance of this urine, examined with a quarter, is represented in pl. XXXVIII, fig. 281.*

When, therefore, distinct *oil globules* are present in urine, they

* The case is fully reported, with analyses of the urine, in vol. I of the "Archives of Medicine."

may have been derived from *oil* or *butter*, which has accidentally fallen into the secretion, or they may be due to the admixture of *milk*. When the oil globules are inclosed within a *cell wall*, or *entangled in casts*, the condition may be looked upon as indicative of '*fatty degeneration*' of the kidney, or of the epithelium situated in some other part of the genito-urinary mucous membrane. And where the fatty matter is in a *molecular state*, the case is one of '*chylous urine*.'

Second Class of Urinary Deposits.

The three deposits in this class to the unaided eye are often very much alike ; but they differ widely in their microscopical characters, in their behaviour with chemical reagents, as well as in pathological importance.*

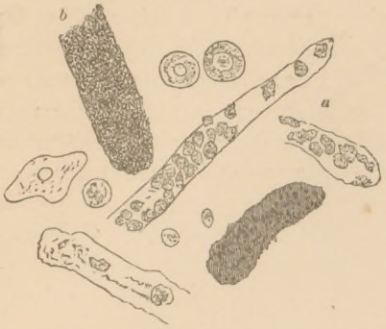
241. Pus.—The microscopical characters of pus have been described in pp. 198, 201. The form of the globules becomes somewhat altered if they have been soaking in urine for a long time, and ultimately they undergo complete disintegration. Fig. 282 shows the appearance of pus globules ; at *a* four are seen which have been acted upon by acetic acid. See also figs. 246, 248, 249, pl. XXXIII. If decomposition of the urea, accompanied with the development of carbonate of ammonia, occurs, the globules become converted into a glairy viscid mass : see p. 213.

A deposit of pus is very frequently accompanied with crystals of triple phosphate, but this is by no means invariably the case. I have noticed that when the pus is derived from the bladder, the crystals are very frequently present ; but in several cases in which large quantities of pus were passed in the urine, but were formed in the kidney, the crystals were altogether absent. This is perhaps to be accounted for by the altered composition of the urine in cases where the kidney is the seat of disease. The phosphate is never derived from the coats of the bladder as was formerly supposed, but when present it is invariably *deposited* from the urine.

Chemical Characters.—Deposits of pus are rendered clear and glairy by the action of strong alkalies. The mixture is so viscid that it will not *drop* from one vessel into another. The urine in which pus is present contains a trace of albumen, which may be detected by the application of heat or upon the addition of nitric acid, and in certain cases it is sometimes a very nice point to decide whether the

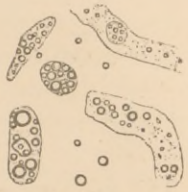
* The method of distinguishing these deposits from each other chemically is described in "Urine, Urinary Deposits, and Calculi."

Fig. 274.



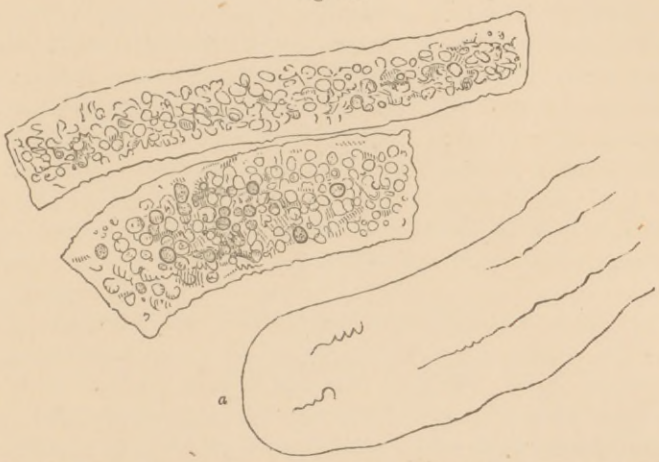
Epithelial casts. *a*, casts containing cells of epithelium. *b*, casts containing granular matter. From urine of acute dropsy.

Fig. 275.



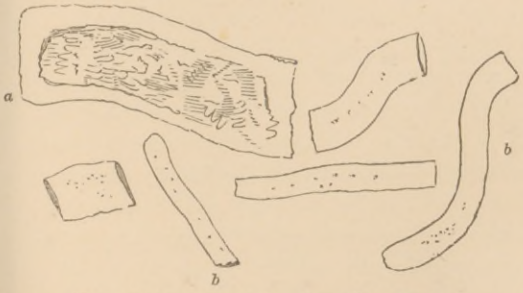
Casts containing fat-cells and oil-globules, from a case of fatty degeneration of the kidney.

Fig. 276.



Large casts: some containing many cells; others consisting of a perfectly transparent wax like material.

Fig. 277.



Waxy casts. *a*, of large size. *b*, small waxy casts.

Fig. 278.

Small granular casts, from the urine of a patient suffering from chronic nephritis.

1000th of an Inch ⌊___⌋ × 215.

All these figures × 215.

References to p. 230.

[To face page 222.

albumen results from chronic disease, or is due merely to the pus which is present in the urine.

242. Earthy Phosphates.—The earthy phosphates which occur in large quantity in urine are *triple phosphate*, generally accompanied with amorphous granules, or small rounded globules of *phosphate of lime*. This deposit often occurs in considerable quantity. Upon microscopical examination, numerous prisms of triple phosphate (HO,NH_4O,MgO,PO_5), in their well-known triangular form, with obliquely truncated extremities will be observed, pls. XXXVIII, XLI, figs. 283, 307.

Some of the crystals are more quadrilateral in form, while others appear almost like an octahedron, in consequence of the central part of the crystal not being developed. A crystal of this form is represented in fig. 283, pl. XXXVIII. In consequence of the two ends being closely approximated, the appearance of a square crystal, the opposite angles of which are connected with straight lines, is produced. Various modifications of the above forms will also be met with very frequently. The faces of the crystals become roughened by standing long in the urine, or, indeed, in pure water, unless a small quantity of some ammoniacal salt be dissolved in it, in which case the crystals will keep unimpaired for a length of time.

When triple phosphate is precipitated by the addition of liquor ammoniæ to urine, it occurs as beautiful feathery snow-like crystals, pl. XLI, fig. 308.

The more uncommon modifications of the crystals of earthy phosphate will be considered in the third class of deposits, as they most frequently occur only in small quantity. The deposit of triple phosphate is always accompanied with phosphate of lime ($2CaO,HO,PO_5$) if the urine be alkaline. This phosphate occurs in the form of small spherical masses or amorphous granules, pl. XLI, figs. 309, 310. Often two small globules are joined together so as to resemble a small dumb-bell crystal. It also occurs crystallized.

Chemical Characters.—Phosphates are soluble in acetic acid, and very readily so in nitric or hydrochloric acid. If ammonia be added to the acid solution, the triple phosphate is precipitated in the form of beautiful stellate crystals, fig. 308, which gradually become altered until prisms are formed, *a*.

243. Urates.—These deposits are sometimes found in very large quantity. The sediment composed of urates may vary in colour from a pale buff to a tolerably deep red; often, however, it is almost colourless. It is this deposit to which the terms 'nut-brown sediment,' 'lateritious deposit,' &c., have been applied, according to the proportion of colouring matter it may contain. It

consists principally of urate of soda, with small and variable proportions of urates of ammonia and lime, and traces of urate of magnesia.

Upon microscopical examination it is found to consist entirely of minute granules which are unequally aggregated together in different parts of the field, pl. XXXVIII, fig. 284. More rarely the deposit contains spherical masses of the urate, or small rounded globules, fig. 289. In children, urates are often found in the form of perfectly spherical masses, somewhat resembling in form the crystals of carbonate of lime occurring in horses' urine. Such crystals are figured in 'Urine, Urinary Deposits, and Calculi.' In the adult also, such spherical crystals are occasionally met with. Dr. Kennion, of Harrogate, sent me a short time since a specimen of urine containing the largest spherules of this description that I have ever seen. These are figured in vol. I, of the 'Archives of Medicine.'

The appearance of urate of ammonia artificially prepared, is shown in fig. 286. Fig. 285 shows the appearance of the spherical masses of urate of soda, which form part of the scum of urine while it is evaporating. The smooth semi-transparent flakes consist of phosphates which form a very thin film to which the urates adhere; and fig. 287 represents spherical crystals of urate of ammonia, prepared artificially.

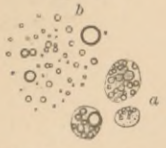
Chemical Characters.—Urates are soluble in boiling water, and very soluble in potash. Upon the addition of excess of acetic acid, the soluble urate is decomposed, and after the lapse of a short time, well-formed crystals of uric acid, which may be examined by the microscope, are deposited. Urates are entirely combustible at a red heat, and by being treated with nitric acid and ammonia, yield the beautiful purple colour characteristic of murexid (see Uric acid).

For the method of analyzing these deposits, see Heintz's "Zoochemie," Lehmann's "Physiological Chemistry," vol. i, Bowman's "Medical Chemistry," by Bloxam.

Urate of soda is not unfrequently met with in urinary deposits in the form of small spherical masses, from the surface of which spicules of uric acid project in various directions, pl. XXXVIII, fig. 289.

Occasionally, the very dark granular appearance of certain casts is due to the deposition of urates upon their surface and in their substance, after the casts have been passed. Epithelial cells which have been standing for a long time in urine rich in urates, also exhibit the dark granular appearance in every part. Spermatozoa are sometimes invested with a granular covering of urate of soda, and a variety of curious appearances are sometimes thus produced. In these cases the granular appearance is removed upon applying a gentle heat to the slide upon which the deposit is placed, or by the addition of a little dilute potash.

Fig. 279.



a, oil-globules enclosed in cells. *b* free oil-globules as they appear when oily matter has been mixed with urine × 215.

Fig. 280.

Epithelial cells and oil-globules from the membranous portion of the urethra. × 215.

p. 221.

Fig. 281.

Fatty matter in a molecular state, as it occurs in chylous urine. × 215.

Fig. 282.

Pus corpuscles. *a*, treated with acetic acid.

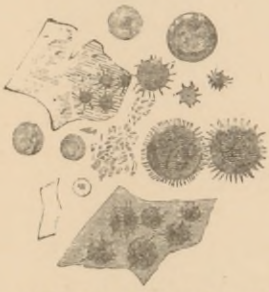
Fig. 283.

Crystals of triple phosphate. Small globules of phosphate of lime with vibriones. × 215. p. 223.

Fig. 284.

Urate of soda, as it commonly occurs in urine. × 215. p. 224.

Fig. 285.



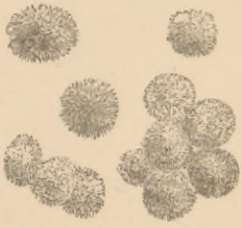
Urate of soda and films of triple phosphate, formed on the surface of concentrated urine.

Fig. 286.

Urate of ammonia, prepared artificially. × 215.

p. 224.

Fig. 287.

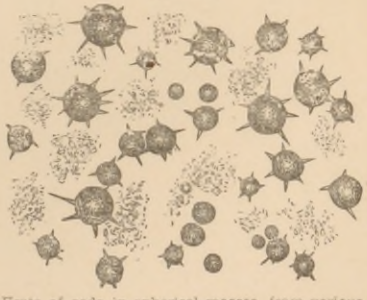


Urate of ammonia, prepared artificially. × 215.

Fig. 288.

Rare form of urate of soda, from urine of a patient suffering from peritonitis. × 215.

Fig. 289.



Urate of soda in spherical masses, from various parts of which minute acicular crystals of uric acid project. × 215.

p. 224.

1000th of an inch ——— × 215.

[To face page 224.

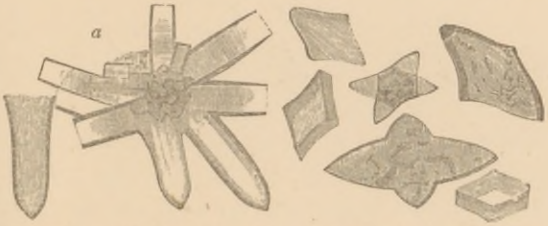
Fig. 290.

Uric acid crystals, formed by adding nitric acid to urine.
× 215.

Fig. 291.

Uric acid crystals. Human urine. × 130.

Fig. 292.



Large halbert-shaped crystals of uric acid. *a*, 'cayenne pepper' grain.
× 215.

Fig. 293.

Small crystals of uric acid of a rhomboidal form; many of them resemble sections of small cylinders.

Fig. 294.

Large crystals of uric acid. Deposited in urine after standing. × 130. p. 225

Fig. 295.

Less common forms of uric acid crystals. *a*, crystal like cayenne-pepper grains. *b*, six-sided crystals. *c*, mass with small uric acid crystals projecting from it. *d*, small pyramidal crystals of uric acid; very uncommon. *e*, peculiar forms of uric acid. p. 225.

Fig. 296.

Common forms of uric acid crystals. p. 226.

1000th of an Inch ⌊⌋ × 130.

References on p. 225. ,, ,, ⌊⌋ × 215. [To follow PL. XXXVIII.

Third Class of Urinary Deposits.

244. Uric or Lithic Acid.—This is one of the most common urinary deposits. Uric acid is frequently deposited after the urine has left the bladder, in consequence of the occurrence of acid fermentation, a process which has been studied by Scherer.* In some instances, however, the uric acid is undoubtedly precipitated before the urine is passed. Like the urates, deposits of uric acid vary very much in colour. Sometimes they are nearly colourless, while in other instances, the crystals are arranged in the form of large grains of a deep red colour "Cayenne pepper grains." In pl. XXXIX, figs. 292, 295, the appearance of two of these crystalline masses is depicted. The crystals also vary very much in size, so that the deposit may appear to the unaided eye as a granular layer, or as a distinctly crystalline sediment. Deposits of uric acid usually occupy an inconsiderable bulk, compared with that of the urine from which they have been precipitated. Uric acid is occasionally deposited in a granular form. In some cases a very abundant precipitate of minute crystals of uric acid is produced upon the addition of nitric acid to urine. So minute are the crystalline particles that the precipitate forms a cloud which has been many times mistaken for albumen.

The forms which the crystals assume are very various. The most characteristic, and those most frequently met with, approach the rhomb, and it is in crystals of this character that uric acid is usually deposited when solutions of any of its salts are decomposed by the addition of a stronger acid. Some of the most common forms are represented in pl. XXXIX. Fig. 293 shows the form in which uric acid is often found in the urine of cases of 'acute dropsy,' and of 'dropsy after scarlatina.'

Six-sided crystals of uric acid must not be mistaken for cystine, pl. XLI, fig. 315. They may readily be distinguished by two of their sides being longer than the others, and also by their chemical characters.

In fig. 290 are represented some crystals of uric acid, which are occasionally met with. They may often be produced by the rapid crystallization of uric acid in urine, to which nitric or hydrochloric acid has been added. Very many other forms of uric acid are represented in the plates in my work on 'Urine, Urinary Deposits, and Calculi.'

* "Untersuchungen," 1843. Lehmann's "Chemistry;" translated by Day, vol. ii, page 408.

Chemical Characters of Uric Acid.—A deposit suspected to consist of uric acid, but having no well-defined crystals, may be examined as follows :—A drop of liquor potassæ is to be added to it. If uric acid be present it will be dissolved, and the alkaline solution will deposit well-formed crystals of uric acid after the addition of excess of acetic acid. The mixture should be allowed to stand for some time to admit of the formation of crystals. Uric acid is soluble in nitric acid, and if the solution be evaporated to dryness, and a drop of ammonia added, it yields the most beautiful purple colour dependent on the formation of murexide. This is a good test for uric acid when free or in combination.

245. Oxalate of Lime.—Oxalate of lime was first shown to be a common urinary deposit by the late Dr. Golding Bird. It occurs as a scanty sediment, in which the crystals, if they are large, appear, to the unaided eye, as minute glistening points. Large crystals of oxalate of lime present a beautiful appearance when examined by reflected light, pl. XL, fig. 303, *d*. If they are subjected to examination in the dry way, they appear like dark cubes, with a clear bright centre, *a*. Their appearance in water and in Canada balsam is shown in the same figure at *b* and *c*. More commonly, however, the crystals do not all sink to the bottom of the liquid, but are, as it were, buoyed up by the small quantity of mucus present. They vary very much in size.

Oxalate of lime crystallizes in well-defined octahedra, one axis of which is much shorter than the other two. Viewed in various positions, the crystals present a very different appearance, which has given rise to the idea that this substance crystallizes in several different forms in urine. In fig. 302, several of these appearances are represented ; the crystals being the same in each case, but viewed in a different position. In the four lower figures the crystal is shown as it appears when one of its lateral angles is towards the observer, and it is rotated upon its long axis. I have been able to observe all these different forms by causing the crystals to turn over in the field of the microscope. With the aid of a little glass model, it is very easy to demonstrate the different appearances to any one.

Octahedra of oxalate of lime are frequently deposited after the urine has left the bladder, and continue to increase in size for some time after their first appearance ; so that the urine should always be examined soon after it has been passed, and also after the lapse of several hours.

Not unfrequently the crystals are very minute, and without care in the examination they may be passed over altogether. Minute crystals of oxalate of lime often occur amongst deposits of pale

Fig. 297.

Crystals of carbonate of lime, in Canada balsam; seen by transmitted light. p. 229

Fig. 298.

Crystals of carbonate of lime, seen by reflected light. p. 229.

Fig. 299.

Crystals of phosphate of lime, in the form of dumb-bells. p. 228.

Fig. 300.

Crystals of urate of potash, assuming a dumb-bell form, but evidently composed of acicular crystals. p 228.

Fig. 301.

Dumb-bell and octahedral crystals of oxalate of lime. One very large one is seen at the right-hand side of the figure. p. 227.

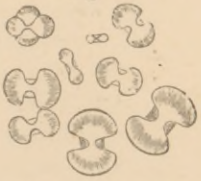
Fig. 302.

The same octahedron of oxalate of lime, seen in different positions. p. 226

Fig. 304.

Collections of dumb-bell crystals firmly adherent to each other. Such a mass might very easily become converted into a small calculus by deposition of material of a similar composition in the intervals.

Fig. 305.

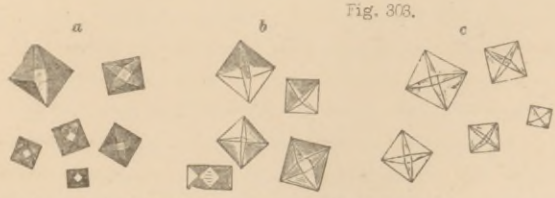


Perfect dumb-bell crystal, from the urine of a child two years old, suffering from jaundice.

Fig. 306.

Dumb-bells subjected to the prolonged action of acetic acid, showing the crystalline material nearly dissolved away p. 228.

Fig. 303.



Octahedra of oxalate of lime. *a*, by transmitted light in the dry way. *b*, in water. *c*, in Canada balsam. *d*, by reflected light. p. 226.

1000th of an Inch ___ × 215.

All these figures × 215.]

[To face page 226.

urates, which may obscure them from view, and they frequently accompany the crystalline deposit of phosphate of lime, pl. XLI, fig. 312. Oxalate of lime is insoluble in potash, so that when present with urate, the latter may be readily dissolved by the alkali, and the oxalate left perfectly distinct.

Chemical Characters.—Oxalate of lime deposits are seldom met with in sufficient quantity for quantitative analysis. The crystals are insoluble in water, potash, and acetic acid ; but soluble in the mineral acids. This deposit, if exposed to a red heat on platinum-foil, becomes converted into carbonate of lime, which effervesces upon the addition of a drop of acid, § 141.

246. Dumb-bell Crystals.—*Dumb-bell Crystals of Oxalate of Lime.*—These crystals were also first prescribed by Dr. Golding Bird, as consisting of oxalate of lime ; but in consequence of their power of polarizing light, he considered it probable that they might be composed of oxalurate of lime. This opinion of Dr. Bird has, however, since been proved to be incorrect. The composition of these crystals is discussed in page 232.

A very perfect form of these dumb-bell crystals is represented in pl. XL, fig. 305 ; they were obtained from the urine of a child, two years of age, suffering from jaundice. Besides the dumb-bell crystals, other allied forms are very often present, such as oval and perfectly circular crystals, fig. 301 ; and not unfrequently crystals of an irregular form occur, one side being even and regular, while the opposite presents different characters. Dumb-bells are usually met with in urine only for a few consecutive days, and they are almost always accompanied with octahedral crystals, fig. 301. I have observed on several occasions that the appearance of the more perfectly formed dumb-bell crystals is preceded and succeeded by the presence of the circular, oval, and less regular forms of crystals.

These crystals are certainly *formed* in the kidney ; for I have seen them in the tubes after death on several occasions, and once I met with them in the fibrinous casts of the uriniferous tubes which had escaped in the urine. The crystals take the spherical or dumb-bell form in consequence of the presence of mucus. Carbonate of lime found in the urine of the horse, fig. 297, and other herbivorous animals is deposited in allied forms, and the earthy matter of shell, as has been shown by Mr. Rainey, takes a very similar form.

By the prolonged action of acetic acid, I have found that the crystalline matter of the dumb-bell was dissolved, a small quantity of organic matter taking the precise form of the original crystal, and appearing like a cell-wall being left, fig. 306.* A similar change

takes place in the case of the spherical and dumb-bell-shaped crystals of carbonate of lime, so common in the urine of the horse and other herbivora.

The dumb-bell crystals appear to be formed by the aggregation of minute acicular crystals; an arrangement which is well seen in the crystallization of other substances, which, under certain circumstances, assume this form. In fig. 300, some crystals of urate of potash (prepared artificially) are represented in this form, but in this case the crystalline material is not associated with any form of animal matter. Phosphate of lime also appears to assume the dumb-bell form occasionally. The crystals delineated in pl. XL, fig. 299, were obtained from the decomposing mucus of the gall-bladder of an ox.

Uric acid also assumes the dumb-bell form; but these crystals are readily distinguished from those of the oxalate of lime by their solubility in solution of potash, and by the difference of their refracting power. See also the observations upon oxalate of lime calculi, page 232.

Chemical Characters.—Dumb-bell crystals possess the same chemical characters as the octohedra of oxalate of lime. They are, however, dissolved by the very prolonged action of acetic acid, fig. 306. Sometimes aggregations of dumb-bells constituting minute calculi are found in sufficient quantity for analysis.

247. Earthy Phosphate.—Besides the ordinary form of crystals of phosphate, figs. 283, 307, 308, there are others which occur more rarely in small quantities. Figs. 311, 312, 313, pl. XLI, represent some crystals of phosphate, which were formerly considered to be a peculiar form of magnesia, but these crystals have been proved to be composed of phosphate of lime by Dr. Hassall. This crystalline form of phosphate of lime is often associated with crystals of oxalate of lime, fig. 312. Beautiful crystals of phosphate of lime may be prepared by causing solutions of phosphate of soda and chloride of calcium in strong glycerine, to mix together very gradually.

248. Cystine.—Cystine forms a deposit much resembling that of the pale urates; from which, however, it is readily distinguished by not being dissolved upon the application of heat. For the deposit from which the drawings, figs. 314, 315, were taken, I am indebted to my friend, Dr. Sankey. An interesting case of cystine deposit, reported by Dr. Milner Barry, is given in vol. I of the "Archives of Medicine," with analyses of the urine.

Chemical Characters.—Deposits of cystine are insoluble in the warm urine or in warm water. They are dissolved by ammonia, and

* "Medical Times," 1851, page 374.

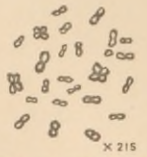
Fig. 307.

Prismatic crystals of triple phosphate, showing their form. p. 223.

Fig. 308.

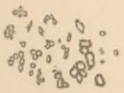
Stellate crystals of triple phosphate. Formed by the addition of ammonia to urine. × 40. *a* is an arm of a crystal. × 215.

Fig. 309.



Large granules of phosphate of lime.

Fig. 310.

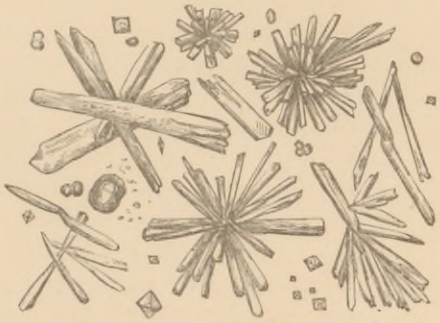


Unusual form of triple phosphate. From the urine of a patient suffering from indigestion in the very hot weather. × 215. p. 223

Fig. 311.

Crystals of triple phosphate. × 130. p. 223.

Fig. 312.



Phosphate of lime. From urine. × 130. pp. 223, 227.

Fig. 313.

Phosphate of lime. × 223. p. 215.

Fig. 314.

Crystals of cystine. × 215. p. 228.

Fig. 315.

Cystine. From urine. × 215. p. 228.

1000th of an inch ⌴ × 40.
" " ⌴ × 130.
" " ⌴ × 315.

[To face page 228.

if the ammoniacal solution be allowed to evaporate, the six-sided crystals are again deposited. This deposit, if incinerated on platinum-foil, leaves no fixed residue.

249. Carbonate of Lime is very rarely met with in a crystalline form in human urine. Not unfrequently it occurs, mixed with a deposit of triple phosphate and phosphate of lime, as an amorphous powder, or forming very small round masses. Occasionally, however, it has been met with as dense spherical stellar masses, composed of aggregations of minute acicular crystals (Dr. Golding Bird). Fig. 297, pl. XL, represents the appearance of carbonate of lime as it occurs in the urine of the horse when viewed in Canada balsam, with the aid of transmitted light, and in fig. 298, the same crystals are represented as seen by reflected light on a dark ground.

The Chemical Characters of Carbonate of Lime are described in § 141.

250. Blood Globules usually form a red or brownish-red granular deposit which sinks to the bottom of the vessel. If the urine be perfectly neutral, or slightly alkaline in its reaction, the colour of the globules will be bright red; while, in those instances in which the reaction is decidedly acid, the deposit of blood will be of a dirty brown colour, imparting to the fluid a smoky hue. This smoky appearance almost always exists when the urine is acid, and the blood is derived from the kidney. In many cases in which it retains its florid colour, it has escaped from the mucous membrane of the bladder, prostate, or urethra. If blood globules remain long in urine they become much altered in form, the outline appearing irregular and ragged, and the surface granular. This change no doubt is chiefly dependent upon physical causes, pl. XLII, fig. 316.

Chemical Characters of Urine containing Blood.—Urine containing blood corpuscles also contain serum, but the quantity of this fluid is in many cases very small, although numerous blood corpuscles are to be discovered by microscopical examination. If there be much blood, the albumen of the serum is readily detected by the ordinary reagents, but if the quantity of albumen present be greater than can be accounted for by the number of blood corpuscles, the practitioner would be led to fear the existence of organic disease of the kidney, and would at once investigate the case very carefully in order to ascertain if there was any evidence of the change. See "Casts of the Tubes," p. 219.

251. Cancer Cells.—Large Organic Globules, Inflammatory Corpuscles, Exudation Cells, &c.—Specimens of cancer cells found in the urine in cancer of the bladder and cancer of the uterus are represented in figs. 322, 323.

Large cells filled with oil globules, which are met with in the urine in cases of fatty degeneration, have already been referred to in p. 221. These when completely filled with oil, appear perfectly dark by transmitted light. They have been termed "large organic globules," by Dr. Golding Bird, and in structure present great similarity to the so-called "exudation cells," "inflammatory globules," or "compound granular cells." They consist essentially of spherical aggregations of minute oil globules which can be readily distinguished by their dark outline and clear transparent centre. By reflected light these cell-like bodies appear opaque and perfectly white. They must be distinguished from cells which even with very high powers the dark parts appear to be composed only of minute granules or molecules, which appear as very fine dots.

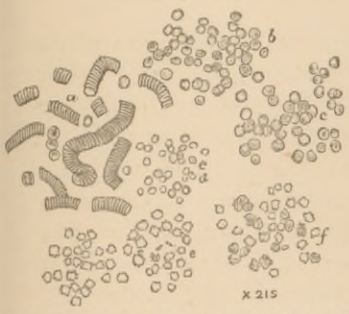
252. Spherical Cells containing Nuclei and Granular Matter.—Cells exhibiting nuclei and granules are not unfrequently met with in specimens of urine, but I have not been able to determine with accuracy the portion of the mucous tract from which many of these cells have been derived, or their pathological importance. The cells represented in fig. 321, were found in the urine of a patient suffering from rheumatic fever. The smaller round bodies are altered blood corpuscles. The large cells above referred to contained several transparent bodies within them, which became very distinct upon the addition of acetic acid (nuclei?). The central bodies did not refract light as oil globules, nor did they present the circular dark and well-defined outline so characteristic of them.

In pl. XLII, fig. 320, are represented specimens of large cells filled with dark granular matter, but not containing any oil particles, from the urine of a case of chronic bronchitis. There were also a few pus globules present in this specimen. It is probable that these cells consisted of altered mucus corpuscles and bodies embedded in mucus which was expectorated and afterwards thrown into the urine. Fig. 318 represents a curious form of cell found in the urine of a case of renal dropsy of seven weeks' duration. Casts of medium diameter, with a few small cells containing oil, were also present in the same specimen of urine.

Cells presenting somewhat similar characters have come under my notice in several other cases; and from that portion of the mucous surface of the bladder known as the trigone, I have obtained cells agreeing with them in general characters. It appears not unreasonable, therefore, to assume that many of these peculiar cells may be regarded as some modification of bladder epithelium.

253. "Small Organic Globules."—Under this name Dr. Golding Bird has described some little bodies smaller than the pus or mucus

Fig. 316.



Blood corpuscles. *a*, *b*, *c*, taken from the living body; *d*, *e*, *f*, from the urine. *d*, corpuscles smaller than natural; at *e* their circumference is serrate and ragged; and at *f* a somewhat similar appearance is shown. p. 229.

Fig. 317.

Small globules and octahedra of oxalate of lime p. 231.

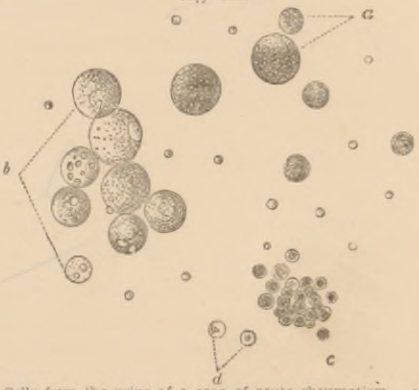
Fig. 318.

Cells found in the urine of a case of renal dropsy. p. 230.

Fig. 319.

Sporules of fungi, resembling blood corpuscles. p. 231.

Fig. 321.

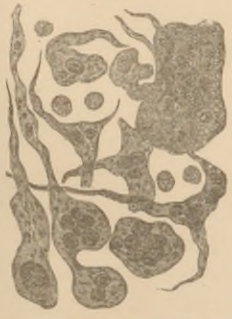


Cells from the urine of a case of acute rheumatism. *a*, in the natural state. *b*, treated with acetic acid. *c* resembling pus. *d*, the same treated with acetic acid. The small circular bodies are blood corpuscles. p. 230.

Fig. 320.

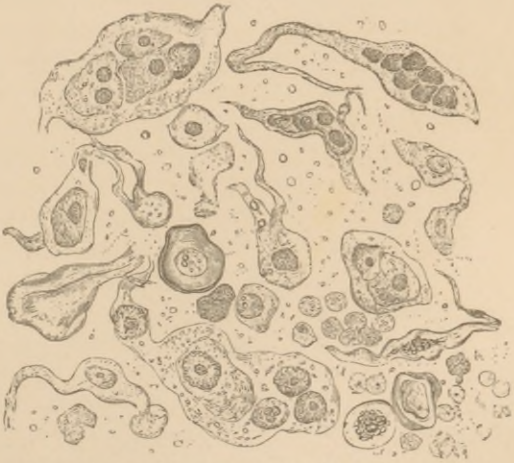
Large cells filled with granular matter in the urine of a case of chronic bronchitis. p. 230.

Fig. 322.



Cancer cells found in urine. From the bladder. p. 230

Fig. 323.



Cancer cells from the urine in a very bad case of cancer of the uterus. The deposit was very abundant. p. 230.

100th of an inch ⌊——⌋ × 215.
All these figures × 215.

[To face page 230.

corpuscles, with a perfectly smooth exterior, and unaffected by acetic acid. Dr. Bird suggests that they may be nuclei which have been set free from a cell by the bursting of the investing membrane, but this is not very probable. Fig. 317, pl. XLII, represents the appearance of the deposit from the urine of a patient suffering from calculus. The small round bodies represented in different parts of the figure were insoluble in strong acetic acid, and were unaltered on the addition of ether or potash. Many of them contained a central dark spot. They were accompanied with numerous small octahedral crystals of oxalate of lime. From their highly refractive properties and chemical characters just referred to, it is most likely that they were composed of oxalate of lime.

There are other small round bodies met with from time to time in urinary deposits, the nature of which it is not easy to determine. Some of these consist of altered blood corpuscles, others are spores of fungi, fig. 319, while small spherical crystals of oxalate of lime are sometimes present.

It is most desirable that when the practitioner meets with objects, the nature of which he cannot ascertain, careful drawings should be made, §§ 76, 77, and the specimen preserved if possible. Notes of the case should also be taken. Of course care should be taken that the observer is not misled by the appearances of the extraneous substances likely to be met with, p. 210, and he should therefore make himself familiar with these as soon as possible.

Urinary Calculi.

254. Formation of Urinary Calculi.—The structure and formation of urinary calculi have been studied with the aid of the microscope, and most important facts have been recently ascertained concerning their origin. It is important to bear in mind that there was a time when even the largest calculus was a microscopic object,—when it might have been removed from the organism, and the formation of 'stone' entirely prevented.

I have found that the 'nucleus' of almost all calculi exhibits the same composition and characters, and is formed in the same manner. If small *uric acid* calculi be soaked in liquor potassæ, the uric acid will be dissolved, and a 'nucleus' will be left which consists of a little mucus with small fragments of oxalate of lime; and in very many cases *well-formed dumb-bell crystals* of oxalate of lime may be clearly demonstrated. The same remarks apply to other calculi, and of course to the ordinary oxalate of lime calculi themselves. And I have been gradually led to the conclusion that *dumb-bell* and

spherical crystals of oxalate of lime, which I have shown are formed in the uriniferous tubes, are very frequently the 'nuclei' around which other insoluble or partially soluble materials are deposited. The formation of the nuclei may be studied in specimens washed away from the kidney, and in the uriniferous tubes of the kidney which may be obtained in the post-mortem room.

Fig. 304, pl. XL, represents a mass of dumb-bell crystals, many of which collections were passed in the urine. Although the mass is seen to consist of a number of distinct crystals, these are firmly attached to each other, so that the whole may be rolled over and over without the individual crystals being separated from one another. Such collections I have many times seen in the uriniferous tubes in kidneys obtained from post mortem examinations, which leaves no doubt as to the precise seat of formation of these bodies. Gradually the interstices between the individual crystals become filled up with the same material, and at the same time a few of the larger crystals increase in size at the expense of the small ones. At length a small crystalline mass of an oval form results, which clearly consists of a microscopic mulberry calculus, and if retained, would have gradually increased in size. Two small calculi of this description are represented in my work on 'Urine, Urinary Deposits, and Calculi.' When such calculi reach the bladder, they doubtless sometimes increase gradually by the deposition of various salts upon their exterior. Such small bodies would easily become entangled in the mucus, and might remain in the pelvis of the kidney without exciting any disturbance until they had grown so large as to cause great inconvenience. This observation is of great interest also as showing the chemical composition of the dumb-bells, which has long been a disputed point, as it is very difficult to obtain sufficient of the deposit of the dumb-bell crystals for an accurate chemical examination. We know that the mulberry calculus consists of oxalate of lime, and it has been shown that it is composed of aggregations of dumb-bell crystals. There can, therefore, be little doubt of the chemical composition of an individual dumb-bell crystal. It is of great importance that cases in which these dumb-bell crystals are deposited should be very carefully watched.

Microscopic calculi, composed of mucus, cells, and phosphate of lime, are also formed in the prostate gland, and several specimens are represented in 'Urine, Urinary Deposits, and Calculi.'

The microscopical calculus having been formed, the same material may be added upon its surface layer after layer, or if the urine be rich in uric acid, urates, or phosphate, layers of these salts will be deposited, and as is well known, it often happens that from time to

time the characters of the urine become modified, when layers of different salts may be deposited alternately.

The physician therefore has two objects to attain in the management of the health of persons who are the subjects of calculous disorders—

1. The expulsion of the 'nucleus' of oxalate of lime and the prevention of the formation of more 'nuclei.'
2. The prevention of the various states of urine which favour the deposition of uric acid, urates, and phosphates.

On the Preservation of Urinary Deposits.

It is very desirable to preserve many urinary deposits permanently, particularly when their nature is doubtful, in order that they may be compared with other specimens; and as this point presents some difficulties to the student, it will be advantageous to discuss it here somewhat in detail. While some of the substances met with are preserved with comparative facility, others are only prevented from decomposing by dint of employing the greatest care in mounting them, and by the use of good preservative solutions. There are three methods of mounting urinary deposits:—1st. As dry preparations. 2nd. In Canada balsam, turpentine, oil, and other fluids of similar characters. 3rd. In an aqueous preservative solution.

The first method is only applicable in a very few cases, as the greater number of substances forming urinary deposits are so altered by the processes of washing and drying as to be afterwards recognized with difficulty. Large crystals of uric acid, crystals of oxalate of lime, and certain forms of phosphates and urates may, however, be mounted as dry objects, but they of course exhibit different characters when examined in fluid.

255. Preservation of Urinary Deposits in the Dry Way.—Specimens which are to be mounted in the dry way must undergo the same preliminary washing and drying as those which are to be put up in Canada balsam. The same description will, therefore, serve for both. Suppose we require to dry some crystals of uric acid:—after the crystals have been allowed to collect at the bottom of a conical glass vessel, the clear supernatant fluid is to be poured off, and the crystals are to be washed with a little dilute alcohol, or with a very weak solution of acetic acid. When the process of washing has been repeated two or three times, a small quantity of the deposit is to be transferred by means of a pipette to a glass slide, and the greater part of the fluid soaked up with a small piece of blotting paper. The

crystals are next to be spread a little over the glass, with the aid of a fine needle, in order to separate the individual crystals from one another, and the slide is to be placed in a warm place, or in the sun, until quite dry; but care must be taken that the drying is not carried on too rapidly, and that too great a degree of heat is not employed. A narrow rim of paper or cardboard is next to be gummed on the slide so as to include the crystals in a sort of shallow cell; and, lastly, the glass cover is to be put on, and kept in its place either by anointing the edges with a little gum water, or by pasting it down with narrow strips of paper, which may be variously arranged and ornamented according to taste.

256. Preservation of Urinary Deposits in Canada Balsam.—If the crystals of uric acid are to be mounted in Canada balsam, they should be carefully dried first, as above directed, and afterwards over sulphuric acid, and then moistened with a small drop of spirits of turpentine. The slide is now to be slightly warmed, in order to volatilize the greater part of the turpentine, and a drop of Canada balsam is to be dropped upon the preparation from the end of a wire, which may be readily effected by holding the wire with the balsam over the lamp or hot brass plate for a few seconds, in order to soften it. The slide is next to be held over a lamp, or placed upon a hot brass plate, in order to keep the balsam fluid until any air bubbles which may be present have collected into one spot on the surface of the liquid balsam, an operation which is expedited by gently moving the slide from side to side. The air bubbles may now be removed by touching them with a finely-pointed wire. Lastly, the glass cover is to be taken up with a pair of forceps, slightly warmed over a lamp, and one edge is allowed to touch the balsam. The surface is permitted to fall gradually upon the balsam, so that it is wetted by it regularly, and only by very slow degrees, for otherwise air bubbles would yet be included in the preparation. The glass slide with the preparation may now be set aside to cool.

257. Preservation of Urinary Deposits in Aqueous Solutions.—For the preservation of urinary deposits, the most important method is to keep them in some preservative fluid, for in this manner alone can the characteristic appearance of many specimens be retained. Mounted in the dry way, and in Canada balsam, it need scarcely be said that the object presents different characters to those observed when it was examined in the urine; and although those methods are of great advantage for demonstrating the structure of some crystals, they are ill adapted for the preservation of the great majority of urinary deposits, and are wholly inapplicable for the preservation of epithelium, casts of the renal tubes, &c.

When preservative solutions are employed, the objects must always be placed in shallow cells; and the most convenient form of cell for this purpose, according to my experience, is that which is made by painting upon the glass slide, with a fine brush, a narrow border of Brunswick black, inclosing either a square or circular space as may be most convenient. In cases where a deeper cell is required, those composed of thin glass or tinfoil are the most useful. The forms of cell just referred to, I can recommend from experience, for I have many preparations put up in them which have been well preserved for some years. H. to W. §§ 116, 117, 118.

Preservative Solutions.—Next, with regard to the preservative fluids best adapted for mounting urinary deposits;—weak spirit answers pretty well for some sediments, but as a general rule is not suitable for substances occurring in urine. Glycerine may be employed in many cases diluted with a little water or spirit. The preservative gelatine I have found answer exceedingly well for the preservation of dumb-bell crystals of oxalate of lime and some other crystalline deposits: with care, epithelium may also be preserved in it. I have used the creosote and naphtha solution most successfully for the preservation of casts and various kinds of epithelium, &c., pp. 85, 86.

Whatever preservative fluid is used, care should be taken that the deposit to be put up is thoroughly saturated with it, for unless this object be attained, there is danger of the preparation being destroyed after a time. Glycerine if used must be added in very small quantities at a time, so that cells, casts, and other soft bodies may swell out again after they have been caused to shrink.

258. Method of Separating the Deposit from the Urine, and placing it in the Preservative Fluid.—The most simple manner of mounting deposits in these fluids is by allowing the sediment to subside to the bottom of a conical glass, pouring off the supernatant urine, and adding a small quantity of the preservative solution. The deposit is again allowed to subside, and the solution poured off, and replaced by a fresh quantity. This method must be followed when glycerine, the naphtha and creosote fluid, or carbolic acid water is selected as the preservative fluid. After the subsidence of the deposit, a small portion may be removed with a pipette, placed in one of the forms of cells above referred to, and the glass cover placed on the surface of the liquid, care being taken that the whole surface of the glass is well wetted with the solution, in order that no air bubbles may be included in the preparation. Any excess of fluid is now to be soaked up with a clean cloth, or with blotting paper, and the cover cemented to the cell by applying a little Brunswick

black or other varnish with a camel's hair brush. The name of the deposit, with any other particulars, is to be appended to the slide, and the preparation laid flat in the cabinet.

In the manner just detailed, the following may be readily preserved: various kinds of epithelium, casts, fat cells, torulæ, confervæ, pus, mucus, uric acid, oxalate of lime, urates of soda and ammonia, and other substances, whose characteristic appearance is not altered by aqueous fluids. If uric acid, oxalates, phosphates, or other crystals, are to be put up as objects for examination with polarised light, they should be mounted in strong glycerine, balsam, or turpentine.

259. Preservation of Crystals of Triple Phosphate. Cystine.—Crystals of the triple phosphate may be preserved in water to which a little ammonia and muriate of ammonia have been added. In this solution the surfaces of the crystals preserve their beautiful smooth character, while in pure water or in creosote fluid the surface becomes roughened. Dumb-bells, as I before noticed, may be preserved in the preservative gelatine, and they are not liable to shift their position in consequence of being well supported by the jelly. Crystals of cystine cannot be preserved in the creosote solution, because they are slowly dissolved by it; but as they are insoluble in vegetable acids, a dilute solution of acetic acid will keep them unchanged. If cystine or uric acid is to be mounted in glycerine the fluid should be made acid by the addition of a very little acetic acid.

CHAPTER VII.

OF MORBID GROWTHS.—*General Characters of Morbid Growths.—Observations upon the Nature and Origin of Morbid Growths.—Of the Germs of Morbid Growths.—Of extirpating Morbid Growths.—Structure of Morbid Growths.—Fibrous Tumours.—Cartilaginous, Bony, and Myeloid Growths.—Phlebolithes.—Fatty Tumours.—Vascular Tumours.—Cystic Growths.—Colloid Tumours.—Cholesteatoma.—Recurring Fibroid Tumours.—Epithelial Growths.—Melanoid Tumours.—Fungus Hæmatodes.—Cancer.—Examination of Morbid Growths.—Preservation of Morbid Growths.*

I propose in this chapter to offer a few remarks upon the general nature, origin, and structure of morbid growths, and to refer to the most important microscopical characters of some of those which frequently come under the observation of the practitioner, but I shall not attempt to give a detailed description of any. Upon this subject the reader should consult the works in the note.*

THE GENERAL NATURE AND ORIGIN OF MORBID GROWTHS.

260. The Names of Morbid Growths.—The elementary structures which may be met with in morbid growths have been already referred to; they are, granules, globules, cells, fibres, membrane, tubes. Formerly, it was considered necessary to give a definite name to every morbid growth, but since the minute anatomy of these structures has been carefully investigated, many of the received names have been found inappropriate, and as fresh peculiarities were

* Paget, "Lectures on Tumours," 1853. Bennett, "Clinical Lectures," 1858, "On the Structure of Tumours." "Cancer and Cancroid Growths." Jones and Sieveking's "Pathological Anatomy." Wedl's "Pathological Histology," translated by Mr. Busk, Sydenham Society. "Reports of the Pathological Society." Rokitansky's "Lehrbuch der Pathologischen Anatomie," 3rd Edition.

discovered, the names have been multiplied to a most inconvenient extent. Most of these names are highly objectionable on many grounds, and such terms as *encephaloid*, *colloid*, *amyloid*, *fibroid* may be applied to a number of structures different in their history and progress, in the results to which they lead, as well as in their minute structure and chemical composition. There can be no harm in saying a growth has a consistence and colour like *brain* or *gum*, or resembles cells found in the medullary cavity of bones, or has a *fibrous appearance*—because we only refer to one of its characters, and there may be many growths agreeing in this, although they differ widely in other essential particulars. If, however, we say it is an *encephaloma*, or a *colloid tumour*, &c., we speak of it as a definite structure which ought to agree in all important characters and vital endowments, with other tumours to which the same name is applied, and with these only. Observation however proves that although two tumours may be alike in their general resemblance to brain matter when examined by the unaided eye, they may differ in all *essential* particulars. It is therefore our duty in alluding to the characters of a tumour, to investigate its minute structure, and ascertain as far as possible, its history, instead of merely endeavouring to assign to it a name, such as, *scirrhus*, *fibrous sarcoma*, &c. There can be no doubt that many tumours have been called *scirrhus* which were merely *fibrous*, and vice versâ. The slovenly methods of observation which have been adopted even by some who have been *most* rigid in classifying tumours, have led to very erroneous conclusions. Statistical inquiries applied to investigating the frequency of the occurrence of these growths, and their association with other conditions, must lead to the formation of most erroneous inferences and doctrines, if the greatest care is not exercised in determining the general nature of the growth in the first instance. As yet we know too little of the anatomy, mode of development, and history of morbid growths, to attempt anything like a systematic classification, and it seems to me much more important that we should endeavour to give good drawings of the structure of the growths with a short description of their most important characters, than attempt to give them names, still less to hide our ignorance of their real nature by the use of such imposing but ill-defined terms as "*Fibrocystic sarcoma*," "*Cylindroma*," "*Cholesteatoma*," and many others, which merely embrace one or two characters, and may, with much reason, include a number of structures essentially distinct from the one in question. Rather let us say that a tumour is like brain or marrow, or that it has a fibrous, cartilaginous, vascular, glandular, or osseous appearance; or that it contains plates of cholesterine, or cysts, &c.; or that it is composed

of fibrous tissue, epithelium, cancer cells, mucous tissues, a gum-like material, &c. If we do this, any one who examines our work afterwards can form an idea of what we saw, while by merely attaching a name to the structure we simply add to the doubt and confusion which already exist, especially as the meaning of the term we use will, in all probability, be much altered in the course of a few years.

It is very difficult to point to any special characters by which many of these growths could be grouped together in well-defined classes. Although there are certain points in which many growths resemble one another, it is often very difficult to apply to them any specific name. Not only is there a difficulty in defining the different tumours by their microscopical characters, but the so-called benign tumours pass by almost imperceptible shades into those of a malignant and dangerous nature.

261. General Characters of Morbid Growths.—Morbid growths and tumours are met with in various parts of the body, sometimes appearing quite superficially; sometimes united to the adjacent tissue by the intervention of a long narrow pedicle containing the necessary vessels and nerves for the supply of the tumour; while in other instances we find tumours deeply embedded in the substance of solid organs, such as the liver or brain, and deriving their nutriment from every point of the surrounding texture.

A tumour may be produced by the irregular growth of a tissue at a particular point, in which case it consists simply of the elements of this tissue. Fatty tumours, certain tumours of a fibrous structure, exostoses from bones, and many others, are produced in this way, and, as might be expected, but little difference can be made out between their minute structure and that of the tissue of which they are, as it were, the off-growth. In other instances, however, and these are extremely numerous, the morbid growth is found to possess a structure of a different character; and although it may contain the elements of one or more of the tissues in a healthy state, it cannot be compared with any normal texture of the body.

In taking a general survey of the more common morbid growths which are brought under our notice, and examining carefully into the tissues involved, or inquiring from what particular texture the morbid structure has originally sprung, we cannot fail to remark the peculiarly localized condition of many of them. Often an enormous mass appears to have been formed by the rapid and circumscribed growth of one or more elements of a tissue. By a redundant growth of epithelium on some part of the cutaneous surface, large warts are produced;—by simple hypertrophy of the subcutaneous areolar tissue of the leg and foot, or of that of the scrotum, most formidable diseases

are caused; subcutaneous fibrous tumours depend upon a morbid development of the same tissue, only it is circumscribed instead of affecting a large extent of surface. Figs. 324, 325, pl. XLIII, show the general appearance of hypertrophied areolar tissue. The specimen from which this drawing was made was taken from the scrotum of a patient operated upon by Sir W. Fergusson. Upon the addition of acetic acid to the preparation, the fibres of the yellow element, fig. 325, became very distinct. Ordinary white and yellow fibrous tissues are represented in figs. 327 and 328, as they appear when examined in water.

By a rapid and irregular development of epithelium in various parts, either of the cutaneous or mucous surface, which extends inwards, and so leads to the invasion of deeper structures, a class of tumours and ulcers are produced which have been deservedly termed "*malignant*," in many senses in which that word has been used. These have been grouped together under the term "*cancroid growths*."

The truly *cancerous* growths frequently commence deep in the substance of a tissue, and gradually make their way towards the surface. In many instances the tendency to the development of cancerous growths is hereditary. As Mr. Moore has remarked, they often occur in persons who have exhibited remarkable health and vigour of constitution. Sometimes they appear to spring up in different and very distant parts of the body at the same time. The cells, of which these tumours are in great part composed, possess a very remarkable power of multiplication, and it has been said that if even a little of the '*fluid*' they contain be carried to distant parts of the body, it may give rise to the development of germs which will become tumours, and encroach upon the structure in which they may have taken root. Schroeder van der Kolk holds that from the fluid of a morbid growth cells may be developed, which increase until a tumour like the original one is formed. Dr. Bennett entertains a similar opinion. The fact is that the '*fluid*' contains millions of germs, every one of which is living and will grow under favourable conditions. The tumours thus formed usually resemble the first one in their essential points of structure, but differ from it according to the nature of the tissue which has been invaded. If for instance, the growth takes place in a part where areolar tissue is abundant, and where there is considerable resistance to its increase, we may expect to find a hard, condensed and fibrous tumour; but if the growth commences immediately beneath the surface of the peritoneum, or in a like situation, where it will encounter little resistance, a soft, spongy structure will probably be formed, in which the cells preponderate over the fibrous element.

262. Observations upon the Origin of Morbid Growths.—It may be considered as a fact beyond dispute that every healthy and morbid tissue formed under any circumstances in living beings results from changes taking place in germinal matter; and that this germinal matter whatever its properties or powers may be, came from germinal matter which existed before it possessing in some cases similar, in others very different, properties or powers. The germinal matter of every texture in the body is derived by continuous descent from the original embryonic germinal mass and every particle of morbid germinal matter must also be regarded as a direct descendant of this.

I doubt if there is anything more interesting than to contemplate the extremely complex but orderly phenomena which result in the formation of a normal tissue. The multiplication of the masses of germinal matter, the production of formed material, the supply of pabulum, the removal of the substances resulting from chemical changes which take place, must all proceed with regularity, and in perfect order, for otherwise the resulting tissue will not be normal. Even if the supply of nutriment be modified in quantity or quality, a difference in the character of the tissue or organ produced will be manifested.

It has been remarked that many morbid growths could not be distinguished in their ultimate structure from the healthy tissue. In fact the only difference in some instances seems to be that the growth of the latter is regular, even, and restricted; while the former grows irregularly as regards the rate of increase, unevenly as regards its form, and there seems to be no limit to the size it may attain, if it be freely supplied with nutrient material. Whatever may be the nature of those complex conditions to which the symmetry of the body is due and which necessitate or enforce a symmetrical arrangement and definiteness of form of the various parts of which the organism is composed, they must be absent in the case of some of the simplest morbid growths. Many of these are supplied with vessels which could not be distinguished from those of healthy tissue. The arteries, capillaries, and veins exhibit precisely the same structure; the arrangement of the muscular fibres of the walls of the first and last channels is precisely the same as that met with in healthy vessels, and there can be little doubt that they are supplied with nerve fibres upon the same plan. But it is not impossible,—indeed it seems very probable, that the regular growth and destruction which are so remarkable in every part of the nervous system in the normal condition are departed from in the case of the nerve centres and of the nerve fibres which are distributed to morbid growths.

There is one system of vessels intimately connected with the blood vessels, the importance of which in vertebrate animals is far

greater than has yet been supposed, of the arrangement of which in morbid growths nothing is yet known; and its existence in many, at least in its normal characters, is extremely doubtful. We know that in health *lymphatics* are freely distributed upon the surface of those elementary organs of which the lungs, the liver, muscles, &c., may be said to be made up. And we know that these lymphatics contain a fluid in which particles of living germinal matter, capable of taking up various materials resulting from the decay of tissues are suspended. It seems at least probable that the lymphatics may have much to do with maintaining regularity of growth, and of preventing a redundant production of tissue. And it would therefore be extremely interesting if we could obtain an accurate knowledge of their distribution in morbid growths.

Whatever may be the circumstances which lead to the production of a morbid growth there can be little doubt concerning the general nature of the texture of which it consists. Nor can there be a question that the very germinal matter from which this so-called adventitious growth has proceeded, originally sprang from the same germinal matter which gave origin to that which took part in the formation of the normal tissues of the body.

In some cases in which the abnormal is directly continuous with the normal structure it is impossible to define the limits of either, and to state exactly where the morbid tissue commenced or the normal one ceased.

But yet we shall probably be correct in considering it impossible that the anatomical elements of a *fully-formed* normal tissue could give origin to a morbid growth. We know, however, that in all normal textures are collections of small masses of embryonic germinal matter from which new texture is from time to time formed to take the place of that which is gradually destroyed in the performance of its function, and by which, in some cases, portions of new tissue may be formed, if that existing is called upon to do an increased amount of work, or where a portion is destroyed by disease. Such embryonic masses are to be demonstrated in all growing tissues at every period of life. And the rate of their growth and development varies according to the rate of destruction and removal of the textures which are to be replaced. And this must vary extremely at different periods of life and under different circumstances; thus almost any tissue or organ in a man's body may at one time of life be considerably reduced in volume, and the amount of work performed by it greatly diminished, while at another it may be greatly increased in size, and the quantity of work performed by it may be doubled or trebled. And there is reason to think that the process may be repeated more than

once at different periods of life if the organism is a healthy one. Now, suppose that one such embryonic mass should be irregularly and abundantly supplied with nutrient material, and sprout, as it were, into active growth when it was not required,—a shapeless lump of tissue would result, partaking of the characters of the normal tissue, and apparently continuous with it,—in fact, a small tumour which would continue to grow by the formation of new germinal matter in precisely the same manner as the normal texture is developed, except that the conditions which regulate and limit growth, and preside over the symmetry of the texture formed, are absent, or their influence counteracted.

These embryonic masses of germinal matter connected with the normal tissues, invariably, I believe, form the source or origin of all morbid growths. And it seems not unreasonable to suppose that by a mechanical injury, or in consequence of changes proceeding in tissues in the immediate neighbourhood, the position of one or more of the masses of embryonic germinal matter may be somewhat altered, and being more abundantly supplied with nutrient material, they would grow out of their proper order and very quickly. Such irregular and increased growth might commence at almost any period of life, and might be determined by change in the distribution of nutrient matter, by irregularity of development consequent upon changes commencing perhaps at an early period of intra-uterine life, or by important changes having taken place in the arrangements connected with the processes of destruction and removal of tissue or in the mechanism which regulates and governs these phenomena.

As we find that the masses of germinal matter resulting from the original embryonic mass, and continuously descended from it, exhibit very different properties and powers to the original mass itself, it is not surprising that masses of germinal matter resulting under the influence of unusual conditions and altered pabulum, should manifest powers which the original mass from which they proceeded did not possess. Nor is it remarkable,—seeing that for the acquirement of the utmost symmetry and perfection which it is possible for the organism to attain, the multiplication and development of the several masses of germinal matter must proceed with marvellous regularity,—that the irregular nutrition and too rapid multiplication of such masses should result in the production of a chaotic texture which serves no useful purpose in itself, and ultimately leads to the destruction of the organism in connection with which it is developed.

It was shown on page 152, that under altered conditions the germinal matter of an elementary part, or cell of epithelium would give origin to masses differing extremely in property from the original

mass. Its descendants could never again form epithelium, or probably perform any office advantageous to the individual, but they would grow and multiply faster than the original mass, and would retain their vitality under circumstances which would have led to the destruction of the first.

It is therefore only in accordance with facts which I think may be relied upon, to assume that where the altered conditions affect not only the elementary parts already formed, although young, but those from which vessels and those from which tissues are to be developed, that these latter should possess powers which are not ordinarily manifested in the normal tissue, or at any rate under the ordinary conditions to which it is exposed.

If the embryonic masses of certain normal tissues be transplanted from one part of the body to another, or even be removed to a different organism, they will grow, and a new texture precisely corresponding to that from which the germs were taken will be produced in the new situation. When the multiplication of germinal matter has gone on with undue rapidity, the resulting masses acquire increased powers of living under varying conditions.

Under certain altered conditions masses of germinal matter resulting from these embryonic masses may acquire such exaggerated powers of growth as to move very freely, and multiply with great rapidity. Insinuating themselves between the elements of the normal fully-formed texture, they grow and multiply at its expense, and, of course, lead to its destruction, and the faster they multiply the more independent they become. They may pass into lymphatic vessels or into the blood, or they may travel long distances, like the germs of entozoa, until having arrived in a locality where they are abundantly supplied with nutrient material, they grow and establish new formations in distant parts, resembling at least in important particulars—that in which the local change first occurred. Such masses of germinal matter also live and grow andmultiply at the expense of the very formed material they have produced.

That tumours should differ materially in the rate at which they grow is exactly what we should expect when we consider how the normal tissues of the body differ from one another in this particular. A growth allied in its character to fibrous tissue, will increase much more slowly than one which partakes of the characters of epithelium, and some other more rapidly-growing tissues. But the morbid growths which correspond to the tissues which grow most slowly, increase very rapidly when the rate is compared with that of the former; and it is commonly observed that the power of rapid growth increases as the multiplication of the cell proceeds. Thus the

elements of a bony tumour which grows very slowly at first may multiply with wonderful rapidity after the growth has attained a certain size. The observer will notice that as the rate of growth of the cells increases their characters become modified, and the proportion of the germinal matter to the formed material is considerably greater in a quickly than in a slowly growing cell.

Anything interfering with the regular growth of a continuously growing structure in the adult, may ultimately lead to the formation of a tumour more or less closely allied to cancer; thus, suppose there be any impediment to the escape of the growing hair from the surface of the skin, growth would continue from the bulb, and the modified hair produced might be caused to assume the form of a compressed spiral, and this, with the change necessarily resulting in adjacent textures would soon give rise to the formation of a considerable tumour, exhibiting a very complex structure. If the regular growth of cuticular epithelium be interfered with, a morbid growth closely allied to epithelial cancer may result. The state of things which brings about this change usually soon disturbs the relative position of the papillæ, upon the surface of which the cuticular cells are formed. Many of these may be made to grow towards one another, so that there is no escape for the modified epithelium which is produced. And after this irregular growth of epithelium and of papillæ with the modified connective tissue, vessels and nerves of which these are composed, has gone on for some time, a tumour results with a very varied structure, but in which nevertheless the structures representing all the normal anatomical elements of the cutis and cuticle can be detected without difficulty.

It seems to me that from the different normal textures may be formed morbid structures, which at length differ so remarkably from them that it is often difficult to discover any relationship; but on the other hand a careful examination of a vast number enables us to discover transitional differences of every degree. Moreover, the characters of a tumour may differ remarkably at different periods of its growth. A tumour which would at an early period be regarded as benignant, may, at a later time, take upon itself a malignant aspect, and, I believe, in many instances different names would be applied to the same tumor, if it could be examined at different periods of its life, and although it used to be supposed that tumours apparently composed principally of modified fibrous tissue, would not return if extirpated, experience has proved that this is not universally the case, and hence it has been necessary to separate certain fibroid tumours, which are known to recur after extirpation from ordinary fibrous growths, and arrange them in a group by themselves, under

the term recurrent fibroid. These tumours have been particularly studied by Paget.

Of the Germs of Morbid Growths which may be transmitted in the Blood or Lymph to different parts of the body.—The particles which are capable of giving rise to a morbid growth may be extremely minute —so small that they could readily pass through the walls of a capillary vessel. Many observations render it certain that insoluble particles possessing marvellous powers of development are far more minute than used to be supposed. And there is no doubt that powers and properties which were formerly attributed to fluids, are really due to the insoluble particles of living matter suspended in the fluid. Just as a minute particle of a living pus corpuscle, pages 200, 204, if transplanted to a new soil suitable to it, may grow and give rise to new pus corpuscles, having precisely the same properties; so, the most minute germ of a cancer cell may, under favourable circumstances, give rise to the production of cell forms exactly resembling those in the original tumour.

Of Extirpating Morbid Growths.—The germs of the most fatal varieties of cancer are remarkable for their rapid multiplication and for the power they exhibit of resisting the influence of adverse external conditions. Not only do they invade, destroy, and live at the expense of normal textures, but they travel for such considerable distances and spread so far from the focus of their origin that after a tumour has been growing for some time it is almost impossible to extirpate it. And although a considerable portion of surrounding healthy textures may be removed with it, it but too often happens that particles of the cancerous germinal matter far too minute to be detected by ordinary examination remain behind, and soon grow and multiply, leading to the formation of masses closely resembling the original growth. Various remedies which have the property of destroying living tissues have been employed for the purpose of extirpating these growths, more effectually than was possible by the knife. Of these substances probably a solution of chloride of zinc is by far the most effectual. And the recent very valuable observations of Mr. Campbell de Morgan, of the Middlesex Hospital, have conclusively proved the advantages of this plan of treatment in many cases. Moreover, what we know of the nature of abnormal, rapidly growing germinal matter, really justifies the hope that ere long remedies may be found which will destroy it without acting deleteriously on normal textures.* The highly interesting observations of Mr. Crookes proved

* Dr. Broadbent has very recently advocated the use of acetic acid, which being injected into the tumour causes it to gradually waste away. "Cancer, a New Method of Treatment," 1866.

conclusively that carbolic acid would destroy the life of certain living particles while others resisted its influence. And the evidence adduced by me from a totally different method of enquiry went far to prove that the virus of a contagious disease differed remarkably in its vital properties and powers from that of a healthy tissue. Now, since there are certain vapours and solutions which will destroy the life of rapidly growing particles which I believe constitute the virus of contagious diseases while they do not affect the normal germinal matter of the organisms of man and the higher animals, protected as this is for the most part by its formed material, it seems not unreasonable to anticipate that a destructive material may be discovered and employed of such strength as to destroy cancer cells and leave the normal tissue and its germinal matter intact. And it seems even possible that something of this kind might be introduced into the blood, and thus circulating through the system, extirpate the germs of rapidly growing morbid structures. At any rate the considerations above very imperfectly sketched surely point to the more minute investigation of the structure of morbid growths, and to the more thorough and careful study of the conditions under which they originate and grow. So far from such minute enquiry being opposed to common sense or unlikely to lead to practical results, it alone can enable us to answer questions that would suggest themselves to any sensible person with reference to the origin, nature, prevention, or cure of these structures.

Structure of Morbid Growths.

I shall not adopt any classification of morbid growths, for it seems to me that specimens may be found which may be regarded as intervening links between healthy textures, and morbid growths which differ from them in structure, properties, and powers to the greatest extent. Nor do I think it possible to separate the so-called malignant from the benignant tumours, for I feel sure that many a tumour which at the time of its extirpation would be properly termed malignant, if examined at an early period of its formation would have been regarded as benignant or harmless.

263. Fibrous Tumours.—There are a vast number of morbid structures which may be said to be *fibrous*, which, however, differ very much from each other in important characters, as for instance in their mode of origin, rapidity of growth, and minute structure. Some are composed of exceedingly delicate fibres, others of wide fibrous bands having distinct nuclei scattered in them. In some a number of minute elongated cells may be detected, while others seem to be com-

posed of fibres with oval masses of germinal matter. Much difference in structure is often observed in different parts of the same tumour. In many cases this is to be ascribed to difference in age.

Fibrous tumours may be connected with the skin, mucous membrane, glands, muscle, nerve, bone, cartilage, and other textures. Some are exceedingly soft, and consist of a delicate network of fibrous tissue containing a soft albuminous material in its meshes. Others are almost of a cartilaginous consistence, and not a few contain bone. Fig. 331, pl. XLIII is an example of a rare form of fibrous tumour, in which the germinal matter is very abundant. It was removed from the tongue of a patient, and had been growing about two years. It was painless, and very slowly increased to the size of a pea. This specimen was sent to me by my friend Dr. Eade, of Norwich.

In the examination of fibrous tumours, advantage will be derived from the use of *glycerine*, *acetic acid*, and *solution of soda*. In describing the microscopical characters, the *vascularity*, the *character of the fibres*, their *number* and *course*, the number and size of *cells*, and the presence of other elements such as *bone*, *adipose tissue*, &c., should be noticed. It is desirable to avoid the use of such terms as *fibro-sarcomatous*, *fibrocystic sarcoma*, &c., and to give a simple description of what has been seen, with drawings, whenever it is possible to make them.

Involuntary muscular fibre sometimes becomes so thickened, as to give rise to the appearance of a fibrous tumour. In many cases of the so-called cancer of the pylorus, the tumour consists entirely of bands of coarse unstriped muscle, which has entirely lost all powers of contractility and has assumed a fibrous character. Fig. 330 represents the appearance of a section of a tumour of this description, which was sent to me by Dr. Hall, of Brighton. It was taken from the body of a patient who had vomited sarcinæ for a considerable period of time.

264. Cartilaginous, Bony, and Myeloid Tumours.—Müller was the first observer who described cartilaginous tumours under the term *enchondroma*. In structure they closely resemble cartilage. Bone is not unfrequently developed in them, but sometimes calcareous matter in a nodular or granular form is deposited. Enchondroma occurs in connection with various bones, and occasionally with fibrous textures not in the neighbourhood of bones, as for instance in the testicle.

Bony Growths are generally found projecting from bones, and are seldom met with in connection with the soft tissues. As is well known in old age bone is liable to be formed in the permanent cartilages, and not unfrequently it is met with in fibrous tissues. When the bony growth projects from the exterior of a bone, it is termed an

exostosis. These are particularly common in old rheumatic cases. *Myeloid growths* generally originate in periosteum or in the medullary membrane. Bony growths have even been found in the eye. Professor Bennett quotes one case in the possession of Dr. Förg, of Munich; Dr. Kirk refers to another, and my friend Mr. Hulke has reported two very interesting cases.*

Both cartilaginous and bony growths sometimes recur after removal, and become developed in various parts of the body like other forms of cancerous tumours. The bones are the seat of development of many forms of cancer, but several instances are recorded of osseous tumours being developed in various organs destitute of any structure allied to osseous tissue, in consequence of the original formation of a tumour connected with bone. I examined an interesting case in which cartilaginous tumours existed in considerable number in the lungs. The original tumour was developed in the thigh, which was amputated by Sir W. Fergusson. The tumours in the lung exactly resembled the original growth in structure.† It will be found that many cartilaginous growths start from the perichondrium and osseous tumours from the periosteum.

Thin sections of hard tumours may be made with a very firm, strong knife, or by grinding a thin piece removed with a saw, to the proper degree of tenuity, according to the method employed for obtaining thin sections of bone, p. 34.

Myeloid Tumours.—This term was applied by Mr. Paget to a soft, pulpy growth which probably has its origin in the deep layers of the periosteum or medullary membrane. It often presents many of the characters of soft cancer, but its mode of growth, its history, and its anatomical characters distinguish it from tumours of this description. Cells differing considerably in shape and size, but containing a vast number of nuclei, are present in these tumours. These cells closely resemble certain bodies which were originally described by Professor Kölliker, and are found in the medullary cavity of fœtal bones, and to a less extent in adults. I have shown that these so-called myeloid cells are masses which take part in the development of the bony threads and plates which are ordinarily found in connection with the cancellated structure of bone, see pl. XLIV, fig. 335.

Myeloid tumours are more common in connection with the jaw-bones than other bones of the skeleton, and certain forms of *epulis* have a myeloid structure. Mr. Paget has described such tumours

* "Clinical Lectures," second edition, by Dr. Bennett. "Monthly Journal of Medical Science," November, 1853, Dr. Kirk. "Pathological Society's Transactions," vol. viii, page 319, Mr. Hulke.

† "Transactions of the Pathological Society," vol. v, page 321, 1854.

connected with the bones of the skull, and they are not uncommon in those of the lower extremities. The microscopic characters of these tumours have been very carefully described by Mr. Gray, and an excellent example of the disease has been reported by Mr. Hulke,* fig. 334.

265. Recurring Fibroid Tumours.—This term has been applied by Mr. Paget to a form of fibrous tumour which returns after extirpation. These tumours are hard and firm, and consist of elongated cells and long fibres prolonged from small cells arranged in an arched manner. Mr. Paget has remarked that when new fibrous growths are formed after removal of the original one, they exhibit a greater resemblance to truly cancerous tumours than the original growth.

Fig. 336, pl. XLIV, is an example of a growth probably of this nature. It was removed from the testicle of a man aged sixty. It was as large as the fist, and the testicle was adherent to its lower and outer part, but was not contained in it. This was sent to me by my friend Dr. Eade, of Norwich.

266. Phlebolithes are hard rounded bodies which are not uncommonly found in the cavities of veins. They are more common in the veins of the pelvis than in those of other parts. Sometimes the vein is obliterated and the concretion appears to be connected to adjacent parts merely by a pedicle. They consist of phosphate and carbonate of lime with animal matter. The materials are deposited in successive layers, and the most internal ones, being the oldest, contain the largest quantity of inorganic material.

267. Fatty Tumours have a structure resembling that of ordinary adipose tissue. They are often found in connection with the normal fatty tissue of the body. Some of them contain a considerable quantity of fibrous tissue. The subcutaneous adipose tissue, especially of the nose, is liable to increase considerably in quantity, producing horrible deformity. This condition is termed lipoma. Fig. 326, pl. XLIII, shows the structure of a large fatty tumour connected with the testicle, which was removed by Sir W. Fergusson. This tumour was as large as the head, and was in part fibrous and partly fatty. In fig. 329, ordinary adipose tissue with its capillaries is shown. After fatty tumours have been preserved for some time, crystals of *margarine* form upon the surface of the oily fat, as represented in the drawing, fig. 326. Some fatty tumours which contain a quantity of fibrous tissue as well as adipose vesicles, are termed *steatomatous*. Steatoma

* "Transactions of the Medico-Chirurgical Society," 1856. "On Tumours connected with Bones."—Archives of Medicine, No. II, page 104, and pl. XIII. See also a memoir by C. Robin, "Sur l'Existence de deux Espèces Nouvelles d'Eléments Anatomiques qui se trouvent dans le Canal Médullaire des Os." Paris, 1849.

Fig. 324.

Hypertrophied areolar tissue, showing coarse white fibrous tissue in great quantity. × 215. p. 240.

Fig. 325.

Fibres of yellow elastic tissue, from the scrotum of a man, operated on by Sir W. Fergusson. In this case the areolar tissue had undergone considerable hypertrophy. × 215.

Fig. 326.

Large fat vesicles, with crystals of margarine, from a large tumour connected with the testicle, removed by Sir W. Fergusson. × 130 p. 240.

Fig. 327.

White fibrous tissue, unravelled from a tendon. p. 240

Fig. 328.

Yellow fibrous tissue, the fibres of which have been unravelled; from the ligamentum nuchæ of a sheep. p. 240.

Fig. 329.

Adipose tissue, with vessels injected from the capsule of the kidney of a dog. × 130 p. 250.

Fig. 330.

Section of the thickened pylorus, showing bands of pale muscular fibres cut across. × 215.

Fig. 331.

×215

Nucleated fibrous tumour, from the tongue. × 215. *a*, part where the cells are very distinct. *d*, fibres seen to be continuous with the cells. *c*, small lobule only containing a few cells, and showing the manner in which the tumour grows. M. B., 643. p. 248.

1000th of an inch ⌊ × 130.
" " ⌊ × 215.

[To face page 250.

is also applied to encysted tumours originating in the sebaceous follicles, and containing a soft, pulpy material, rich in fatty matter, but not containing fat vesicles. The fat is in the form of small globules or merely granular.

268. Vascular Tumours are those which consist principally of small vessels. Aneurisms by anastomosis, and certain forms of nævi are of this character. The tumour contains besides vessels a certain quantity of fibrous tissue. Many of these tumours consist principally of veins of considerable size, but others are formed originally of capillaries which undergo considerable dilatation. Vessels in various organs are liable to become varicose, and sometimes irregular dilatations are met with in the brain, retina, and in glandular organs. Cancerous tumours are often very highly vascular. The so-called *Fungus hæmatodes* is a malignant tumour infiltrated with blood and containing a number of gorged vessels. The presence of the cancer cells, however, if these be well marked, at once determines the nature of the tumour. In some of these vascular growths there can be little doubt that the vessels are developed in the structure itself, from cells, as in embryonic tissues. When an opportunity offers of investigating the structure of these growths, the tumour should be injected with size and glycerine slightly tinted with Prussian blue injection.

269. Cystic Growths are met with in almost all parts of the body. They are produced in many different ways and their contents are various. Some are filled with a perfectly transparent fluid as limpid as water; others with a thick pasty material; and some contain perfectly hard calcareous matter. Cysts may be formed as follows :—

1. *If the duct of a gland be obstructed, and the secretion accumulates behind the occluded point, the tube becomes dilated, and a cyst is at length produced, with probably ultimate destruction of the gland structure.* The contents of the cyst undergo gradual alteration, and often when examined are found not to resemble in any way the secretion of the gland. In this way cystic tumours connected with the ducts or secreting tubes of the liver, kidney, sebaceous, mammary, salivary, and other glands are formed. The whole kidney has been converted into one large cyst from obstruction of the ureter. Cysts may be developed in the uriniferous tubes in the cortical and medullary portion of the kidney.

2. *By the increase in size of the areolæ or spaces between the structures entering into the formation of different glandular organs.* The small serous cysts in connection with the villi of the placenta, and choroid plexuses of the brain, and certain cysts met with in the liver, kidney, and other glandular organs, are probably formed in this manner.

3. *By the gradual formation of cavities by the degeneration and absorption of portions of the normal structure.* The spaces become occupied with fluid and a smooth wall is gradually formed upon the interior of the cavity. Some cysts which are met with in the brain, liver, and other solid organs are probably formed in this manner.*

4. *By the increase in size of a single cell, the walls of which become thickened by the deposition of new material.* The cavity of the cyst is supposed to correspond to the cavity of the original cell. This view is still maintained by some, but I doubt if it is correct.

The walls of cysts are composed of fibrous tissue, and not unfrequently bone is deposited in them. They vary much in vascularity and sometimes the lining membrane is soft and spongy, occasionally covered with small papillary elevations and invested with a cellular layer. The characters and number of the cells vary much.

The characters of the fluid found in many cystic growths is described in page 178.

270. Colloid Tumours are soft and jelly-like. They are composed of a viscid albuminous material, held in the meshes of an exceedingly delicate network of fibrous tissue in which the vessels ramify. In many cases, a number of round or oval cells containing oil globules are observed in the course of the walls of the areolæ.

Colloid Cancer has been applied to tumours of this description which are more rich in cellular elements, and prone to appear in different parts of the body. By some the *ovarian tumour* is considered as a form of *colloid*, but its history and mode of development differ from the gum-like growths met with in other localities. Drawings of good examples of colloid tumours will be found in vol. v. of the "Transactions of the Pathological Society," page 320. The peculiar appearance of these growths is due to the large amount of albumen they contain. I found the composition of one weighing three pounds, removed from the calf of the leg, by Sir W. Fergusson, to be as follows :—

Water	904·60
Solid matter	95·40
Extractive soluble in water	15·20
Albumen	64·20
Fatty matter...	5·53
Alkaline salts	7·60
Earthy salts	2·85
Sulphuric acid	1·05
Phosphoric acid	2·912

* See "Archives of Medicine," No. I, page 33.

The so-called *colloid corpuscles*, are small, round, or oval bodies composed of several layers of a clear transparent substance. They have been described by Hassall, Virchow, Kölliker, and others, and have been termed *corpora amylacea* (p. 146) by some observers. They have no connection with the colloid growths, and are only alluded to here in consequence of the term *colloid* having been applied to them.

271. Cholesteatoma is a rare form of tumour, which was first described by Müller. Besides containing much fatty matter and crystalline plates of cholesterine, the soft, pulpy material of which these tumours consist, is composed of a number of glistening pearly scales, which may be easily separated into very thin laminæ. Upon examining these with a power of 200 diameters, they are seen to consist of egg-shaped vesicles. They are for the most part perfectly clear, but some exhibit a slightly granular appearance. Others again resemble cells of the epidermis which have been soaked in nitric acid. The peculiar structure of these tumours is represented in pl. XLIV, fig. 332, which was kindly sent me by Mr. Simon. The chemical composition of this tumour was as follows :—

		In 100 parts of solid matter.
Water	87·78	
Solid matter	12·22	
Extractive soluble in water and alcohol	3·119	25·52
Extractive soluble in water only	1·030	8·44
Fixed alkaline salts, consisting of sulphates, chlorides, phosphates, carbonates, with a trace of iron	·396	3·24
Fatty matter	·053	·43
Albuminous matter insoluble in boiling water	6·999	57·27
Earthy salts, consisting of phosphate and sulphate of lime ...	·608	4·97

The extractive matter soluble in alcohol had the same peculiar smell as the mass itself. The odorous material was volatile, and was present in the fluid which passed over in distillation in considerable quantity. The fatty matter was treated with alcohol, but no cholesterine crystallized out, probably in consequence of being protected from its action by the hard fat present. The total quantity of fatty matter was so small that no further experiments could be resorted to. It should be borne in mind, that an amount of cholesterine, which

when examined in the microscope would be accounted considerable, is often so small as not to be appreciable by the balance.—"Archives of Medicine," No. I, page 42.

272. Rare form of Tumour beneath the Tongue of a Girl aged 23.—The tumour projected beneath the chin, and extended upwards into the mouth. It had been growing for about two years. It was opened by Sir William Fergusson, and about an ounce and a half of a soft pultaceous mass was removed.

Analysis—1000 grains contained—

Water	838·72
Solid matter	161·28
Extractive matter	13·44
Alkaline salts	·68
Fatty matter...	45·00
Tissue, &c., insoluble	99·88
Earthy salts	2·28

The microscopical characters of the tumour were peculiar. These are represented in fig. 333, pl. XLIV. The mass was found to be composed of numerous cells, like adipose vesicles, filled with fatty matter, but some appeared nearly empty, and closely resembled cells of squamous epithelium, *a* and *b*. The microscopical characters of the contents somewhat resembled those of cholesteatoma, but no plates of cholesterine were present in the specimen. In structure, however, this tumor was closely allied to the cholesteatomatous group. "Archives of Medicine," vol. I, p. 318.

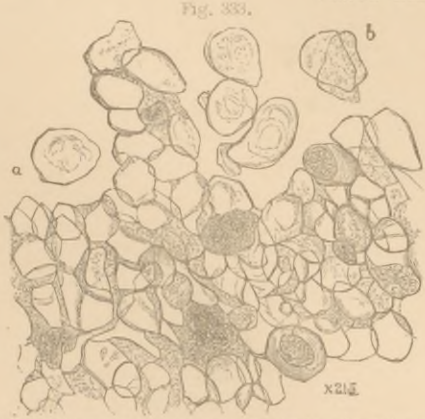
273. Epithelial Growths.—*Epithelial Cancer.*—*Epithelioma.*—The tumours included under these heads resemble the cancerous growths more closely than any other structures. The distinctive characters of these have been carefully investigated by Paget. See also Bennett "On Cancerous and Cancroid Growths." Lebert, "Traité pratique des Maladies Cancéreuses et des affections curables confondues avec le Cancer." Walshe, "The Nature and Treatment of Cancer." Paget, "Lectures on Tumours," second edition, 1863.

Under this head are included the following forms of disease: cancer of the lip, noli me tangere, cauliflower excrescence of the uterus, chimney sweeps' cancer, &c. *Warts* consist merely of a superabundant formation and accumulation of the epithelial cells of the cuticle; and tubercles, which occur on the external genital organs, have a very similar structure. In cancer of the lip, tongue, &c., fissures are formed, in which an abundant growth of epithelium takes place, accompanied with an ichorous discharge. The papillæ also become much modified, and, like other textures, entering into the formation

Fig. 332.

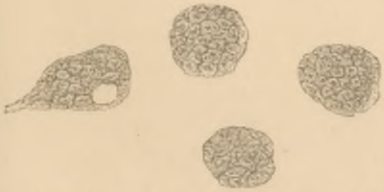
Cholesteatoma. *a*, large cells, of which the laminæ forming the pearly scales were composed; some of these are shrivelled and flattened, resembling the superficial scales of the epidermis. *b*, fibrous tissue from the inner surface of the capsule. *c*, crystals of cholesterine; oil globules and granular matter are seen in various parts of the field. p. 253.

Fig. 333.



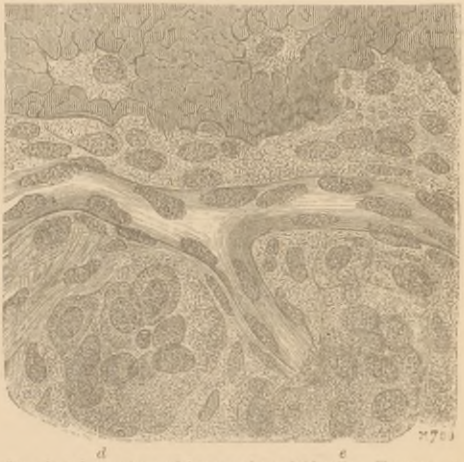
Section of tumour, situated under the tongue of a girl, aged 2½. The dark shaded portions consist of fatty matter. *a*, separate cell membrane. *b*, ditto, resembling cells of epithelium. The structure of this tumour is closely allied to that of a cholesteatomatous tumour. p. 254.

Fig. 334.



Myeloid cells from a soft tumour at the lower end of the shaft of the femur. × 220. From a drawing by Mr. Hulke. p. 250.

Fig. 335.



Cancellated structure of bone and myeloid cells. Human. *a*, fully formed bone. *b*, capillary vessel. *c*, fibrous or connective tissue. *d* one of the so-called myeloid cells. *e*, another myeloid cell, forming a curve round the capillary. p. 249.

Fig. 336.

Fibroid tumour, from the testicle. × 215. *a*, *b*, fibres separated from each other. *c*, portion of the tumour in which the separate cells are not distinct. Collections of oil globules are scattered through this part of the mass. Fibre cells of various forms are represented. p. 250.

Fig. 337.

Muscular fibre cells, from the small intestine. × 215.

Fig. 338.

Softened cerebral tissue surrounding a cavity in the posterior part of the optic thalamus and the corpus striatum, and which extended some distance into the white substance of the hemisphere. The cavity contained fluid and also a firm clot.

1000th of an inch ——— × 215.

" " ——————— × 700.

To face page 254.

of the cancerous tissue, grow very irregularly. The edges become indurated, and as the disease gradually advances, it invades deeper structures.

If a thin section of one of these growths be examined, interspaces will be observed, pl. XLV, fig. 339, from the walls of which the cells appear to grow. The cells often seem to be arranged in laminæ; they do not vary so much in size and form as the cells of true cancer; the masses of germinal matter "nuclei," do not differ so much in size; they rarely contain large nucleoli, and usually adhere to each other by their margins, fig. 340; frequently three or four, or more, will be found united together. In fact, these cells very nearly resemble, in their general characters, the ordinary epithelial cells of the surface upon which the growth is developed, but they are softer and of course contain more water, and grow much more quickly.

274. Melanoid Tumours.—The terms *melanosis*, *melanoma*, and *melanoid*, have been applied to those cellular tumours which contain a considerable quantity of pigment. The colour may vary from a darkish yellow to a purple or black, and the material of which it is composed consists of minute granules or small masses, varying much in shape and size. They are composed entirely of organic matter with a mere trace of iron, and are precipitated amongst the germinal matter at an early period of the growth of the cell, and they are therefore found in the substance of the cells in their fully formed state. The cells of many true cancerous tumours contain much pigment, and these are consequently said to be *melanotic*.

The lungs and bronchial tubes of colliers, sweeps, and those who work in many factories, often contain a quantity of black material which has been introduced into the lungs suspended in the air breathed. This state has been termed *false melanosis*.

275. Cancer.—A cancerous growth may be described as consisting of a fibrous matrix, pl. XLV, fig. 342, more or less abundant, and arranged so as to form areolæ, or interspaces, *a*, upon the walls of which the vessels ramify. These interspaces contain cells in considerable number, suspended in a more or less viscid fluid, with much granular matter which is found when examined in a perfectly fresh state under very high powers, to consist of *a*, minute particles of living germinal matter, the germs from which new cells may be formed; *b*, fatty matter as minute granules of molecules and globules, and minute crystals of fatty matter; and *c*, shreds of fibrous tissue.

The great difficulty of deciding as to the cancerous or non-cancerous nature of a tumour, arises principally from the fact, that no single element of which the structure is composed, can be looked upon as characteristic of the cancerous form of growth only. Neither the cha-

racter of the cells, nor the nature of the matrix, nor the arrangement of the elementary constituents can separately determine the point, and it is only by carefully noting the collective appearances observed upon microscopical examination, that we can decide. In the great majority of cases, however, it is possible to speak with tolerable certainty; but at the same time it must be borne in mind that instances come under notice from time to time, in which the most careful and experienced observers would be unable, from a microscopical examination, to determine the nature of the tumour.

A well-defined cancerous growth, in its microscopical characters, does not resemble, and cannot be confounded with, any healthy texture; while many of the non-malignant tumours, in their essential characters, bear great similarity to certain healthy tissues, or are actually identical with them in structure.

Cancerous tumours have been divided into three principal varieties according to the relative quantities of the viscous juice, fibrous, or cellular elements present.

From the freshly cut surface of a *cancerous tumour*, a more or less turbid juice exudes, which, upon examination in the microscope, is found to contain cells varying much in size and form, as well as in the character of their contents; a few fragments of fibrous tissue; a number of free oil globules, and, perhaps, a few cells containing oil globules; and much free granular matter, pl. XLV, fig. 342. Upon examining a thin section made with a Valentin's knife, the relation of these structural elements to each other may be observed. The fibres will be seen to form meshes or interspaces, in which the cells and fluid are contained, fig. 342 *a*. In some instances the fibres resemble those of ordinary areolar tissue; sometimes they consist chiefly of fibres resembling those of yellow elastic tissue; and not unfrequently the fibres become perfectly transparent upon being treated with acetic acid, showing the absence of the yellow element. Amongst these fibres, helping to form the boundaries of the spaces, are the capillary vessels which cannot be discerned in many cases unless they are injected. Many forms of cancer prepared according to the directions given in § 101, yield most beautiful and instructive microscopical specimens.

The cells of cancerous tumours vary much in size and form: they may be perfectly round, or prolonged at either end into delicate fibres, or of most irregular outline, pl. XLV, figs. 341, 342, 343, pl. XLVI. They usually contain one large mass of growing germinal matter, "nucleus," but very often two masses are met with, and not unfrequently many more may be observed. These are formed by the subdivision of the original mass. The masses of germinal matter

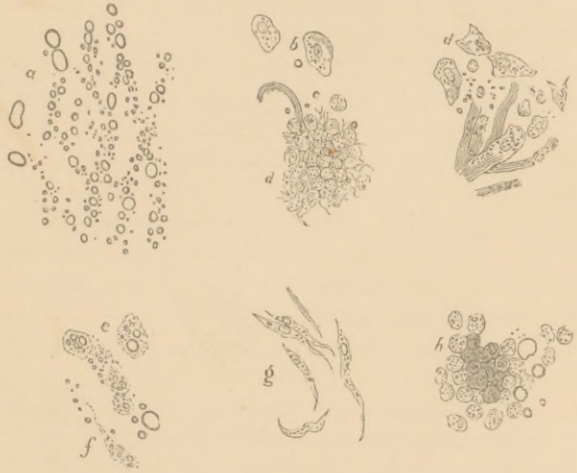
Fig. 339.

Epithelial cancer. × 42. p. 255.

Fig. 340.

Cells from an epithelial cancer. × 215. p. 255.

Fig. 341.

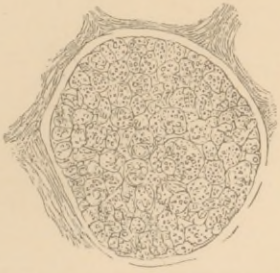


Drawings from a case of cancer diffused through the entire liver. Sent by Mr. Robert Cesly, of Aylesbury. Case reported in 'Archives,' No. II.
The specimens were taken from the collections of cancerous matter, and from the intervals between them. *a*, remains of the secreting structure of the lobules. *b*, liver cells from the interval between two collections. *c*, *d*, also from the surface of one of the cancerous masses, showing delicate fibrous tissue, cells, and fibre cells. *e*, remains of secreting cells in the interval between the cancerous collections. *g*, fibre cells from the surface of a collection. *h*, cells from a short distance within one of the tumours. × 215 p. 256.

Fig. 342.

From a cancerous tumour. *a*, portions of fibrous matrix. *b*, cells, many of them containing smaller ones in the interior. × 215. p. 255.

Fig. 343.



Small cancerous tumour from a portal canal, containing a number of cells. × 215 diameters. From a woman aged fifty-one, who died of medullary cancer of the liver, in King's College Hospital.—M. B., 572. p. 257.

1000th of an inch ⌣ × 42.

" " |___| × 215.

[To face page 256.

"nuclei" of different cancer cells often differ much in size. They generally contain several granules, and much granular matter exists between them and the formed material or "cell wall." Cells are often found which contain several smaller cells in their interior; these have, on this account, been termed "mother-cells," fig. 342, fig. 344, *b*, *d*, *q*, etc. The cells readily separate from each other, and exhibit no tendency to aggregate together, nor do they appear ever to have been adherent to each other at their margins. Fig. 343, pl. XLV, is a beautiful example of a very young growing cancerous tumour, consisting of only a few cells which are multiplying rapidly.

The characters of many cancerous growths entirely depend upon the locality in which they grow, and a cancer may assume the form of a solid, hard, or soft circumscribed tumour, a soft spongy mass, prone to spread in all directions, a highly vascular papillary growth, or other forms too numerous to mention. Cancerous growths also differ in density, colour, rapidity of growth, as well as in the form and character of the cells of which they are composed. It is impossible to lay down any definite characters which shall in every case serve to distinguish a cancerous tumour from other forms of morbid growths; but a tumour from the cut surface of which a milky juice is poured out, and which, upon microscopical examination, is found to consist principally of cells exihibiting the general characters above referred to, and arranged in the meshes of a fibrous stroma, may be pronounced to be of a cancerous nature.

The so-called *epithelial growths* resemble *cancerous tumours* more closely than other structures. These commence on some epithelial surface, as the skin, or mucous membrane, or in the duct or follicles of a gland. The chief differences to be observed in the minute structure of these two classes of tumours are tabulated as follows :—

Cancerous.	*Epithelial Growths.*
Cells not connected with the matrix in a regular manner, or forming laminæ.	Cells connected with the matrix, often forming distinct laminæ.
Cells differing much from each other in size and form.	Cells resembling each other in size and general outline.
Cells readily separable from each other.	
Cells not connected together at their margins; their edges seldom forming straight lines.	Cells often cohering by their edges, which generally form straight lines; three or four cells being frequently found united together.
Cells containing several smaller cells in their interior often met with.	Cells usually containing one nucleus.
Nuclei varying much in size and number in different cells.	Nuclei not varying much in size in different cells.
Juice scraped from the cut surface containing many cells floating freely in the fluid, and not connected with each other.	Juice scraped from the cut surface, containing small collections of cells, which are often connected with each other.

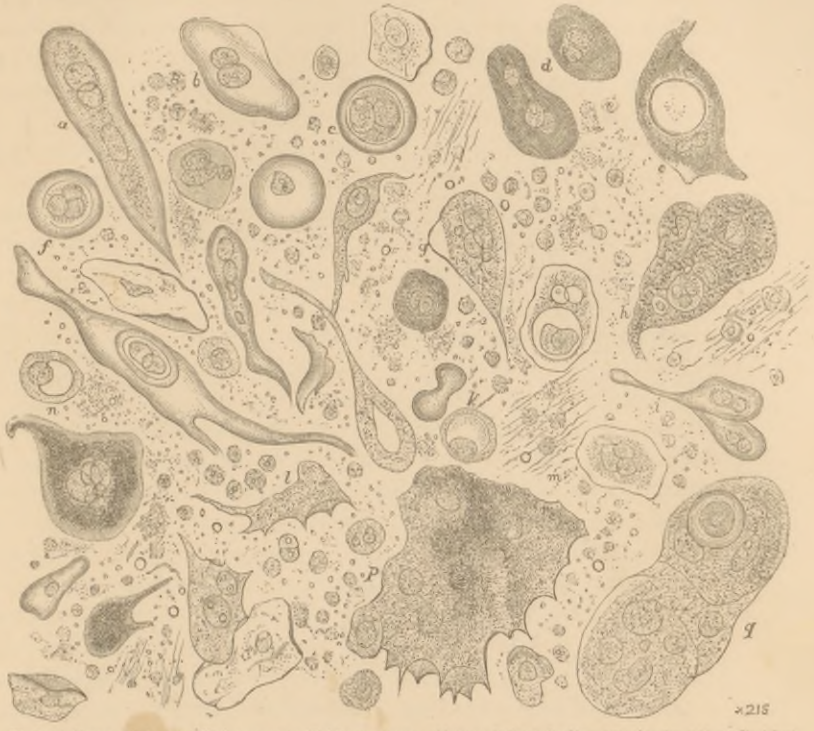
A beautiful specimen of cells from a cancerous growth from the pharynx is represented in pl. XLVI. The cells were expectorated by the patient during life. I am indebted to my friend, Mr. Newham, of Bury St. Edmunds, for the specimen and account of the case published in the fifth number of the Archives of Medicine.

It will be observed that the cells represented in pl. XLVI, fig. 344, are not all composed of the same material. Some refract light differently to others, as indicated by the different varieties of shading, and there is an absence of that granular appearance which is observed in the greater number of specimens figured. The cellular appearance of many of the bodies in question is fallacious, and many that would be termed "mother cells" are only masses of soft formed material with nuclei (germinal matter) irregularly scattered through them. In some instances these have broken in such a way as to leave cavities into which the germinal matter evidently fitted. At *p*, fig. 344, such a mass is seen, and at the lower portion is a cell-like piece nearly detached, with others which are quite separated. The specimen was not treated with any reagent. Water was not even added, so that the appearances represented are not produced by any artificial processes whatever. A portion of the mass removed after death is represented in fig. 345, and in fig. 346, the microscopical characters of one of the cervical glands are indicated. Other forms of cancer are represented in pl. XLV.

276. Examination of Morbid Growths.—In the first place the fluid or juice, if any exists on the free surface of the tumour, should be examined: secondly, the microscopical characters of the juice, which exudes from the freshly-cut surface should be ascertained: and, lastly, a thin section ought to be made, in order to determine the relation of the constituents of the tumour to each other, and especially the proportions in which the different elements are present. Its connection with surrounding structures may be ascertained by examining a thin section, which should include a portion of the adjacent texture; and these observations should be made first with low powers, and afterwards with a power of from 700 to 1800 diameters.

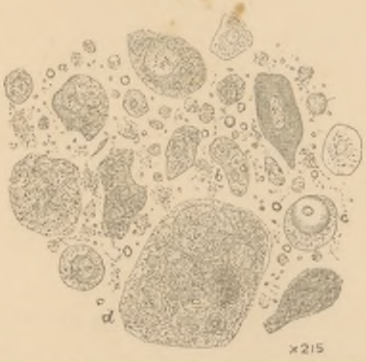
The disposition, arrangement, and general direction of the fibres in the fibrous portion of the tumour should be carefully noted, and the form, size, shape, and contents of the "cells" (especially with reference to the presence or absence of oil globules or molecules, nuclei or masses of germinal matter, &c.), should be especially dwelt upon. Every opportunity should be taken of carefully delineating the appearances observed, in order that the structure of one tumour may be compared with that of others which may

Fig. 344.



Various forms of the so-called cancer 'cells' in sputum. Many of these bodies are clearly not 'cells,' but fragments of a mass containing nuclei, or small masses of germinal matter, irregularly scattered through it. At *p* is represented a piece from the lower part of which the nuclei and portions of the mass surrounding them have been broken off, leaving cup-shaped cavities in which they were lodged p. 268.

Fig. 345.



Portion of the tumour itself, removed after death. p. 268.

Fig. 346.

Portion of a cervical gland. p. 268.

1000th of an Inch ⌊⌋ × 215.

subsequently fall under notice, and if the growth presents anything unusual, a section ought to be put up in some preservative fluid. It is extremely important that every opportunity of obtaining very minute cancerous tumours should be taken advantage of. More is to be learned with reference to the history and mode of growth, from microscopic tumours, than from those of large size. Accurate notes should be made of every examination, and these, with sketches, should be entered in a note book kept for the purpose.

The observer should examine tumours in several different parts. Sections may be made in different directions with Valentin's knife, an ordinary scalpel, or a strong knife, according to the consistence of the tumour. In examining the cells it is better to employ a little serum or gum-water, for sometimes if water alone be used, they become swollen and much altered.

Lastly, the influence of certain chemical reagents upon the sections and portions scraped from the cut surface of the fresh tumour must be ascertained. The most important reagents in the examination of morbid growths are, acetic acid, solution of soda, and ether; but the stronger acids and other tests will occasionally be required. The two former are of advantage in rendering the tissues more transparent, and displaying the nuclei. Ether is sometimes required to ascertain if certain globules which resemble fatty matter, are really of this nature.

The method of preparation described in § 101 is eminently adapted for the investigation of morbid growths. Tumours of the most delicate structure may be injected by the process there described, and the germinal matter of the cells may be stained, and thus very beautiful and highly demonstrative specimens may be prepared.

277. Preservation of Morbid Growths.—Morbid growths will require different preservative solutions according to their nature. Glycerine to which about a third of its bulk of water and a little alcohol have been added answers well in some cases, and retains the character of cells better than other solutions which I have tried. Strong glycerine is well adapted for the preservation of some growths, very thin sections of which appear opaque when examined in water. But when fibrous structures are immersed in glycerine, the transparent appearance due to this medium must be considered when describing their characters. It is very important in this and other cases to subject the same specimen to examination in various media. The naphtha and creosote solution, and carbolic acid water, p. 85, preserve many delicate structures very efficiently, but after some specimens have been immersed for a long time, minute oil globules make their appearance, and gradually increase in number. The other preservative

solutions which I have yet tried, so totally alter the characters of the cellular tumours, as to obliterate all appearance of their former structure. I have found it better to cut off small pieces of the tumour, and place them in a little bottle with the preservative fluid, which must be changed two or three times, than to mount a thin section permanently in a cell. Each bottle should be carefully labelled. Sections must be cut when it is intended to submit the tumour to examination. For the last few years I have preserved morbid growths in strong glycerine, according to the plan given in § 101, which I find succeeds admirably.

CHAPTER VIII.

ANIMAL AND VEGETABLE PARASITES.—ANIMAL PARASITES.—*Acarus Scabiei.—Entozoon folliculorum*, or *Demodex.—Examination of Entozoa.—Tænia Solium, Tænia Mediocanellata.—Bothriocephalus Latus.—Hydatids, Echinococci.—Trichina Spiralis.—Bilharzia Hæmatobia.—Other Entozoa.—Strongylus Gigas.*—VEGETABLE PARASITIC STRUCTURES.—*Sarcina Ventriculi*, or *Merismopædia Ventriculi.—Other Forms of Algæ.—Leptothrix Buccalis.—Penicillium Glaucum.—Achorion Schœnleinii.—Tricophyton Tonsurans.—Tricophyton Sporuloides.—Microsporon Mentagrophytes.—Microsporon Audouini.—Microsporon Furfur.—Puccinia Favi.—Chionyphe Carteri.—Early Stages of Fungi.—Oïdium.—Apthæ, Muguet.—Diptheria.—Fungus from External Meatus of the Ear.—Other forms of Fungi.—Of the Manner in which Fungi enter the System.—Examination of Vegetable Growths.*

In this chapter, I shall only attempt to refer to the structure and mode of examination of a few of the animal and vegetable parasites which are most frequently met with in the human body. For a complete account of these organisms, I must refer the reader to Küchenmeister's treatise translated for the Sydenham Society, and the works enumerated at the end of this chapter.

ANIMAL PARASITES.

The only epizoa which need be referred to here, are the itch insect *(Acarus scabiei)* and the entozoon from the sebaceous follicles *(Entozoon*, or *Demodex folliculorum)*.

278. Acarus Scabiei, or Sarcoptes Hominis.—The itch acari are rather difficult to procure from the cases of itch usually met with in this country. They may sometimes be extracted from the itch pustules or vesicles by passing a fine needle into

the burrow, the opening of which is always at the side, and may be known by the presence of a little dark point. The male is very much smaller than the female. See figs. 347, 348, pl. XLVII, for which I am indebted to my friend Mr. Richardson, of Dublin, and note the difference of magnifying powers. They may be dried carefully at a gentle heat, and preserved in Canada balsam. The itch mite bores into the skin from the outer surface. At first the direction of the gallery is perpendicular, but it passes obliquely through the cutis. In order to obtain the mite, the Corsican women pass a needle or other sharp pointed instrument into the opening in such a manner that it might be forced below the mite, the portion of skin elevated, and the acarus turned out. The process requires some practice and dexterity for its performance. A sharply pointed thin knife is an efficient instrument for obtaining the acarus. In order to examine the galleries the creature makes, the skin, with the vesicle or pustule, is to be pinched up, and the latter shorn off with a knife or scissars. It is then inverted and examined in fluid or in glycerine, or allowed to dry slowly on a glass slide, when it may be mounted in Canada balsam.

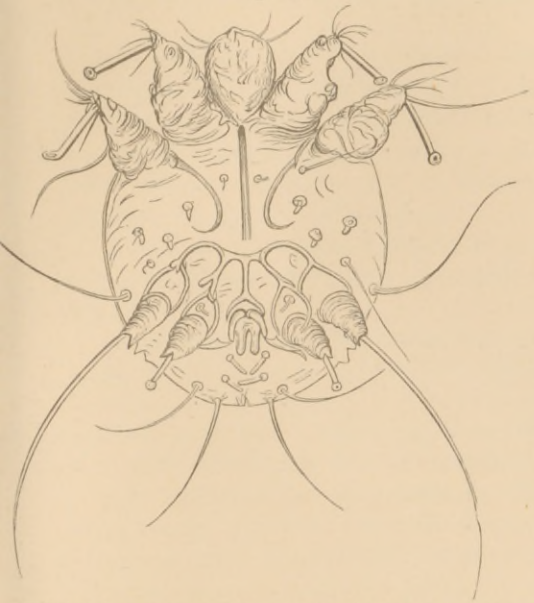
In bad cases of itch, *crusts* may be removed which contain numerous specimens of the acarus in various stages of development with ova. Mr. B. W. Richardson, of Dublin, received from Dr. Neligan a piece of scab from a *case of Norway itch*, which, although not more than a quarter of an inch square, contained one hundred specimens in it. They were all *six legged*, as represented in pl. XLVII, fig. 349. In a case which occurred at Wurzburg, and is alluded to by Mr. Anderson, a piece of the crust "not half a line square, contained two females, eight six-legged young, and twenty-one pieces of acari, six eggs, and fifty-three egg shells. In the deepest and softest parts of the crusts, masses of living acari wallowed and tumbled about."*

The hexapod acari are not, as some have supposed, a distinct species, but merely young specimens of the ordinary acarus which have not moulted. They are found in numbers never met with in this country in the severe forms of Norway itch. The female lays more than fifty eggs. Ova of the acarus scabiei, in different stages of development, are represented in fig. 350, which has been copied from Küchenmeister.

279. The Entozoon Folliculorum is generally present in the follicles of the skin of the scalp, nose, chin, and other parts of the face. It may usually be procured very readily from the nose, by squeezing out the contents of the sebaceous follicles by pressing the skin firmly between the finger and thumb, or between two of the finger nails.

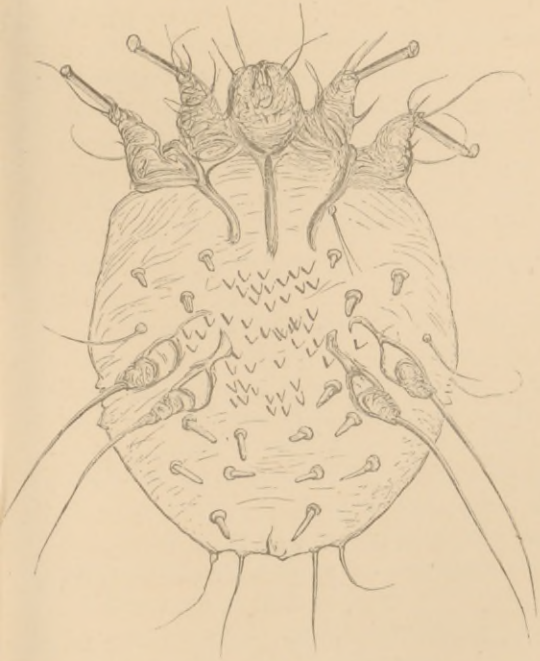
* Mr. B. W. Richardson, "On hexapod acari scabiei, from Norway, Itch." Dubin Medical Press, June 7, 1865.

Fig. 347.



Eight-legged acarus scabiei. Male. × 300. After Richardson. p. 261.

Fig. 348.

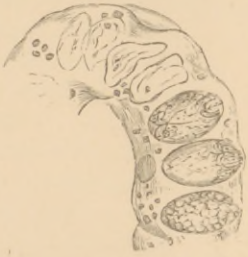


Eight-legged acarus scabiei. Female. × 130. After Richardson. p. 262.

Fig. 349.

Six-legged acarus scabiei. × 200. After Richardson. p. 262.

Fig. 350.



Eggs of acarus scabiei in various stages of development. After Kuchenmeister. p. 264.

Fig. 351.

Entozoa folliculorum. From the external auditory meatus. *a c*, short variety. *b*, long variety. × 130. p. 263.

1000th of an inch ⌴ × 130.
,, ,, ⌴ × 215.
,, ,, ⌴ × 300.

[To face page 262.

The white cheesy matter thus expressed must be torn with needles, and then placed on a slide in a drop of oil, and covered with thin glass. One or two of the entozoa will usually be found. There are two varieties, and these are constantly met with in the same individual. One is much longer, and the body more thin and taper than the other, fig. 351, *a*, *b*, *c*, pl. XLVII.

I have found them in considerable number in the wax which collects in the ear. If the wax is tolerably moist the addition of oil is unnecessary.

Small parasites may be stained with carmine and preserved in strong glycerine, § 101. After proper soaking in glycerine they may be preserved in the glycerine jelly, or they may be carefully dried and mounted in balsam. Potash and soda dissolve the soft parts, and thus we may display the skin very beautifully.

280. Tape Worms—Tænia Solium.—The common English tape worm is often met with. A fresh joint may be placed under the microscope and examined with low powers. If dried upon a glass slide, and mounted in Canada balsam, it makes a very instructive preparation. The ovaries of many joints are often distended with ova some of which should be squeezed out and mounted separately.

The mode of development of the tape worm is now quite understood and it has been proved experimentally that the cysticercus cellulosæ becomes in the stomach transformed into Tænia solium. The cysticercus is introduced into the organism in measly pork: it has been remarked that cases of tape worm are most common in those parts where much pork is eaten. The cysticercus cellulosæ has been met with in several cases in the human eye, as in the anterior chamber, in the vitreous, and in some instances it has migrated into the brain.

Tænia Mediocanellata,—Is the tape worm developed from a cysticercus infesting cattle, and derives its name from the peculiar distribution of the water vessels in the head. It is larger every way than tænia solium. The head is very large, flattened, and hookless, with four suckers much larger than those of tænia solium, surrounded by much black pigment. Dr. Cobbold remarks that this hookless tape worm is as common in this country as the tænia solium. In pl. XLVIII, fig. 352, is a drawing of a beautiful specimen of the head of this entozoon which was passed by one of my patients in the hospital after oil of male fern.

Bothriocephalus latus is the tape worm most common in Russia, Sweden, Poland, and Switzerland. It is seldom met with in this country, and out of upwards of 100 cases of tape worm I have only

obtained one specimen of the bothriocephalus. The head is elongated and destitute of hooks and suckers. This parasite may be examined and preserved in the same manner as the common tape worm.

281. Means of Procuring the Head of the Tape Worm.—It may be advantageous just to refer to the most effectual manner of obtaining the head of the tape worm. Of all the remedies I have seen tried, the ethereal oil of male fern is certainly the most efficacious. Out of about thirty cases which I carefully watched in 1851, when I was house physician to King's College Hospital, the head was expelled in six or seven. Some of the patients had been treated with kousso, and others with the oil of male fern. All the successful cases had been treated with the latter; indeed, although I have seen many cases treated with kousso, I never was successful in finding the head; the greater part of the worm, however, was invariably expelled. The oil of male fern is to be administered as follows:—two drachms to half an ounce, according to age, &c., are suspended in eight ounces of water, with the aid of mucilage. After fasting for twenty-four hours (only a little water, or, at most, milk being allowed), the patient is made to take the draught early in the morning, and an hour or an hour and a half afterwards, a dose of castor oil is to be given. The worm is usually expelled in the course of the day. The fasting appears to be a very important part of the treatment, and it seems essential that the oil should be suspended in a large quantity of water. I have since obtained many entire worms in this manner.

The head may be examined in fluid with an inch object-glass as an opaque preparation, or it may be put up in balsam, but it must be dried with great care. I have found that specimens of tape worm may be preserved exceedingly well in strong glycerine to which a little acetic acid has been added.

282. Hydatids. Echinococci.—Hydatids may occasionally be obtained from bodies in the post mortem theatre. They are usually found in large cysts, occupying a considerable portion of the liver. The parent cyst is often surrounded by a layer of purulent fluid. Upon opening this parent cyst numerous smaller round cysts (*acephalocysts*) with much fluid, escape. The walls of the cysts are usually quite white, not unlike the boiled white of egg; and they vary much in thickness. The thick, white membrane consists of several superimposed laminæ which increase in number as the cyst advances in age. See fig. 356, pl. XLVIII. These may be well seen in a thin section of the walls of the cyst. Often a considerable number of crystals of triple phosphate will be found, especially if the hydatid be not quite fresh. The structure of the wall appears homogeneous or at most slightly granular, as if it had been merely

deposited by the inner germinal membrane from the inner surface of which the echinococci and new cysts are formed.*

The granular appearance of the inner membrane arises from the presence of little elevations with which the surface is studded. By scraping these gently with a knife, not unfrequently many echinococci will be removed. The echinococci may also be obtained by allowing the fluid contents of the acephalo-cysts to flow into a conical glass. After a short time the echinococci sink, and may be removed with a pipette. They grow as buds or offsets from all parts of the internal surface of the vesicle. Many soon become detached from the wall of the cyst and die. Echinococci are represented in pl. XLVIII, figs. 353 to 360.

The echinococcus is developed from some of the masses of germinal matter of which the inner wall of the cyst seems to be almost entirely composed. They may be seen at different stages of development in many cysts projecting like buds from the surface, pl. XLVIII, fig. 353. Two species of echinococci have been described, *E. hominis* and *E. veterinorum*, but it is probable that these are really the same.

The echinococcus has been proved to be the immature condition of the *tænia echinococcus*, a minute tape worm found only in the dog and wolf. The tænia echinococcus is about ¼th of an inch long, and consists of only four joints, including the head, which has four suckers and a circle of hooks. The eggs contain a six-hooked embryo which does not develope into a cysticercus, but into a spherical vesicle containing a granular material. The echinococci are afterwards developed by budding from the inner wall of the vesicle. My friend and pupil, Mr. Nettleship has published some very interesting observations upon the development of this parasite in the Proceedings of the Royal Society for June 21st, 1866, and I have to thank him for some beautiful specimens of the tænia in the dog's intestine which were developed from the echinococci taken from the liver of a sheep. Some of the brood are represented in pl. XLVIII, fig. 353, and the tænia in fig. 354.

Fig. 355, represents the appearance of echinococci magnified with an inch object-glass, and in figs. 359, 360, are shown two specimens magnified with a quarter. In one of these the hooks are seen to be extruded, a condition which has been considered to result from the occurrence of endosmosis and commencing decomposition. They may be made to protrude their hooks by leaving the opened cyst for twenty-four hours in the fluid. The echinococcus is about 1-200th

* See also a communication by Dr. Hyde Salter, in the fifth volume of the "Transactions of the Pathological Society," page 303.

of an inch long. It is nourished by imbibition only. The hooklets are thirty-four in number.

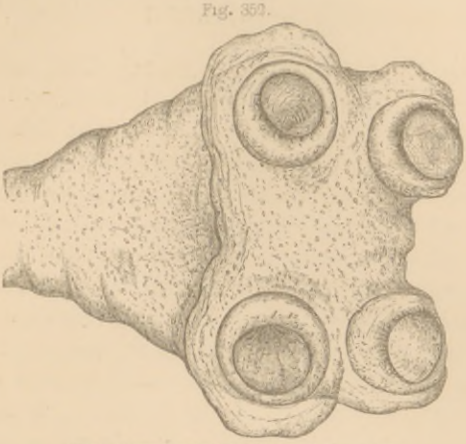
If a little of the fluid from the interior be evaporated upon a glass slide, numerous crystals of chloride of sodium will be formed. Heintz gives the following plan for detecting *succinic acid* in the fluid of the hydatid cysts. The fluid concentrated by evaporation is to be treated with a little hydrochloric acid and agitated with water, and ether free from alcohol, until nothing more is taken up. The impure succinic acid obtained by evaporating the etherial solutions, is dissolved in water. The solution is to be filtered and evaporated to dryness. The residue is then treated with alcohol and completely recrystallized.*

The character of the claws, pl. XLVIII, figs. 357, 358, 361, should be particularly noticed, as their presence is characteristic of echinococci. Hydatids are occasionally expectorated; usually in consequence of a cyst in the liver opening into the base of one being. The appearance of the cysts in the sputum will direct attention to the origin of the pulmonary mischief, but the observation should be always confirmed, if possible, by the microscopical examination of the claws or hooks. Echinococci may be preserved in the creosote solution or in preservative gelatin. The hooks may be preserved moist in fluid, or dry in Canada balsam.

283. Trichina Spiralis—Is a species of entozoon which is sometimes found in the voluntary muscles. It was first described by Owen, in 1835. The researches of Leuckart and Virchow have shown that the Trichina spiralis cannot be regarded as the brood of the Tricocephalus dispar engaged in migration, as was formerly supposed. When introduced into the human intestine, the larval trichinæ rapidly arrive at sexual maturity, and the young filariæ soon after their escape from the uterus of the mother commence their migrations by boring in every direction through the surrounding tissues, till they arrive at the voluntary muscles. They rarely stop anywhere else. In the muscles they become completely developed, and ultimately surrounded by a cyst which eventually calcifies. It appears, however, that these cysts are by no means essential, and that they may be wanting even where the Trichinæ are very numerous, so that a careful microscopical examination would always be necessary to determine the absence of the parasite. Encysted trichinæ are represented in pl. XLIX, figs. 362 and 364, in a portion of human muscle from a patient who died in the London Hospital. I am indebted to Mr. Curling for a specimen of the muscle. A figure of the

* Heintz, "Lehrbuch der Zoochemie," page 239.

Fig. 352.



Head of tænia mediocanellata. × 20. p. 263.

Fig. 354.

Tænia echinococcus. × 15 p 265.

Fig. 353.

Echinococci from hydatid. Liver of ox. × 40. p. 265.

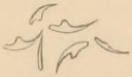
Fig. 355.

Echinococci. × 42. p. 265.

Fig. 356.

Layers of which the wall of an hydatid cyst is composed. × 215. p. 264.

Fig. 357.



Free hooklets from echinococcus. × 215. p. 266.

Fig. 358.

Hooklet of echinococcus. × 700. p. 266.

Fig. 359.

Echinococcus. Showing the head and suckers withdrawn. × 215.

Fig. 360.

Echinococcus, with the hooks extended. × 215. p. 266.

Fig. 361.

Hooklets of echinococci, masses of germinal matter, oil globules, crystals of fatty matter, and debris. Deposit from fluid of an hydatid cyst. × 215. p. 266.

100th of an inch ⌊⌋ × 15.
1000th ,, ⌊⌋ × 40.
,, ,, ⌊⌋ × 215.
,, ,, ⌊_____⌋ × 700.

[To face page 266.

trichina removed from the cyst is given in the same plate, fig. 363. This entozoon has acquired a peculiar interest of late in consequence of the fatal results which have occurred in many cases in Germany, from eating flesh infected with trichinæ. The trichina disease usually commences with diarrhœa or abdominal pains, from the presence of the larvæ in the intestines. The next symptoms are those which result from the invasion of the muscles by the parasite, and consist chiefly of great prostration, severe pain in the muscles, and inability to extend the limbs, forcible extension being accompanied by great pain. The face and limbs become œdematous, and there is much fever. Recovery from this stage is sometimes followed by debility, wasting, and death from the impaired capacity for exertion of the muscles consequent on the presence of the Trichina cysts in them. The disease is not invariably fatal. It is remarkable that the same species of Trichina should flourish in a number of very different species of animals.

The calcification of the cysts renders them opaque, so that the contained worm cannot be distinctly seen till the calcareous matter has been dissolved out by dilute hydrochloric acid, pl. XLIX, fig. 362.*

284. Bilharzia Hæmatobia.—Dr. John Harley has recently called attention to the existence of endemic hæmaturia in certain parts of the Cape of Good Hope, and in Natal, and has shown it to be due to a species of Bilharzia which, after careful comparison with Griesinger's figures of Bilharzia hæmatobia, he has been induced to refer to another species named by him, B. Capensis.† As no opportunity has yet been afforded of examining the adult animal, it is, however, probable that the species is identical with B. Hæmatobia.

Dr. Harley found in the urine of his three patients the eggs and ciliated embryos of the parasite, also part of its intestine, and a portion of ciliated integuments. Drawings of the eggs embedded in mucus and free are given in pl. XLIX, figs. 365, 366, and 367. For the specimens from which these drawings were made, I have to thank my friend and colleague. This parasite is a non-hermaphrodite trematode worm. It has two suckers, and in the body of the male is a peculiar channel, the "gynæcophoric canal," which contains the female during copulation. The parasite is chiefly found in the vesical mesenteric and portal veins, and by its presence in their minute branches gives rise to lesions of the mucous membrane of the intestines, bladder, ureters, and pelves of the kidneys. The principal symptoms are

* On the Trichina, see the memoirs of Dr. Althaus and Dr. Thudichum.

† Medico-Chirurgical Transactions, vol. xlvii, p. 55.

diarrhœa and hæmaturia, accompanied by great anæmia and prostration of strength. After a certain time the ova and embryos of the parasite are found in the urine. Dr. John Harley considers that the eggs often become, after the total disappearance of the hæmaturia, the nuclei of renal calculi. After death the mucous membranes affected are found studded with extravasations of blood, and more or less thickened and ulcerated.

285. Other Entozoa.—The common *fluke (Fasciola hepatica)* forms a very interesting object for examination. One species may generally be met with in the bile-ducts of the ox and sheep. The digestive and water vascular systems may be injected with different colours—the former through the oral opening in the anterior sucker, the latter through the caudal aperture of the aquiferous system.

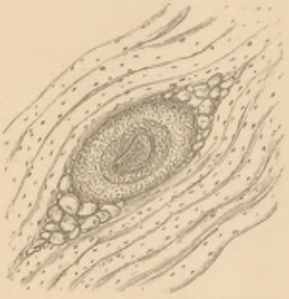
The small thread worms *oxyuris vermicularis* are common in children, and are met with chiefly in the rectum. The *tricocephalus dispar* is met with in the cœcum and colon. The *ascaris lumbricoides* or great round worm, is usually found in the small intestine.

Ova of several of the most common entozoa are represented in pl. XLIX, figs. 365 to 377. An explanation is appended to each figure.

The only other entozoon which need be alluded to here is the *Strongylus gigas*, the largest of the entozoa. This is very rarely met with in man, but is not unfrequently seen amongst animals. It is usually found in the kidney. Some years ago I met with three of these creatures, two males and a female, coiled up in what had been the kidney of a dog, but which was now reduced to a thin membranous cyst. The ureter was quite pervious, and the mucus on the surface of its mucous membrane, with that of the bladder, contained very numerous ova. For microscopical examination of the tissues of this creature, it must be dissected under water. The intestine is square, and contains altered blood. The ova form beautiful objects.

285.* Entozoon-like Bodies in the Muscles.—In the muscular fibres of the heart, and less frequently in the voluntary muscles of many of the animals killed for food, are found some peculiar living bodies which have long been known to observers, although their nature has not yet been determined. They were discovered in 1843 by Miescher in the muscles of a mouse. Hessling found them in the muscular fibres of the heart of the sheep and ox. Siebold and Bischoff demonstrated them in the rat and mouse, and they have been also found in the deer. In 1855, Rainey found and figured similar bodies from the muscles of the pig, and by him they were supposed to be the cysticercus cellulosæ in an imperfectly developed state. "On the structure and development of the Cysticercus

Fig. 362.



Trichina spiralis, with capsule. From human subject. × 40. p. 267.

Fig. 363.

Trichina spiralis. From human subject. × 215. p. 266.

Fig. 364.

Capsule containing two trichinæ. From human subject. × 130. p. 266

Fig. 365.

× 215.

Fig. 366.

× 130.

Ova of bilharzia hæmatobia, from urine. Drawn from Dr. Harley's preparations. p. 267

Fig. 368.

Distoma lanceolatum. × 370. p. 268.

Fig. 369.

Tænia mediocanellata. After Leuckart. × 37.

Fig. 370.

Tænia solium × 370. p. 268.

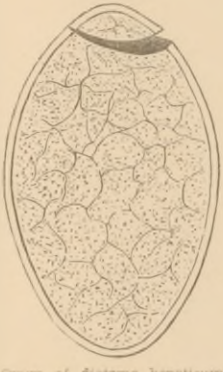
Fig. 371.

Bothriocephalus latus. × 215.

Fig. 367.

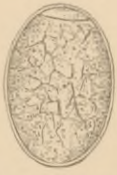
Ova of bilharzia hæmatobia in urinary deposit. Drawn from a preparation of Dr. Harley's. × 15. p. 267.

Fig. 372.



Ovum of distoma hepaticum. After Leuckart. × 370. p. 268.

Fig. 373.



Ovum of bothriocephalus latus. × 370.

Fig. 374.

Oxyuris vermicularis. × 215. p. 268.

Fig. 375.

Fig. 376.

Ova of trichocephalus dispar. After Leuckart. × 370.

Fig. 377.

Ovum of ascaris lumbricoides. After Leuckart. × 370. p. 268.

1000th of an inch ⎵ × 40.
" " ⎵ × 130.
" " ⎵ × 215.

[To face page 268.

Cellulosæ, as found in the muscles of the pig," Phil. Trans., vol. 147, p. iii, 1857. They have since been often termed Rainey's bodies. The observations of later observers have not confirmed the conclusions of the last-named writer, and although it is not known what these unquestionably parasitic bodies really are, it is not probable that they have anything to do with the cysticercus cellulosæ.

In my investigations upon the muscles of animals destroyed by the cattle plague, I found these bodies in enormous numbers. While they are ordinarily found, largely in the muscular fibres of the sheep's heart, and to a less extent in that of the ox; they are not to be detected in the best beef and mutton. On the other hand in almost every specimen of cattle plague beef which I examined, these entozoon-like bodies were present, and in many cases, in immense numbers. Moreover, the bodies found in the systemic muscles attain a size and degree of development seldom, if ever, observed in those found in the heart.

As further observations upon this subject are much required, I feel that it is desirable to call attention to it in this place. In plates L and LI, I have repeated several of my figures from my report on the Cattle Plague, 1866. The conclusions I arrived at may be summed up as follows:—

1. That in almost all, if not in all, animals dying of Cattle Plague, entozoon-like bodies exist in considerable number in the voluntary muscles of the system and in the heart.

2. They are occasionally found, but in comparatively small numbers in animals apparently in perfect health when killed.

3. These or closely allied species have been known for more than twenty years, but their nature has not yet been determined. They have been found in the ox, sheep, deer, pig, rat, mouse, and perhaps other animals.

4. In the muscles of a calf killed by Cattle Plague, under *six months* of age, these bodies were found in immense numbers.

5. They vary in length from less than the $\frac{1}{300}$th of an inch to at least a quarter of an inch in length. They are, for the most part, imbedded in the contractile material of the elementary muscular fibre, but they are occasionally found free.

6. They are for the most part spindle-shaped, and the external investment or envelope exhibits a very beautiful and peculiar structure being completely covered with delicate hair-like processes.

7. The mass within appears granular to low powers, and exhibits a division into numerous segments, but it is found to consist entirely of minute bodies resembling one another, possessing very definite characters, less than $\frac{1}{2000}$th of an inch in their longest diameter, and

of peculiar form, being oval, flattened, the body slightly curved laterally, with one extremity blunt, and the other almost pointed, pl. LI.

8. The entire mass increases in size as those small bodies increase in number, probably by division and subdivision within the cyst.

For further information upon this subject, and other drawings of the bodies in question, the reader is referred to the "Medical Times and Gazette" for 1866, the Cattle Plague Report, a paper published in the "Popular Science Review," No. 19, April, 1866, page 153, and Prof. Gamgee's work on the Cattle Plague; and for a full account of the literature of the subject, to a paper by Dr. Cobbold in the "Lancet" for January 27th, 1866.

Peculiar entozoa are occasionally met with in the systemic muscles of the frog, newt, and toad, and I think it very probable that by more careful and detailed investigation, the number of parasites inhabiting the voluntary muscles will be largely increased.

286. Examination of Entozoa.—The microscopical examination of entozoa does not usually present any great difficulty. The smaller species may be examined entire in the usual way, but the larger ones require dissection, and as the structures are often very delicate, the operation had better be performed under water, after the creature is quite dead and muscular contractility has passed off.

Many entozoa are preserved very satisfactorily in glycerine. I have some beautiful preparations of flukes mounted in this medium which have retained their characters for several years. The process of staining with carmine and preserving in strong glycerine as described in § 101, is well adapted for investigations on the entozoa. Entozoa may be mounted in preservative fluids, or dried and placed in balsam.

Vegetable Parasitic Structures.

There are many vegetable organisms of simple structure and of a low degree of organisation, which not unfrequently fall under the notice of the practitioner. Some of these are found growing upon the surface of the skin or mucous membrane in certain forms of disease, others in the recent fluid secretions, others again are developed after the secretions have left the body, but a certain number appear to originate in the very substance of the internal tissues and organs, into which the germs must have previously penetrated. All these vegetable parasites belong to the class *Cryptogamia*. A few of the most important species will be briefly referred to.

Fig. 378. Fig. 379. Fig. 380.

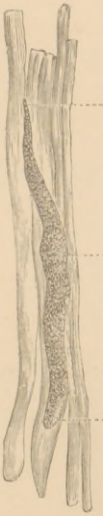
Fig. 381.

a

Worm-like bodies of different sizes. From the voluntary muscles. Cattle plague. × 25. The largest, Fig. 378, *a*, is about the eighteenth; the smallest, Fig. 381, less than the one-hundredth of an inch in length

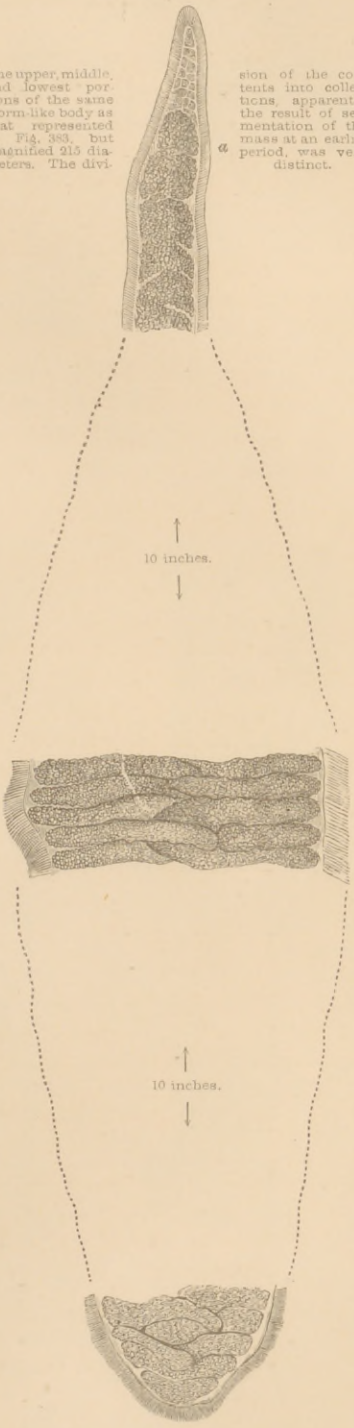
Fig. 382.

Fig. 383.



Worm-like bodies, from elementary muscular fibres from the voluntary muscles. Cattle plague. × 25. Fig. 383 is more highly magnified in Fig. 384, the portions marked *a*, *b*, *c*, being alone represented.

Fig. 384.

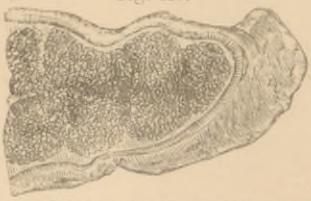


The upper, middle, and lowest portions of the same worm-like body as that represented in Fig. 383, but magnified 215 diameters. The division of the contents into collections, apparently the result of segmentation of the mass at an earlier period, was very distinct.

100th of an inch (_____) × 29.
1000th " (_____) × 215.

[To face page 270.

Fig. 385.



Lower or rounded extremity of one of the worm-like bodies, showing how closely it is surrounded by the sarcous tissue of the muscle. × 215.

Fig. 386.

Very young worm-like body in elementary muscular fibre of the leg. × 215.

Fig. 390.

Very young worm-like body, from a muscular fibre of the heart of a cow. Cattle plague. × 700. *a*. muscle nucleus.

Fig. 391.

Very young worm-like body undergoing development in an elementary muscular fibre. Heart of cow. Cattle plague. × 700.

Fig. 394.

Worm-like body from elementary muscular fibre. Showing escape of its contents through lateral pores or fissures. × 130.

Fig. 392.

Portion of young worm-like body embedded in elementary muscular fibre, which has been broken transversely. × 215.

Fig. 395.

Portion of upper extremity of one of the worm-like bodies, embedded in muscular fibre, showing the fissure, *a*, by which it gained access to the interior of the fibre at an early period of its development. *b*. muscle nuclei. × 215.

Fig. 387.

Cilia-like processes, covering the whole surface of the external investment of the worm-like body. × 1000.

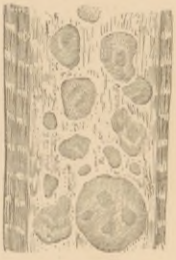
Fig. 388.

a. portion of membrane with hair-like processes distended with fluid and subjected to strong pressure.
b. two of the small bodies in their fully developed state, from the interior of a very long worm-like cyst.
× 1800.

Fig. 389.

Cilia-like processes, covering whole surface of envelope of worm-like body. × 700.

Fig. 393.



a

Tubular space in the central part of an elementary muscular fibre, extending from one extremity of a young worm-like body, showing an early stage of development of the bodies found within the envelope. × 2800. I regard the particles marked *a* as a young stage of the bodies represented in Fig. 388 at *b*.

Fig. 396.

Portion of one of the worm-like bodies, ruptured, showing structure of wall and escape of little bodies from its interior *a*. muscular tissue, in which it is embedded × 700.

1000th of an inch ⌊⌋ × 130.
" " ⌊⌋ × 215.
" " ⌊⌋ × 700.

287. Sarcina Ventriculi* or Merismopœdia Ventriculi.—This alga (?) was originally discovered by Goodsir, in 1842, among the matters vomited by a patient. Since this period it has been found by a great many observers, and indeed, may now be looked upon as by no means uncommon. The sarcina is represented in pl. XXXII, fig. 242, and in pl. LII, figs. 397, 398.

The vomited matters in which it occurs, have usually, but not invariably, very much the appearance of yeast, and fermentation proceeds for some time after they have been ejected. In vomit presenting these characters, the sarcinæ are, I believe, never absent; but they have been found in other cases and in other situations: by Lebert, in a case of cancer, accompanied with black vomiting; and by myself in a case in which there was a very abundant ejection of coffee-ground vomit for a few days before death. In this vomit the sarcinæ were very abundant, but there was no fermentation. The most minute sarcinæ I have ever seen are represented in fig. 398.

The sarcina has been found in the urine, three times by Heller, once by Dr. Mackay, of Edinburgh, twice by Dr. Johnson, and twice by myself.† It has also been detected in the urine by Welcher, Johnston, and Begbie. In the fæces it has been met with frequently by Bennett and Hasse; it was observed by Virchow in an abscess of the lung, and once by Dr. Jenner in the fluid of the ventricles of the brain. Zencker found sarcinæ in cavities of a lung affected with enceplaloid disease, and also in the stomach of the same patient. He considers that it was drawn into the lung after vomiting (Henle's Zeitschrift, Band ii, Heft I). Sarcinæ have been detected in the fluid of hydrocele by Dr. Lowe, Edin. Med. Phil. Mag. N. S., July 1840; in gangrenous intestines by Demme; in cholera stools by Wedl, Mic. Journal, vol. viii, p. 163; in stagnant water by Dr. Lowe, Gardener's Chronicle, 1857; in Tinea tonsurans by Tilbury Fox; in the stomach of a rabbit by Virchow, and in that of an ape by Eberth, who also found sarcina in the cœcum of a fowl and in a tortoise.

Schlossberger considered that the sarcina was only disintegrated muscular fibre. A moderately good glass, however, will convince any one that its structure is very different from that of muscle. Dr. John Lowe agrees with Mr. Berkeley in the opinion that the sarcina is only a peculiar form of a very common microscopic fungus. Dr. Brinton and Dr. Tilbury Fox regard the sarcina as a modification of

* M. Robin has arranged it under the genus Merismopœdia (Meyen), and he calls it Merismopœdia ventriculi.

† For the opportunity of observing the sarcina in one of these cases, I have to thank my friend Mr. Brown, of Lichfield.

Penicillium, and therefore an ordinary mould. Dr. Brinton states that he has seen the development of the penicillium from masses of sarcina, but as spores of the latter fungus are commonly present amongst the sarcinæ, it seems possible that the penicillium might have been developed from these. I cannot agree with this view of the nature of the sarcina, and I think that the evidence advanced in its favour is at present far from convincing.

Various plans of treatment have been employed to prevent the development of sarcinæ, but hitherto with very imperfect success. Hyposulphite of soda has been found advantageous in some cases, but the disease was not cured. Great relief to the burning sensation which frequently occurs in these cases, is experienced by the use of large doses of common salt. Several cases of this disease, with remarks, will be found in the clinical lectures of Dr. Todd.* In all those which have come under my own observation, the matter in which the sarcina was present was acid, although in several instances, in consequence of the ejection of much clear fluid (pyrosis), the vomit generally, had an alkaline reaction. But in these cases, the brown flocculi which contained the sarcinæ were intensely acid. The sarcina is generally, but not invariably, accompanied by a great number of oval torulæ, which vary considerably in size and form in different cases, pl. XXXII, fig. 242, pl. LII, figs. 397, 398. These torulæ were not present in the specimens of urine which contained the sarcinæ.

By the action of acids and alkalies the sarcina becomes paler, but is not destroyed by these reagents even if warm. The cells, however, exhibit a tendency to separate from each other in a quadruplicate manner. Iodine communicates a slightly brown colour to it. It is not destroyed by the decomposition of the vomited matters in which it was developed; but in one case, in which it was present in the urine, the cells were completely broken down, and all traces of them lost, as the fluid decomposed and became alkaline. The development of the sarcina has been investigated by Frerichs in a dog with a fistula in his stomach. See also a paper "On Sarcina Ventriculi," by Dr. John Lowe, Edinburgh Philosophical Journal, new series, July, 1860.

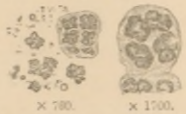
288. Other Forms of Algæ (?) are found in different situations; for instance, in the cavity of the mouth, especially towards the back of the tongue mixed with, and adhering to, or growing from, the cells of epithelium, will be seen, with a power of 200 or higher, a vast number of little hair-like bodies, which consist of filaments of a very minute alga

* "Medical Times and Gazette," May 2nd, 1851.

Fig. 397.

Sarcinæ ventriculi, ordinary size, from vomit. *a*, sarcinæ. *b*, starch granules partially dissolved and rendered translucent. *c*, minute oval fungi usually present in vomit containing sarcinæ. *d*, vibriones. *e*, oil globules. *f*, starch globule from bread, cracked but not as yet softened. × 215.

Fig. 398.



× 700. × 1500.

Sarcinæ, from vomit. 'Archives,' vol. II., p. 286.

Fig. 399.

Leptothrix buccalis, from the back of the tongue and tartar of the teeth. *a*, epithelial cells, upon and in which the fungus is growing. *b*, collection of fungi. × 400.

Fig. 401.

Yeast fungus from urine, covered with minute crystals of oxalate of lime. × 700.

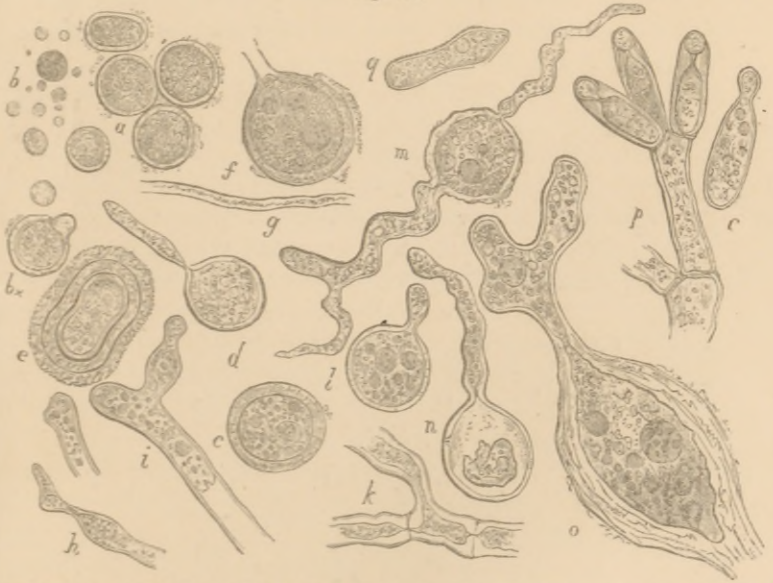
Fig. 400.

Penicillium glaucum. × 215.

Fig. 402.

Penicillium glaucum. × 215.

Fig. 403.



Various stages of growth of ordinary mildew. *a*, aerial spores. *b*, smallest germinal particles within these. *b*×, a spore bursting, germinal matter escaping. *c*, a spore enlarged by growth. *d*, a spore sprouting. *e* an old spore the formed material of which has much increased. The remaining figures show the mode of growth of the mycelium, and the fructification of the fungus, *p*, *q*, *r*. p. 152. (1859.)

1000th of an Inch ⌊⌋ × 215.

" " ⌊_____⌋ × 700.

" " ⌊_____⌋ × 1800.

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(*Leptothrix buccalis*). The filaments grow upon any small particles of food which may remain entangled in the epithelium of the mouth. The papillæ at the back of the tongue are thickly covered with very long filaments, consisting almost entirely of this alga, pl. LII, fig. 399; it is very abundant between the teeth, and the so-called tartar is partly composed of it. The old epithelial cells upon the tongue and buccal mucous membrane are invaded by numerous sporules, which give to them a granular appearance under low magnifying powers, but by the aid of the $\frac{1}{12}$ and the $\frac{1}{25}$ the nature of the particles is readily determined. The bacteria, met with in urine and other fluids, are probably closely allied to this vegetable growth.

Similar vegetable organisms have been found in the stomach, intestines, and fæces, and in the discharge from wounds. One species occurs in the mucus of the uterus. Helmbrecht and Hannover have described minute vegetable growths in the humours of the eye.* Dr. Arthur Farre has described an alga which was passed from the intestinal canal of the genus Oscillaria.†

Dr. Tilbury Fox believes that the leptothrix and the *algal* forms of cryptogams found upon the mucus surface, are nothing more or less than modified phases of Oïdium; 'Leptothrix' being often seen in watching the development of the 'nuclei' of the torula cells.

Growths of leptothrix (?) mixed with oïdium albicans have been found in six cases on the mucous membrane of the female genital organs by Dr. Mayer, forming small, bright, yellow-coloured patches on a congested base, which leave slight ulcers when removed. They occasion inflammation and mucous or creamy discharge. Dr. Mayer calls the disease vaginal mycosis. The fungi are always associated with more or less severe inflammation of the mucous membrane. As soon as the germs had taken root intense itching of the vulva and vagina was produced, which was relieved when the fungi were removed.‡

Many of these lower vegetable organisms require for their examination very high powers, and it is necessary to place only a small portion under the thin glass. Glycerine is a very favourable medium for the examination of fungi. The glass cover should be as thin as possible, for often their characters are not very clearly made out, unless a twelfth or sixteenth object-glass be employed. Sarcinæ may

* Quoted in Küchenmeister's "Animal and Vegetable Parasites," translated for the Sydendam Society, by Dr. Lankester, vol. ii, page 135.

† "Transactions of Microscopical Society," vol. i, page 92, old series.

‡ Dr. L. Mayer "On the Vegetable Parasites of the female genital organs in relation to practice," Monatsch. f. Geburtsk., July 1862, quoted in British and For. Med. Chir. Rev., Oct. 1862, p. 551.

be removed with a pipette from fluids in which they subside as a deposit, or, in cases where the mass is very viscid, with the handle of a knife. If necessary, a little water may be added, and the whole covered with thin glass, which often requires to be pressed down firmly, in order to obtain a sufficiently thin stratum for examination.

To examine the so-called algæ from the mouth, it is only necessary to scrape the upper surface of the tongue, and place the epithelium and débris removed in the usual way, upon a glass slide moistened with a little water, but if it is desired to make a very minute examination of the structures, or to study the changes occurring during development under the highest power, the specimen should be well soaked in glycerine, the strength of which should be gradually increased.

289. Penicillium Glaucum.—Figs. 400 to 404, pl. LII, show the general characters of this fungus, which is often developed in acid urine. It is also found in vomit, in the contents of the intestinal canal in certain cases, and in other situations. Several fungi which have been regarded as distinct species, are probably only modified forms of the yeast fungus and penicillium.

290. The Achorion Schœnleinii usually appears as elongated vesicles, of a more or less oval form (figs. 410, 411), many of them being rather irregular and varying much in size, but often joined end to end so as to form branches. This fungus grows in the hair follicle, and is also found in abundance amongst the epithelium in the neighbourhood. It may frequently be seen within the hair in considerable quantity, fig. 412, pl. LIV, and may be found in abundance in the little honeycomb-like masses, termed favus crusts. The *favus* consists of a little cavity filled with spores of the fungus, granules, and epithelial cells, pl. LVI, fig. 423. One or two hairs usually pass through the centre of the favus. The fungus is composed of the *mycelium* (*a*), or the proper substance of the plant; of a *receptacle* (*b*), or *sporangium*, which contains the reproductive organs; and the reproductive organs themselves, or the *spores*.

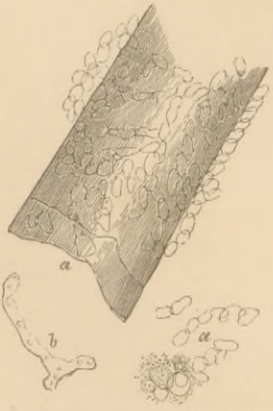
This fungus occurs in *Tinea favosa*, *Porrigo favosa*, *scutulata*, &c. The favus may be placed upon a glass slide, moistened with water, and subjected to microscopical examination. When the hair is to be examined, the same course is pursued, but it will often be found advantageous to treat it with a drop of solution of potash, which renders the hair more transparent, and the fungus more distinct. I have preserved excellent specimens of this fungus in glycerine for a year, and there is every probability of their keeping permanently.

291. Trycophyton Tonsurans.—This fungus is found in the form

Fig. 404.

Achorion Schœnleinii, from the same specimen as Fig. 405. × 403.

Fig. 405.



Achorion Schœnleinii, after Robin. *a*, mycelium. *b*, receptacle containing spores.

Fig. 406.

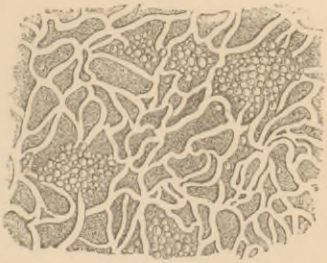
X130

Achorion Schœnleinii in various stages of growth, from the crusts of a very bad case of Porrigo favosa. The boy's scalp was completely covered. It had been entirely neglected, and was of eleven years' duration. The hair was everywhere brittle, and its fibres readily separated from each other. *a*, hair broken near the root. *b*, extremity showing separated fibres. *c*, altered cells of squamous epithelium from the skin. *d*, sporules of the fungus, forming a dense collection. *e*, sporules and thalli of fungus separate. × 130

Fig. 407.

Root of hair invaded by the spores of trichophyton (tinea) tonsurans. After Tilbury Fox.

Fig. 408.



Microsporon furfurans, or fungus of tinea versicolor (chloasma). After Tilbury Fox.

[To face page 374.

of very minute oval or rounded, and perfectly transparent cells, *within* the bulb, and in the central canal of the hair. Its presence depends upon the hair having been broken, and the escape of the contents. It is always developed in the root of the hair. Dr. Tilbury Fox has recently shown that the earliest trace of this fungus is found at the upper part of the hair follicle. By the aid of the microscope he has detected the germs travelling towards and entering the root. It is carried onwards by the subsequent growth of the hair, and by its rapid increase, the structure of the hair is much altered; the hair becomes dry and brittle, its fibres are split up by the growing fungus, which subsequently invades the whole of the shaft, the root, the epithelial lining, and the follicle itself, pl. LIII, fig. 407.

Trichophyton Sporuloides is the fungus of *plica polonica*, and closely resembles trychophyton tonsurans. It is probably a modified form of the same fungus.

Microsporon Mentagrophytes is very like trychophyton tonsurans. It is said to surround the hair within the follicle, and not to appear in the substance of the hair or outside the follicle. Dr. Tilbury Fox has, however, proved that it sometimes invades the structure of the hair, and also attacks the extra follicular part of the shaft.

Microsporon Audouini is the fungus found in *porrigo decalvans*, and is characterised principally by the small size of its spores, by the mycelium containing no granules in its interior, and by forming a tube round the hair *outside* the follicle.

Microsporon Furfur. That condition of the skin termed *pytyriasis versicolor* depends upon the middle portion of the epidermis in the coloured situations being infested with the spores and mycelium of the *microsporon furfur*, fig. 408. Cases have occurred where a previously healthy individual has been infected with the disease after having slept with a person suffering from this affliction. The mycelium is wavy and branched, and the spores form characteristic groups, as in the case of the oïdium. Indeed, Dr. Tilbury Fox has adduced evidence to show that pityriasis versicolor may be produced by implantation of the oïdium.

Puccinia Favi is found in *tinea favosa*, *tinea tarsi*, *pityriasis versicolor*, and *acne.* It is of reddish brown colour, and consists of a body and stalk. The body is composed of two somewhat conical cells articulated to each other by their bases. The stalk joins the apex of the lower cell and the apex of the upper cell is rounded off. The stalk is flat and sometimes appears twisted. The cells may contain sporules. Dr. Tilbury Fox denies that any true puccinia occurs on the human body. Puccinia is a late stage of the ordinary uredo. That which has been called puccinia in the human subject is

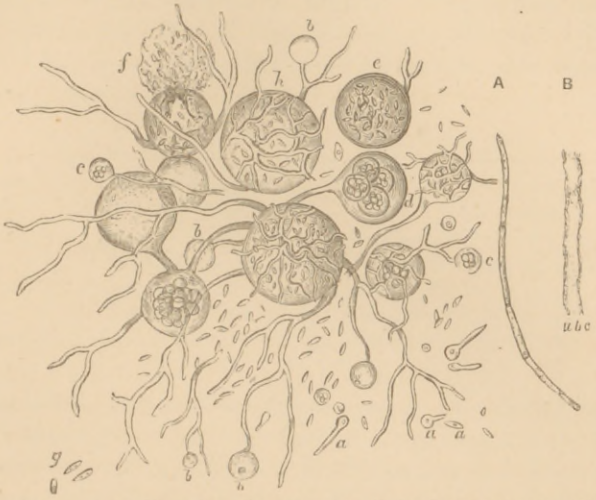
nothing more than a clavate terminal mycelial thread, jointed after the manner of the true puccinia, but in reality a form of penicillium. See pl. LIV, fig. 410.

292. Chionyphe Carteri—is the fungus discovered by Dr. H. V. Carter in the fungous foot disease of India. According to Dr. Carter, there appear to be three principal varieties of the disease and two principal varieties of the fungi. In the first variety the fungus occurs in globular masses, sometimes as large as a pistol bullet, black externally, brown within, and having a radiated appearance on section. The radiated fibres end in globular expansions, rendering the exterior surface tuberculated, and consist of cellular threads, branching and anastomosing. Interspersed here and there are a few granules and large oval cells placed end to end. The globular expansions are composed of fibres formed of large oval cells, united at their ends with oval nucleated spores, situated between the fibres here and there. These globular expansions often become detached, and occur as small granular masses. In the second variety the fungus is always in the form of small particles. These may be light coloured and composed of threads formed of round or oval cells, mixed with granular matter, granular cells, and oil globules, or they may be red or pink grains visible to the naked eye, made up of minute beaded fibres or nuclei, sometimes single and then oval in form, sometimes double, triple, or quadruple, and then angular. The fungus particles may also consist of light brownish granules, made up of minute bodies, each of which has a crystalline fatty envelope, or of similar granules, whose structure is that of the black fungus.

Dr. Carter's drawing has been copied in pl. LIV, fig. 409, reduced to one-fourth the size. The drawing represents a specimen of the *red fungus*, which grows on the surface of the fluid covering the portions of a foot affected with the "Black Fungus,"—magnified to show its development from the germinating sporidia *a*, *a*, *a*, to the formation and bursting of the spore *f*.

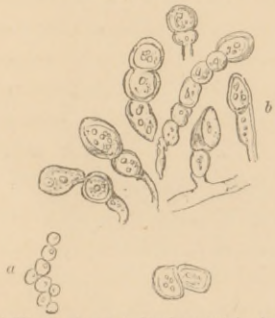
a, *a*, *a*, *a*, germinating sporidia; *b*, *b*, *b*, commencement of spore-cells containing nucleus; *c*, nucleus and contents of spore, cell further advanced; *d*, apparent quadruplication of contents of spore-cell, with further sub-duplication of their interior; *e*, spore and sporidia formed; *f*, spore bursting; *g*, sporidia more highly magnified, to show shape and nucleus; *h*, spore embraced by a condensation of small filaments—very common if not constant. In fig. 409, under A, a filament is represented which is composed of cells with a nucleus at one end of each, and under B, is represented the 'felt-like' form of the layer of red fungus as it grows in the bottle; *a*, filamentous layer; *b*, layer of spores; *c*, filamentous layer below.

Fig. 409.



Chionyphe Carteri, after Dr. Carter. The description of this figure is given on page 276. × about 200 (reduced from large drawing).

Fig. 410.



Penicillium, showing development in form of TORULA, *a*; and in that of PUCCINIA, *b*. After Tilbury Fox.

Fig. 411.

Mycelial form of fungus. Tinea circinata (herpes circinatus). After Tilbury Fox.

Fig. 412.

Fungus formed in tinea tarsi. After Tilbury Fox.

Fig. 413.

Oidium albicans. After Robin.

1000th of an inch ⌊——⌋ × 250.

[To face page 276.

Dr. Tilbury Fox has proposed the adoption of the generic term *tinea* to designate the group of vegetable parasitic diseases. The diseases, with their characteristic fungi, according to this view, would be arranged as follows :—

Tinea favosa.	Syn.	Favus.	Fungus	Achorion Schönleinii.
Tinea tonsurans.	,,	Herpes tonsurans.	,,	Trichophyton tonsurans.
Tinea circinata.	,,	Herpes circinatus.	,,	Trichophyton tonsurans.
Tinea decalvans.	,,	Area.	,,	Microsporon Audouini.
Tinea sycosis.	,,	Mentagra.	,,	Microsporon mentagrophytes.
Tinea versicolor.	,,	Chloasma.	,,	Microsporon furfur.
Tinea tarsi.	,,	Ophthalmia tarsi.	,,	Trichophyton tonsurans.
Tinea Polonica.	,,	Plica Polonica.	,,	Trichophyton sporuloides.

Dr. Fox affirms that nothing but the growth of a fungus can produce the alterations of the hairs observed in the *tineæ*, and this is their *pathognomonic* lesion. It varies in degree, but is present in every instance of fully developed disease of the skin in which vegetable parasites are present; in the least degree in *chloasma*, for here the hairs are really unimportant, and the fungus chiefly attacks the epithelium. Dr. Fox has performed a good many experiments with diseased hairs out of the body, and states that he has succeeded in getting a hair containing spores which germinated and actually produced the splitting up of the hair, and other changes that are observed in ringworm, in fact *he produced "the lesion of ringworm out of the body."*

Early stage of Fungus in Tineæ.—Many observers state that the earliest trace of disease in tinea is to be observed just within the orifice of the hair follicle in an increase of the nuclei of the epithelial cells, but according to Dr. Fox's observations, this minute nuclear material is really the stroma or earliest condition of the parasite, a stage which has been overlooked by most observers. It is best seen in favus. Hence the presence of the nuclear phase of a fungus is to be regarded as grave in a prognostic sense, for a patient cannot be pronounced cured until all the minute particles are destroyed or removed, although none of the more ordinary elements of the fungus may be discovered by ordinary microscopical observations.

293. Oidium: Aphthæ: Muguet.—The aphthæ which occur upon the mucous membrane of the mouth and pharynx of ill-nourished infants, and the whitish matter resembling false membrane, which is sometimes found in the same situations in adults, who have long suffered from exhausting diseases, and to which the term *muguet* has been applied, are composed of a vegetable fungus, which was first described in 1842, by Gruby, and has been spoken of by him under

the names of *aphthaphyte* and *cryptogames du muguet*. It is placed under the genus Oïdium, and termed *Oidium albicans* by Robin.* The appearance of this fungus is shown in figs. 413, 422, pls. LIV and LVI. It is also found in vomited matters.

294. Diptheria has been considered by some observers to be intimately connected with the development of a vegetable growth, and thus its contagious character has been accounted for. Where, however, the fungus is found, its presence is probably explained by the view that the false membrane is a nidus very favourable to its development. At any rate it is quite certain that in many cases of diptheria, among which may be reckoned those which came under my own notice, there is no vegetable growth to be detected in the false membrane removed from the fauces.† The microscopical characters of the false membrane are described in page 187.

295. Fungus found in the External Meatus of the Ear. Aspergillus?—The vegetable growth represented in pl. LVI, fig. 420, was removed by Dr. Grove from the external meatus of a gentleman in good health, who has been suffering from inflammation of the canal. The specimen was given by Mr. Deane to Dr. Sturt, who kindly allowed me to have the accompanying drawing of it made.‡ A case in which a fungus, of the same kind in all probability, was found in the external meatus of a girl, aged eight, is given by Mayer. She was a scrofulous child, suffering from discharge from the ear. Many filaments contained a receptacle filled with spores.§ Link considers this fungus to be a species of Aspergillus, and Robin places it in the same genus.‖ A species of Aspergillus has been detected in the human lung by Prof. Dr. Carlos May Figueira, of the Medical School of Lisbon, ("Jornal da Sociedade das Sciencias Medicas de Lisboa," No. 10, Outubro de 1862).

296. Other Forms of Fungi.—Low forms of cryptogamia have also been found in the lung by Professor Bennett, and have been noticed in the stools by him and other observers. Meissner describes a fungus which he found amongst the cells of the nails of an octoge-

* "Histoire Naturelle des Végétaux Parasites qui croissent sur l'homme, et sur les Animaux vivants," Paris, 1853. See also a review of this work, by Dr. Parkes, in the "British and Foreign Medico-Chirurgical Review," October, 1853.

† In one case there were some algæ, but it was afterwards proved satisfactorily that these had been introduced after the removal of the false membrane from the patient's mouth.

‡ The case, accompanied with a drawing, is given in the "Transactions of the Microscopical Society," new series, vol. v, page 161.

§ Müller's "Archiv," 1844, page 404.

‖ "Histoire Naturelle des Végétaux Parasites," par Ch. Robin, 1853.

narian. The nail was rendered transparent by caustic soda. It was permeated in every part by the fungus. Fungi have been found in glandered lungs; on the pleura (Roger and Gardner); in the expectoration of phthisis (Remak); and in the kidney by Tonge and Powell, pl. LVI, fig. 427.

There is also a group—*Leptomitus*, whose "characteristic feature is an enlarged ovoid cell, mostly terminal with a little projecting joint at the apex, and containing more or less nuclei—the whole resembling a club very much" (Fox). The following varieties have been found, *L. urophilus* in the urine; *L. Hannoveri* in the œsophagus and stomach; in typhus by Robin; in bronchitis by Fuchs. *L. uteri*, called by Dr. Wilkinson, Lancet, 1849, p. 449 *Lorum uteri*, in consequence of the supposed breaking up of the terminal cell into several threads, so as to resemble a rash, and another form has been detected by Gubler in the epidermis in a case of gun-shot wound of the arm. Dr. Tilbury Fox has clearly shown that all the forms of Leptomitus are forms of oïdium. The terminal and aerial filaments bearing the oïdial, and the basal the leptomitus character, see pl. LV. The Lorum uteri is nothing more nor less than a free branching or budding out from the large ovoid cell of the ordinary Leptomitus.

297. Of the Mode in which Fungi Gain Entrance into the System of Living Beings.—Vegetable organisms found even in the substance of the inmost tissues result from the development of germs introduced from without. Since we know that the germs of many entozoa make their way very readily through the tissues of the organism, there is no difficulty in explaining how bodies so very much smaller than these as the germs of the fungi are introduced. These germs have the power of insinuating themselves through the firmest tissue and multiply in number as they make their way through. The appearance of some of the most minute living particles of simple fungi are represented in pl. LVI, fig. 424, but there is reason to think that they possess individual powers of growth and multiplication long before they have grown large enough for us to see them even with the aid of the highest magnifying powers we possess.

Dr. Fox enumerates the modes of invasion as follows: "(1), Through natural orifices; (2), That in which the growing force forces the mycelial thread beneath the layers of the superficial tissues; (3), That in which processes shoot out from the spore and enter by openings such as stomata in plants; (4), That where the cells' contents alone are absorbed; (5), That in which the spores are carried bodily inwards by growing parts; or, (6), Dissolve away the opposing structures by chemical action (as in the hard shells of molluscs); or, (7), Enter by traumatic lesions as in the case of the fungus fort of India.

EXPLANATION OF PLATE LIII.

This plate kindly furnished by Dr. Tilbury Fox, illustrates the views he has been led to form concerning the nature and relationship to each other of many of the fungi occurring in various skin diseases, or developed under different conditions. For fuller information the reader is referred to his work 'On Skin Diseases of Parasitic Origin.'

Fig. 414. Oïdium Albicans.

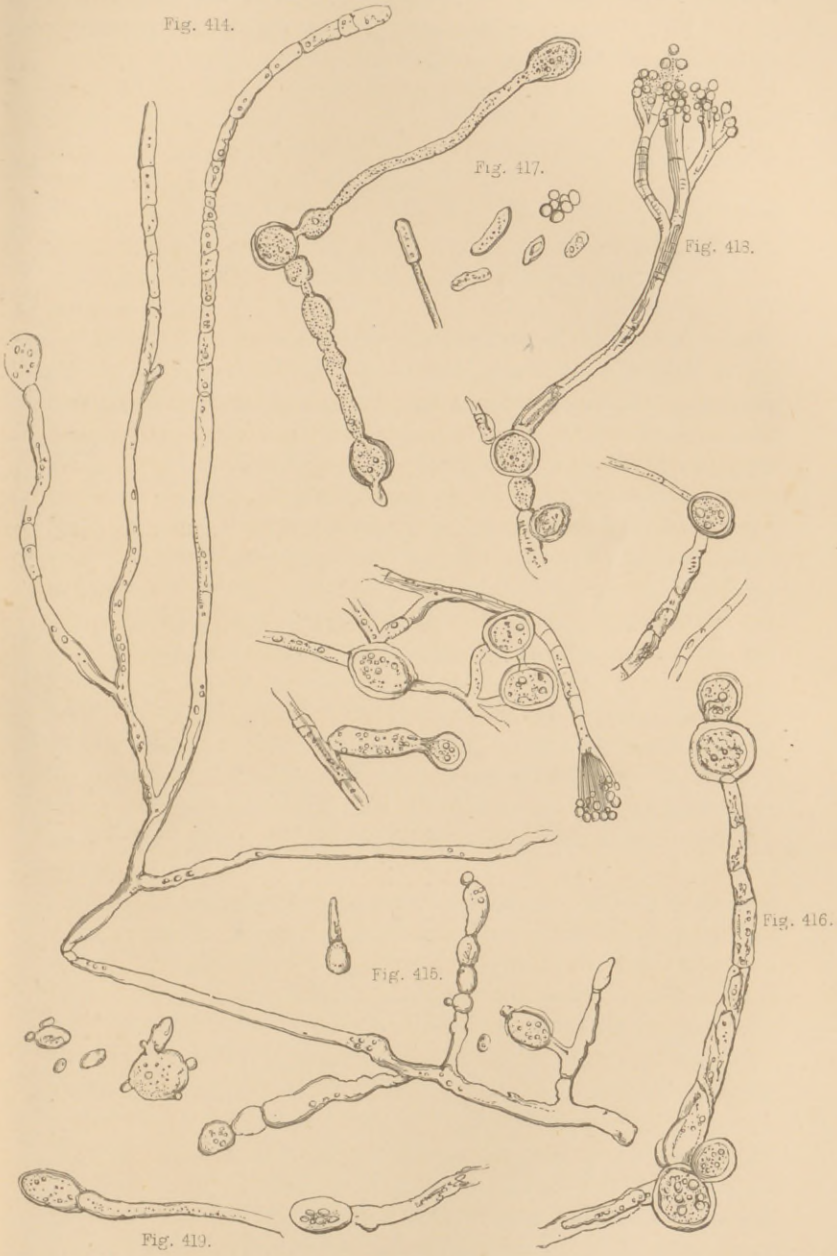
Fig. 415. Leptomitus.

Fig. 416. Leptomitus from the germination of a torula.

Fig. 417. Other changes of torula.

Fig. 418. Penicillium, showing the sacculi in the mycelicum.

Fig. 419. Oïdial threads from torula.



[To face page 260.

In each and every instance the germs of the parasites are derived *ab externo*, and not generated spontaneously."

Even the vegetable nature of fungi has been called in question by some, but it would be absurd to reply to those who entertain such utterly untenable opinions. Any one who knows how to use a microscope can convince himself of the truth of the statements in the text upon this matter without any difficulty.

The part played by fungi in the production of disease has been much disputed. Some regard their presence as merely accidental, others consider them the sole cause of the diseases with which they are associated.

There can be no doubt that a certain state of the tissues is necessary for the free growth of fungi. Young and actively growing tissues resist their invasion, while old textures are often attacked and partially destroyed by them. Any conditions which favour the production of an unusualy soft formed material, probably favour the development of fungi. If the formed material be produced very quickly, it is more likely to be attacked than if it is very slowly formed. This is well seen in the higher vegetable tissues. The weak and sickly plant succumbs to fungi while the strong and vigorous one remains untouched, although equally exposed to attack. The wood of the elms in and near London is rendered rotten and useless by the invasion of microscopic fungi, and this is probably to be explained by the conditions to which the plant has been exposed during its growth, and which were not favourable to the production of firm ligneous tissue. Practitioners are well aware that weak, ill-fed scrofulous children often suffer from parasitic diseases, which strong and healthy ones, although placed under precisely the same conditions, escape.

298. Examination of Vegetable Growths.—The examination of these vegetable growths in the microscope presents no difficulty; but without care they may readily be passed over unobserved, as their structure is very delicate, and they are generally accompanied with epithelial cells and much débris. A very small piece only should submitted to examination, and should be moistened with a little water, glycerine, or dilute syrup. They may be seen with a power of 200; but to bring out their characters clearly, a power of from 500 to 800 is required. All may be preserved in glycerine. The method of preparation described in § 101, is of great value in the investigation of the structure and mode of growth of the various forms of fungi, but, owing probably to the difficulty of destroying their life without completely altering their appearance, staining with carmine is difficult. They should be kept for some

time at a temperature above 100 while immersed in weak glycerine, before they are placed in the carmine fluid. Like other tissues, most of them may be well preserved in strong glycerine, to which a little free acetic acid has been added.

On the subjects discussed in chapter VII, the following works may be consulted :—

George Nayler, "A Treatise on diseases of the Skin." Cobbold, "On Entozoa," also "On Tape-worms." Dr. Althaus, "Trichina Disease." Robin, "Histoire Naturelle des Végétaux Parasites," Paris, 1853. Wedl's "Elements of Pathological Histology," translated for the Sydenham Society, by Professor Busk. Cazenave, "Annales des Maladies de la Peau et de la Spyhiles." Bazin, "Recherches sur la Nature et le Traitement des Teignes," Paris, 1855. Bennett, "Transactions of the Royal Society," Edinburgh, 1842, vol. xv, and "Lectures on Clinical Medicine," 1858. Gruby, "Comptes Rend.," 1843–44. Rayer, "Traité des Maladies de la Peau," Paris, 1835. Papers in the "Transactions of the Microscopical Society." Küchenmeister's "Manuel of Animal and Vegetable Parasites," translated for the Sydenham Society, by Dr. Lankester. Tilbury Fox "Skin Diseases of Parasitic Origin, including the history and relations of the fungi formed in man." Hillier, "Handbook of Skin Diseases." Dr. McCall Anderson, "The Parasitic Affections of the Skin." Dr. Squire, "Atlas of Skin Diseases."

Fig. 420.

Fungi (aspergillus ?) From the external ear. × 215.

Fig. 421.

Fungus (mycelial form) among epithelial scales. Tinea circinata. After Tilbury Fox.

Fig. 422.

Fungi in various stages of growth expectorated by a patient in the last stage of phthisis. × 215.

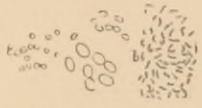
Fig. 423.

Portion of a favus crust, with Achorion Schœnleinii. *a*, mycelium, *b*, receptacle. *c*, spores.

Fig. 424.

The most minute germs of fungi visible under a $\frac{1}{50}$ of an inch object-glass. The smallest is less than $\frac{1}{100000}$ of an inch in diameter.

Fig. 425.



Sporules of fungi and bacteria. × 215.

Fig. 426.

Fungi found in the tissue at the apex of the pyramids of the kidney. After Dr. Tonge. × 215.

Fig. 428.

Blood from a case of leucocythemia, showing a great number of white blood corpuscles. (Omitted from Plate XXIX.)

Fig. 427.

Fungi from the kidney. × 700. After Dr. Tonge.

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SUGGESTIONS FOR TAKING CASES, AND FOR MAKING POST-MORTEM EXAMINATIONS.

For Taking Cases.

It has been thought that it might add to the usefulness of this work, especially to those studying in the wards of hospitals, if some practical suggestions for taking cases and making post mortem examinations were appended. The matter has been condensed into the smallest space consistent with clearness, and reference has only been made to the most important points which should engage attention. It is obvious that such a scheme must be very defective in many ways, but it is hoped that it may help to diminish the difficulties of reporting cases, and remind the reporter of some of the principal points to be inquired into, while he is actually at the patient's bed-side.*

The order I have adopted is the one followed in my own clinical teaching, but it may easily be modified, if thought desirable. Throughout I have endeavoured to make the arrangement simple, and to place the subjects of inquiry in order. I have, however, in a great measure sacrificed theoretical classification to practical convenience.

The questions to the patient should be simple and precise. The facts ascertained should be expressed in as few words as possible, consistent with perfect clearness. No indefinite terms should be employed. The patient should always be made to place his hand over the part which he considers to be the seat of his malady.

Long descriptions of the precise locality of the affection may often be avoided, by the use of the blank forms appended, plates LVII, LVIII. Increased dullness, and various physical signs can be indicated on the forms by different kinds of shading, or by lines of different colours. The meaning of these may be explained by references in the margin.

The case book may be large (8 inches × 13) or small (6 inches × 8), but in all cases a margin of at least an inch and a half should be left on the left side of the page, and it is better to write on one side only.

* The student will also find 'Hints for Clinical Clerks in Medical Cases,' of great use to him. Churchill & Sons, price 1*s*.

I. TO BE NOTED IN EVERY CASE.

Date and Time of the observation.

Name, Age, Address, Occupation, Married or Single, Children, Miscarriages, Date of Birth of last child.

Locality, Drainage, Water, Smells, &c.

Height, Weight,* General Nutrition, Muscularity.

Quantity and Nature of Food, Amount and Kind of Stimulants taken, Well or Badly Clothed.

II. PRELIMINARY ENQUIRIES.

What is the Matter? Where does the Patient Suffer?†

General Health, Previous Illnesses, How Treated.

Was the patient well immediately before the present attack *(acute affection)* or had he been ailing for some time previously *(chronic affection)?*

Description of present Attack.

III. FACTS ELICITED BY OBSERVATION.

Face, Complexion, Expression, Colour, Puffiness, State of Eyes, Pupils, Lips, Sighing, Yawning. **Surface Generally:** cold, hot, dry, moist. **Mouth:** odour of breath, gums, blue or red line, teeth, throat, &c. **Voice and Speech:** thick, hoarse, difficulty of articulation, cough. **Manner:** intelligent, excited, dull, drowsy. Posture, in and out of bed. **Temperature‡** in axilla. Alterations of colour and texture. Eruptions. **Limbs:** peculiarities of form. Staggering gait. Spasmodic twitching, or jerking movements. **Swelling:** local or general. Fluid or air in areolar tissue, in viscera, or cavities; circumscribed collections of fluid. Thickening. New growths, &c., painful or not.

Pain, Uneasiness, or Discomfort: local or general, its precise situation and character. **Pain** *produced by pressure or by certain movements.*

* Excellent weighing machines may be obtained for £3 15*s.*, of Messrs. Pooley, Fleet Street, London.

† These questions will sometimes enable the observer to ascertain the nature of the case at once. He will not write down the answers he receives, but the nature of his subsequent enquiries will be much influenced by the replies.

‡ Excellent Thermometers may be obtained of Mr. Casella, 23, Hatton Garden, E.C. The temperature should be taken at least twice a day. Mr. Casella has lately made for me a thermometer so curved that it can be easily retained in the axilla without being held. The physician should be provided with blank forms in which the temperature can be entered without any loss of time.

Nausea, Vomiting, Rigors.

State of Intellect and Nervous System, Memory, Giddiness, Headache, Restlessness, Delirium, Impaired or Lost Sensation (see p. 291, for method of estimating tactile sensibility), **Paralysis, Convulsions.** Sensations of cold or heat, tingling, numbness, &c.; alterations in **Sight, Hearing, Smell, Taste, Touch.**

Appetite. Thirst. State of Tongue. Discomfort after Food.

Pulse, Respiration: their frequency and character.

Examination by Measurement, Percussion, Palpation, Auscultation of Thorax, *Lungs, cavities of Pleura and Pericardium, Heart and large vessels;* **Abdomen,** *Liver, Stomach, Spleen, Colon, Bladder, &c.* Alterations in form or movements of the walls of these cavaties.

Secretions and Discharges: *general characters.* Results of **Microscopical and Chemical** examination.

The blood.

Surface generally: sweat, sebaceous matter, cuticle.

Eyes: state of conjunctiva, canaliculi.

Ears: secretion in external meatus.

Nose: odour of breath, character of discharges.

Mouth: saliva, fur from the tongue, sputum, vomit.

Bowels: frequency and nature of discharge; quantity.

Urine: frequency of micturition; accompanied with pain or not; a desire to micturate frequently; general characters of the urine; quantity passed in twenty-four hours; specific gravity; microscopical and chemical examination; state of urethra, bladder, kidneys.

Catamenia: state of vagina, character and frequency of discharge. Leuchorrhœa.

Diagnosis.

Objects to be attained by treatment.

Treatment recommended: *the medicines may be written in Latin or in English, and the proportions denoted by the usual signs, but the directions should be invariably given in English.*

All directions *as to diet and treatment should be written very clearly and underscored.*

The course of the case should be noted at regular periods. In many cases *every day or every other day* will be sufficient, but in cases of *acute disease*, notes should be made at *shorter intervals* (*3 to 12 hours*) according to the symptoms.

The frequency of the pulse and respiration, and the state of the principal secretions should be noticed daily in acute cases.

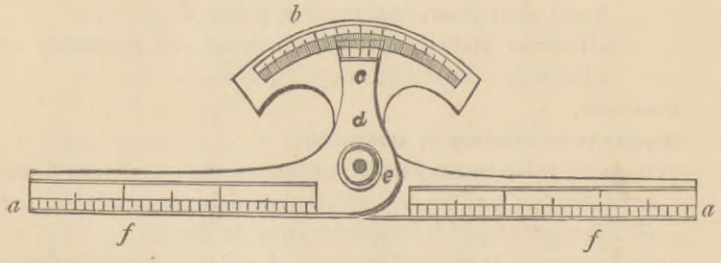
OF MEASUREMENT, PALPATION, PERCUSSION AND AUSCULTATION OF THE CAVITIES OF THE CHEST AND ABDOMEN.

By **Measurement, Palpation, Percussion, and Auscultation,** alterations in the dimensions and form of the walls of, and changes in position, form, texture, and consistence of the viscera contained in, the cavities of the chest and abdomen, are ascertained.

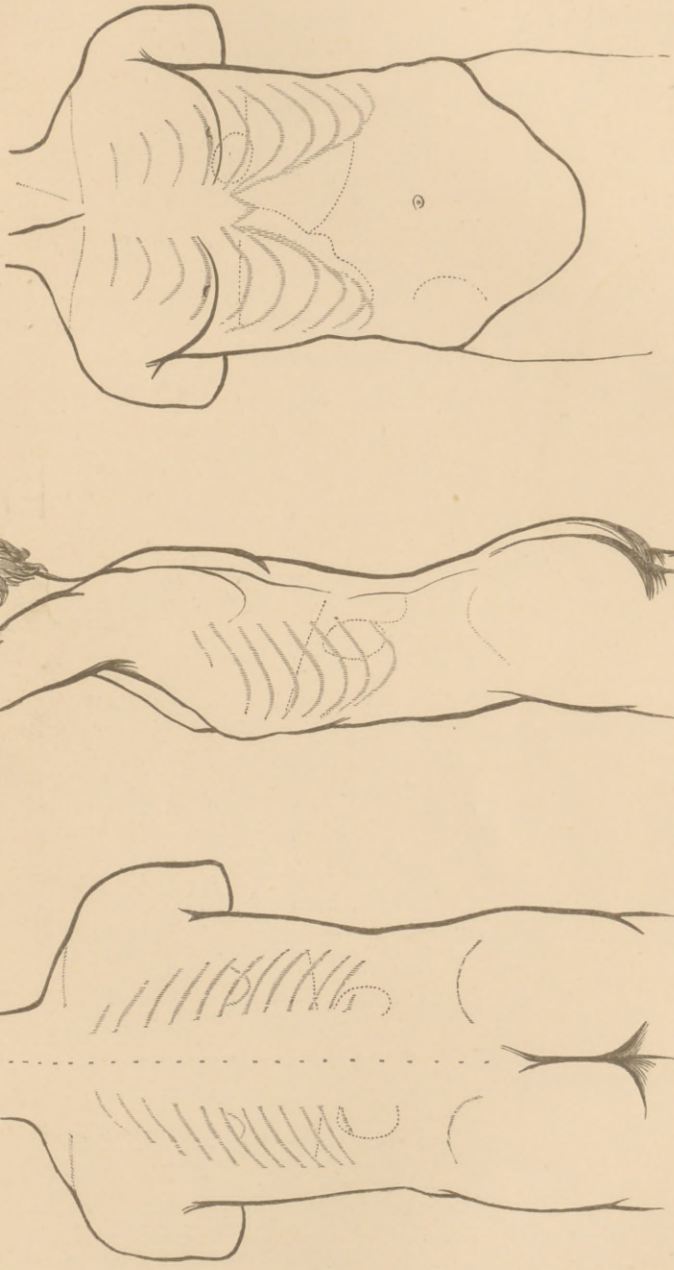
MEASUREMENT.

Most measurements may be made accurately with an ordinary tape, marked with inches divided into eights or tenths. In order to be sure that the tape is applied in the same spot, when measurements are made subsequently, marks may be made on the skin with nitrate of silver, ink, chalk, or various colouring matters, or by applying small pieces of black sticking plaster. Corresponding marks may also be made on the forms, plates LVII, LVIII.

The respiratory movements may be measured with the stethometer of Dr. Quain, and the chest measurer of Dr. Sibson. Alterations in the inclination of different parts of the surface of the chest to each other, are to be ascertained by the instrument figured below, which was invented by Dr. Scott Alison, and was first described in the "Archives of Medicine," vol. i, page 60.



Stetho-goniometer, for measuring the inclination of different parts of the walls of the thorax in cases of disease. *a*, *a*, the arms. *b*, the arc of a circle, graduated from 120° to 220°, the latter degree being on the left hand. *c*, the vernier, with the arrow at zero; the index of degrees. The vernier is divided into twelve equal parts, the whole being equivalent to 1° on the arc, or to 60′. *d*, Vernier arm. *e*, Joint. *f*, Inches and tenths of inches, marked by lines which when brought into line by bringing the two arms nearly together, would determine the first degree, if instead of an arc it had been an entire circle.



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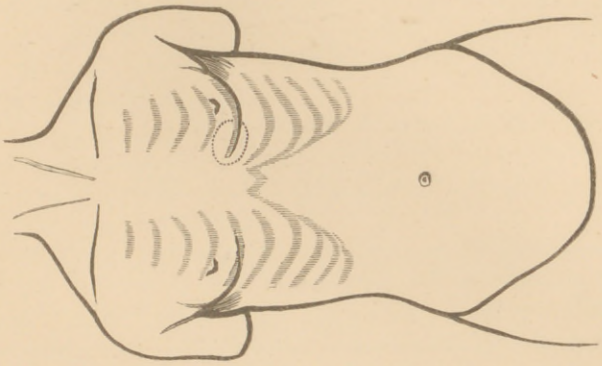

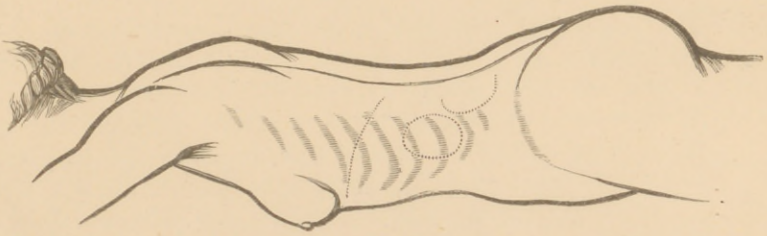

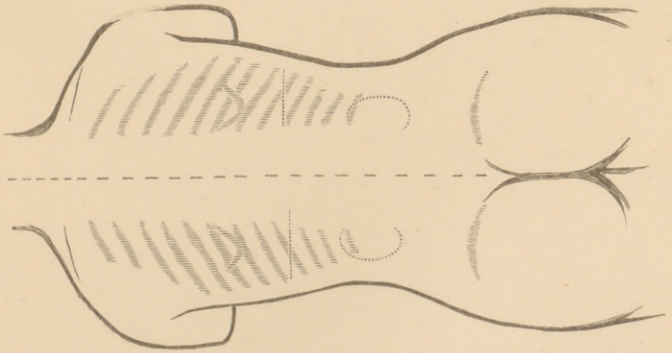

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[To follow PL. LVII.

PALPATION.

This word comes from the French *palper*, to feel. It means exploring by touch or feeling, or by applying pressure. The tips of one or more fingers may be employed, or the whole hand, according to the size of the space to be felt.

By palpation we are enabled to judge of the size, form, and consistence of tumours, which are not too deeply situated to be felt; the existence of fluid in certain cavities of the body. Pressure and movement of parts often cause pain.

FLUCTUATION is the tremulous vibration excited in fluid which has accumulated in a cavity with elastic walls. If vibrations are communicated to one portion of the wall of the cavity with the finger of one hand, while the other hand is applied flat over another part, the 'fluctuation' will be detected.

PERCUSSION.

In percussion, one or more fingers of the left hand are placed in contact with the skin, and as flat as possible over the region to be percussed, and the dorsal surface of one finger is to be struck sharply with the tip of the middle finger, or with the tips of two or three fingers of the right hand, the movement of the hand being produced at the wrist and not at the elbow joint. The exact spot over which a certain sound is elicited may be marked as shown in plate LVII.

Clear or Resonant, as the sound produced by percussing those parts of the thorax which are situated over healthy lung.

Tympanitic or drum-like. The sound elicited by percussing the abdomen when the viscera contain air,—the thorax, when there is a large superficial cavity in the lung just beneath the surface, when the lobules of the lung are permanently dilated so as to form large simple sacs, as in *pulmonary emphysema*, or when the pleural cavity contains air (*pneumothorax*).

The **cracked-pot sound** occurs in some cases when sharp percussion is made over a cavity which is empty or contains only a little fluid, and communicates freely with the bronchial tubes. The patient should be made to open his mouth at the moment of percussion. The sound is not of very common occurrence.

Dull. The sound produced on percussing solid substances, somewhat modified according as it is due to a thick layer of *fluid*, *solid organs* as the liver, the thick muscular substance of the limbs or the bones.

All these sounds vary much in *intensity*, and considerably in *character*. The intensity of the dulness can be indicated in the forms by the depth of the shading. The sounds heard upon auscultation may be indicated by different kinds of shading, and by short descriptions written on the margin of the forms, or figures referring to descriptions in the case book may be employed.

AUSCULTATION. THE LUNGS.

The ear may be simply applied to the walls of the chest covered with one thickness of linen; but for auscultation under the clavicles, and in some other parts of the chest, a *stethoscope* is not only desirable but necessary. By the latter instrument also, sounds occurring in circumscribed spaces are isolated, and to some extent separated from those occurring in the immediate neighbourhood.

Different forms of stethoscopes have been recommended by authorities. Upon the whole a cedar wood stethoscope with a broad and nearly flat ear-piece is to be preferred. The double stethoscope is valuable in certain investigations, but its inconvenience precludes it from being generally used.

1. Sounds Produced by Air passing to and from the Air-cells of the Lung.

Dry.

Vesiculuar breathing or *normal respiratory murmur* heard in health.

Puerile respiration, when the respiratory murmur is more intense than in health, like the loud breathing of children.

Feeble Respiration, when the respiratory murmur is only slightly audible.

Prolonged Inspiration or *expiration*, when the duration of the inspiratory or expiratory murmur is increased.

Rough, harsh, or coarse breathing, when the respiratory murmur is rougher than in health. When this modified respiratory murmur is heard over a very small space, it indicates that a change has taken place in the character of the walls of some of the air-cells.

Moist.

Fine Crepitation. A fine crackling sound produced by the passage of small bubbles of air to or from the air-cells, through viscid fluid, or in consequence of the air-cells being diminished in size and their walls thickened from the pouring out of exudation.

2. Sounds Produced by the Air passing to or fro in Air-tubes, or in Cavities.

Dry.

Rhonchus. A harsh, rough, or snoring sound, caused by the passage of the air along the larger bronchial tubes, when the mucous membrane is swollen or covered with viscid mucus, or when the calibre of the tube is diminished from any cause.

Sibilus. A hissing or whistling sound produced in the smaller bronchial tubes, under the same circumstances which give rise to rhonchus in the larger ones.

Bronchial breathing. A sound resembling that heard on listening over the trachea during respiration. When heard over a part of the chest, normally occupied by healthy lung, it may result from the air-cells of the lung being rendered solid by the accumulation of lymph and serum, tubercle, cancer, &c., and thus rendered a better conductor of the sound which is produced by the air as it passes along the larger bronchial tubes. This sound is often heard in pneumonia, tubercle, or cancer, but it may depend upon the pulmonary tissue being somewhat compressed and forced close to the parietes of the chest, as from the accumulation of fluid in the pleural cavity.

Cavernous breathing. A loud, harsh sound, produced by air rushing through a tube or dry cavity.

Amphoric breathing. The sound produced when air passes to or from a narrow orifice into a large cavity containing air.

Moist.

Large crepitation. Large or coarse crepitation. Mucous râles. Moist sounds, produced by bubbles of air passing through tenacious mucus or a viscid secretion in the larger bronchial tubes, or in small cavities.

Gurgling. A sound produced by the passage of successive bubbles of air through fluid contained in a tube or in a cavity.

Metallic tinkling. Probably caused by the sudden escape of a small bubble of air through fluid, or through a narrow opening into a cavity. It may be produced by moving the patient slightly, in a case where fluid and air exist in the pleural cavity.

3. Modified Voice Sounds.

Bronchophony. The voice sound modified by resounding in a tube or small cavity just beneath the walls of the chest, or separated from the surface by solid lung, resembling the sound heard by placing the ear a little below one or other sterno-clavicular articulation of a healthy person while speaking.

Pectoriloquy. Voice sound modified by resounding in a large tube or cavity resembling the sound heard by placing the stethoscope over the larynx of a healthy person when speaking.

Ægophony. A curious trembling, twanging sound, something like the bleating of a goat, generally produced by the voice sounds vibrating over the surface, or through a thin layer, of liquid in the pleural cavity.

Cough. When the patient is made to cough, many of the respiratory sounds are greatly increased in intensity, and during the long drawn forcible inspiration which succeeds, crepitation may be produced, which does not occur in ordinary breathing.

4. Friction Sounds, Produced by the Rubbing together of two Rough Surfaces.

Pleuritic Rubbing. This may accompany inspiration and expiration, but when slight may be audible only at the end of a forced inspiration. It is described as a creaking, grating sound. It may have a dry or a moist character.

To and fro Rubbing or Friction sound, heard over the region of the heart in pericarditis, caused by the rubbing together of the layers of the pericardium, upon which lymph has been effused.

The grating thus produced, which is audible by the ear, may often be felt by the hand in pleurisy and in pericarditis. In peritonitis, if the abdominal walls be moved a little with the fingers applied flat to the surface, a peculiar rubbing is sometimes felt.

Auscultation. The Heart.

The heart may be examined by percussion and auscultation. The sounds produced by its action may be listened to in front, at the side, or at the back of the chest.

Position of the heart determined by percussion.

Impulse of the heart increased or diminished.

Rhythm. Note any alterations in the duration of the sounds, or interval. *Irregular* or *intermittent* heart's action. Any alterations in the character or intensity of the first or second sounds should be noticed. They may be clear, or dull, or muffled.

Murmurs, *bruits or bellows' sounds, sawing, blowing, musical cooing.* Note the nature of the sound, where it is loudest, when it begins and when it ceases so to be heard. A bruit heard most distinctly at the base of the heart, may be situated in the *aorta* or *pulmonary artery,* and may take the place of the first or second sound of the heart. Bruits are usually caused by narrowing of

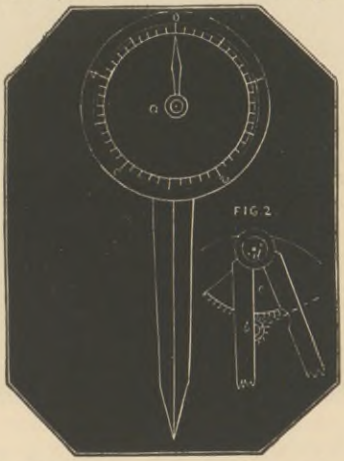
orifices, or by some deficiency of the valves which guard them. In the case of the aorta and pulmonary artery, a *systolic bruit* is produced by a narrowing of the orifice, a *diastolic bruit* arises from a defect in the closure of the valves.

A systolic bruit is often heard over the aorta, and in the course of the large arteries in cases of anæmia, where there is no change whatever, either in the orifices or in the valves. *Venous murmur.* In similar cases, a continuous humming or purring sound is often heard by placing the stethoscope *lightly* over the large veins at the base of the neck.

A bruit, heard most distinctly at the apex of the heart, generally depends upon a defect in the closure of the mitral valve. It is *systolic* and *regurgitant,* depending upon the blood flowing from the ventricle back again into the auricle during the systole.

METHOD OF ESTIMATING TACTILE SENSIBILITY.

In order to form an estimate of the degree of impaired tactile sensibility, it is necessary to ascertain how nearly two points may be



Dr. Ogle's Aphemetric Compass. Fig. 1. The front view of the graduated dial plate, with the indicator. Fig. 2. Posterior view, with the tooth wheel working in the wheeled pinion.

approximated and yet be distinctly felt as two. For this purpose two pins or common compasses may be employed, and the distance between them measured off upon a rule. Dr. John Ogle has invented an instrument which is very useful for such observations. It is called by him the Aphemetric Compass from ἁφή, a touching or close contact. See his paper in the "Archives of Medicine," vol. i, p. 321. See also Dr. Ballard's paper on the "Tactile Sensibility of the Hand," Med. Chir. Trans., vol. xlv, p. 225.

INSTRUMENTS FOR ESTIMATING THE FORCE AND CHARACTER OF THE PULSE, SPHYGMOSCOPES AND SPHYMOGRAPH, THE HEART'S ACTION, &C.

Drawings of sphygmoscopes are represented in the accompanying figures. They were drawn by Dr. Scott Alison. (Proceedings Royal Society.)

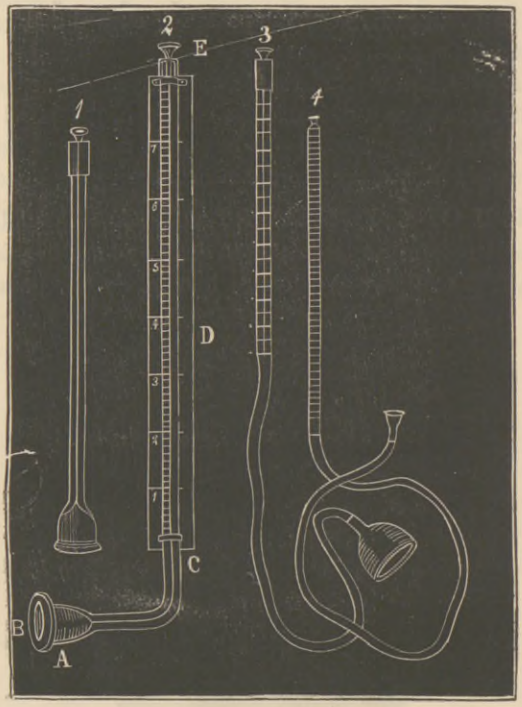


Fig. 1. Artery sphygmoscope. Bore of tube $\frac{1}{16}$ of an inch. Fig. 2. Portable heart sphygmoscope. A. Glass cup containing coloured water; B. Lamina of India-rubber, covering the mouth of the cup; C. Glass tube; bore $\frac{1}{16}$ of an inch; D. Graduated scale; E. Screw stopper. Fig. 3. Heart sphygmoscope supplied with India-rubber tube, to permit of greater facility of comparison with movement of artery sphygmoscope, and greater readiness of observation when listening to the sounds of the heart. Fig. 4. Artery sphygmoscope with India-rubber tube.

The Sphygmograph is a beautiful instrument invented some years ago by Marey. It was exhibited in the Exhibition of 1862. By its aid a line is drawn on paper which represents accurately the movements occurring in the artery. See Dr. B. Foster's work on "The Use of the Sphygmograph in the Investigation of Disease."

CHEMICAL AND MICROSCOPICAL EXAMINATION OF SECRETIONS.

CHEMICAL APPARATUS AND REAGENTS, PAGES 95, 97.

Nitric Acid.
Sulphuric Acid.
Acetic Acid.
Solution of Potash.
Solution of Soda.
Ammonia.
Solution of Chromic Acid.
Nitrate of Silver.
Nitrate of Barytes.
Phosphate of Soda.
Oxalate of Ammonia.
Iodine Solutions.
Sulphate of Magnesia.
Tincture of Galls.
Alcohol.
Ether.
Sulphate of Copper.

Apparatus.—*Glass Slides, Thin Glass, Pipettes, Conical Glasses, Spirit Lamp, Small Retort Stand, Test Tubes, Stirring Rods, Filters and Filtering Paper, Beakers, Evaporating Basins, Small Water Bath, Urinometer, Blue Litmus Paper, Red Litmus Paper.*

The tests may be kept in bottles or in tubes with capillary orifices.

MICROSCOPE AND INSTRUMENTS.

Clinical pocket microscope, p. 1. The powers required are the quarter, magnifying about 200 diameters, and the inch, magnifying about 40 diameters. Needles mounted in handles. Scissars, p. 33, forceps, animalcule cage for examining urinary deposits, &c., p. 81, glass slides, thin glass.

Glycerine for preserving specimens. When a specimen is to be preserved in glycerine, it is to be soaked in the fluid for some hours or days before it is mounted permanently, § 101, p. 84.

MICROSCOPICAL EXAMINATION.

In the microscopical examination of the various secretions and discharges, the observer must constantly bear in mind that various extraneous matters are likely to be present, pp. 183, 210. It is also necessary to be aware that cases of imposition are of very frequent occurrence. The observer should make himself familiar with the microscopical characters of the ordinary articles of food, and the deposits from drinks, as soon as possible, or he will be liable to make the most ludicrous mistakes.

Sebaceous Matter. Oil globules, granular matter, fragments of hair, sometimes crystals of cholesterine. In that from the follicles of the nose, ears, and scalp, the *entozoa folliculorum* are found. These entozoa are very common, and are met with in the upper as well as in the lower classes. They may be examined alive in oil or glycerine, p. 262.

Cuticle. *Epithelial Scales* as modified in skin diseases. *Fungi* are present in various diseases. To be demonstrated by soaking cuticle in glycerine, and examining with a power of 400 diameters or higher, pp. 281, 282.

Contents of vesicles, pustules.

Conjunctiva. Tears. *Epithelium.*

Nose. *Mucus from Nose. Epithelium.* Squamous, ciliated, black particles of carbon. *Pus corpuscles.*

Ears. Oil globules, fragments of hair, granular matter. *Entozoa folliculorum* in wax. *Fungus* rarely observed, p. 278.

Mouth. *Saliva. Salivary corpuscles. Epithelium* from mouth often invaded by fungi, p. 273. Fur from the tongue usually consists of epithelium and the débris of old epithelial particles, oil globules, and various insoluble constituents of the food, granular matter, and minute fungi.

False Membranes on back of tongue and pharynx, p. 187.

Sputum. Small pieces should be taken from different parts of the sputum, and subjected to examination separately. It is only necessary to place a piece about the size of a pin's head on the glass slide, and cover it with thin glass, pressing it until sufficiently thin to be transparent. If it is necessary to moisten it, it is better to use weak glycerine than pure water, p. 181.

Mucus contains small and large granular cells, large spherical

masses containing particles of carbon, and occasionally cells of columnar epithelium from the bronchial tubes, p. 183.

In catarrh, the granular cells are more numerous and more closely resemble pus corpuscles. In the opaque yellow sputum of chronic bronchitis, pus is very abundant, p. 184.

The viscid rusty sputum of pneumonia contains numerous small granular corpuscles, the cells found in ordinary mucus, blood corpuscles, and often much fine granular matter, p. 184.

In phthisis, pus is often present in considerable quantity. Occasionally tubercle corpuscles, may be observed, and sometimes small fragments of pulmonary tissue. The latter prove that softening is taking place, and the pulmonary tissue disintegrating. To discover them, boil the specimen two or three minutes with an equal bulk of solution of soda, 15 grains to the ounce, dilute with four times the quantity of distilled water, pour into conical glass to subside, and examine deposit, if any. (Dr. Fenwick). Care must be taken not to mistake the fibrillation of mucus for the elastic fibres of pulmonary tissue. Besides the above, mucus cells, much granular matter and oil globules are usually present, p. 186 to p. 191.

Vegetable structures are often present in sputum, p. 189.

Fibrinous casts, *masses of calcareous matter*, *portions of hydatid cysts*, and *fragments of echinococci*, are met with in rare cases, p. 190.

In all sputum the observer will meet with fragments of the epithelial covering of the mouth and tongue, and various substances taken in the food, oil globules, starch granules, fragments of muscular fibre, and numerous other bodies, with the microscopical characters of which he must make himself familiar, p. 183.

Vomit. *Epithelium from the tongue*, *mouth*, *œsophagus*, or *stomach*, may be present. Small fragments of various articles of food are constantly found. Very often large oil globules, in which the stearine has crystallised, are met with. *Blood corpuscles.* Various forms of *fungi.* *Sarcinæ*, pp. 193, 271.

The superficial layers of the epithelial covering of the œsophagus are sometimes expelled in the form of a tube, and large flakes of the epithelium of the stomach have been rejected, p. 194.

Discharges from the bowels. *Epithelium* from the large intestine, with flakes of mucus. Sometimes large flakes of the epithelium are passed entire. Blood corpuscles, when present, are often very much altered. In cholera, the epithelium from the small intestine, and complete sheaths of villi, and casts of

the follicles have been found, but are not constantly present. Fungi of various forms are occasionally found. Numerous substances derived from the various articles of food which have escaped the process of digestion; pieces of yellow elastic tissue from the arteries or from the ligamentum nuchæ which have been mistaken for entozoa may be met with, pp. 195, 196.

Discharges from the uterus or vagina. Menstrual fluid contains blood corpuscles, many of which are ragged and much altered, and epithelium from the uterus and vagina. Casts of the epithelial covering of the vagina are sometimes passed entire, p. 196.

Leucorrhœal discharge usually contains pus, modified epithelium from the vagina, and the usual large epithelial scales, p. 197. The trichomonas vaginæ has been found by some observers, p. 217.

Cancer cells are sometimes found in cases of cancer of the uterus or bladder, p. 230.

URINE.

*** Reference should also be made to the Author's work on "*Urine, Urinary Deposits and Calculi.*"

For instituting a rough general examination of a specimen of Urine. The most necessary tests may be arranged under six heads; and, by having recourse to one or more of these, we are enabled to determine roughly the most common morbid states of the urine.

1. *Reaction.*

2. *Specific Gravity.* When very high, we may suspect an increased quantity of urea (excess); the presence of sugar. Apply tests mentioned below. Hysterical urine, and urine of cases where much water has been taken, is of very low specific gravity.

3. *Heat.* Urate of ammonia, distinguished from pus or phosphate. Albumen. Precipitation of phosphate.

4. *Nitric Acid* dissolves phosphates (p. 223); decomposes urate of ammonia (if strong, rapidly); precipitates albumen in urine, even when in very small quantity, and due to the presence of pus. Used also to test the presence of uric acid. Excess of urea. Bile.

5. *Potash.* Urates are soluble in potash, and are thus distinguished from pus or phosphate. Uric acid may also be

distinguished from blood corpuscles. Sugar is indicated by a brown colour, after prolonged boiling.

6. *Nitrate of silver.* Precipitate of chloride of silver, insoluble in nitric acid. In certain cases of extensive inflammation, as in pneumonia, pleurisy, and some others, the urine does not contain a trace of chloride of sodium.

1. Chemical examination with reference to detecting the nature of the deposit.

a. Light and flocculent deposits. Deposits of this class are generally too light, and the quantity is too small for the application of chemical tests. See *microscopical examination* of deposits, below.

b. Dense and opaque deposits, usually present in considerable quantity, are of three kinds, which much resemble each other in appearance.

1. *Urate of Soda,* p. 224. Lateritious, or pale nut-brown sediment. Varies much in colour; may be dark brown or red. Urine acid. *Tests.* Soluble by heat, in potash, ammonia, water. Decomposed by acetic acid, uric acid being set free in a crystalline form.

2. *Phosphates,* p. 223. Urine usually alkaline or neutral. When triple phosphate alone is present, the urine is sometimes feebly acid. *Tests.* Insoluble by heat or in alkalies; soluble in acids, and afterwards precipitated by ammonia.

3. *Pus,* p. 222. Diffused through the urine, rendering it turbid, or forming a bulky creamy deposit, with clear or turbid supernatant fluid. *Tests.* Rendered glairy by potash. Albumen in urine precipitated by heat and by nitric acid. *Caution.* There may be more albumen than can be accounted for by the pus.

c. Crystalline or granular deposits are usually in small quantity, forming a sediment which may either be coloured, or transparent and colourless.

1. *Uric acid,* p. 225. Colour characteristic, usually of a dark mahogany brown, sometimes paler, very seldom quite colourless. Large separate clusters of crystals. It rarely forms a granular deposit. *Tests,* p. 226. Soluble in potash, and in nitric acid. After evaporation with nitric acid, ammonia gives the dark violet colour of murexide. Often mixed with blood, when the urine appears 'smoky' if acid. Albumen detected in the fluid. 2. *Blood corpuscles,* p. 229. See *microscopical examination.* 3. *Oxalate of lime,* p. 226. Seldom in sufficient quantity to form a deposit visible to the unaided eye. See *microscopical characters. Tests for oxalate of*

lime calculi. Insoluble in water, potash, and acetic acid, even when boiled; soluble in mineral acids; and again thrown down amorphous, but unchanged in composition, by ammonia. By incineration, an odour like that of burnt feathers is evolved. Black ash becomes white by decarbonisation; this ash is soluble in acetic acid, with copious effervescence. Oxalate of ammonia, added to acetic acid solution, precipitates oxalate of lime.

4. *Silica* is said to have been found in very minute quantities in urine; rarely met with as a deposit, except in the form of grains of sand in the urine of hysterical patients and impostors. Easily known by its great density, general appearance, and insolubility in strong mineral acids.

2. Chemical Examination with reference to the Discovery of an Abnormal Condition of the Soluble Constituents of the Urine, or of the Existence of Substances of a Soluble form not met with in Health.

1. *Albumen.* Urine pale; often of very low specific gravity, 1005 to 1012 or 1014. Heat or nitric acid, if urine be acid; nitric acid, if the urine be alkaline. Reason: solubility of albumen in alkalies. *Fallacies.* A *trace of nitric acid* prevents the precipitation of albumen by heat. Precipitation of phosphates occurs in some cases by simply boiling the urine. Precipitation of minute crystals of uric acid sometimes takes place upon the addition of dilute nitric acid to urine: hence, necessity for employing both tests.

2. *Excess of Urea.* Urine frequently high coloured; specific gravity, 1030 to 1040. Upon the addition of an equal volume of strong nitric acid, crystals occur within half an hour, if there be much excess. Oxalic acid is often employed when the urea is to be determined quantitatively, but the 'volumetric' process of analysis is more satisfactory.

3. *Sugar.* Urine pale, of high specific gravity, from 1030 to 1050. Trommer's test. Tartrate of copper. Potash tests. Fermentation test.

4. *Sulphates.* Nitrate of barytes or chloride of barium, after the addition of a few drops of nitric acid.

5. *Chloride of Sodium.* Nitrate of silver, after the addition of a few drops of nitric acid.

6. *Bile.* Urine of a dark yellow colour. Nitric acid; play of colours. Pettenkofer's test.

MICROSCOPICAL EXAMINATION OF URINARY DEPOSITS.

Great caution required, p. 207. A large quantity of urine (at least four ounces) should be allowed to subside in a *conical glass*, pls. V and IX, for some (two or three) hours, or the greater portion of the urine may be poured off from the deposit, which may then be submitted to examination. In this case, small bottles only need be taken to collect specimens; but, of course, no idea can be formed concerning the relative amount of deposit present. When the insoluble matter has subsided, the deposit may assume one of three characters.

1. It may occupy a large bulk, and present a flocculent appearance; or

2. It may form a dense, opaque, abundant or scanty stratum; or

3. The deposit may be small in quantity, crystalline, consisting of sparkling colourless points, or of granules more or less coloured.

All these characters may co-exist in one deposit, in which case we observe three distinct strata, each of which must be *separately* submitted to microscopical examination. In most cases, there are two distinct strata.

1. *Substances floating on the surface of the Urine, or diffused through it, but not forming a visible Deposit.*

a. Opalescence produced by urates, p. 223.
b. Opalescence produced by vibriones, p. 213.
c. Milk in urine, p. 211.
d. Chylous urine, p. 221.

2. *Deposit light and flocculent, occupying a considerable Bulk.*

Always take specimens from the bottom of the glass for examination, as well as from the bulk of the deposit.

a. Simple mucus-corpuscles, p. 212, or with bladder or renal epithelium, p. 216. Cells sometimes tinged with yellow bile.

b. Simple mucus, or *epithelium*, with numerous small crystals of oxalate of lime entangled in it, p. 226.

c. Casts. Various forms of casts, p. 217. *α.* Casts of medium diameter. *β.* Casts of considerable diameter. *γ.* Casts of small diameter.

d. Vibriones, p. 213. Torulæ, p. 214. Spermatozoa, p. 216. Sarcinæ, p. 215.

e. Matters of extraneous origin, p. 210. Bed-flock: hair: feathers: dust: starch granules: fibres of deal (distinction from casts), &c., p. 215.

3. *Deposit dense, opaque, and abundant.*

a. Urates. Amorphous deposit soluble by heat.

b. Pus, p. 222. Characters. Rendered glairy by potash. Action of acetic acid on the pus corpuscles as shown in microscopical examination.

c. Phosphates, p. 223. Phosphate of lime, amorphous, p. 223. Crystalline, p. 228. Triple or ammoniaco-magnesian phosphate, crystalline, p. 223. Mixed with carbonate or oxalate of lime.

d. Sand. Starch. Potato: rice: bread-crumbs: arrowroot.

4. *Granular or crystalline Deposits, small in quantity, sinking to the bottom, or adhering to the sides of the vessel.*

a. Uric acid, p. 225. Forms of. Amorphous. Varies much in colour.

b. Oxalate of lime, p. 226. Forms of. Dumb-bells. Distinction of oxalate of lime for triple phosphate.

c. Phosphate of lime. Triple phosphate, radiating crystals, p. 223.

d. Blood-globules, p. 229.

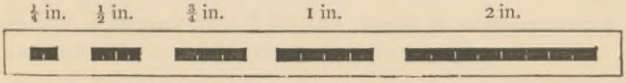
e. Crystine, p. 228. Carbonate of lime, p. 229.

SUGGESTIONS FOR MAKING AND RECORDING POST-MORTEM EXAMINATIONS.

THE different organs may be examined in any order, and in many cases it is only possible to examine those which are considered to be in a morbid state, but, where time is allowed, the following order is recommended.

Notes should be made at dictation, in a book kept for the purpose, while the body is being examined. The observations should soon afterwards be entered in their proper order, in a **Post-Mortem Book**, and the results of the more minute microscopical and chemical examinations which may be necessary, added. The **Rough Notes** taken at the time should always be carefully preserved.

Loose comparisons as to form, dimensions, bulk, colour, weight, specific gravity, consistence, &c., should never be permitted. Form and colour should be indicated by sketches with coloured chalk. Size in eighths or tenths of an English inch.



I. TO BE NOTED BEFORE COMMENCING.

Date and Time of Examination. *Temperature. Hours after Death.*

Name, Age, *or apparent Age. Sex.*

Reference to Case Book.

Measurement and Weight of Body. *Height, Nutrition.*

Cadaveric Rigidity. *Putrefaction.*

External Appearances. Expression of countenance, Peculiarities, Colour of Hair, and of surface generally. *Œdema, Emphysema.*

II. EXAMINATION OF HEAD AND SPINE.

The head is to be opened as follows :—An incision is to be made through the integuments of the scalp, down to the bone, from ear to ear. The flaps are to be drawn *forwards* over the face, and *backwards* over the neck. The saw is to be carefully carried round the head, an inch above the eyebrows in front, and through the occiput behind.

The best saw for the purpose is a bow saw. A chisel-shaped instrument, of a T shape, is most convenient for wrenching off the calvarium, when sawn through. A very thin long knife is required

for removing the brain in slices. A tin can with a spout, having an orifice of rather less than a quarter of an inch in diameter, is the most convenient vessel for pouring a stream of water upon the brain, to ascertain its consistency.

Integuments of Cranium, Bones of the Skull, Dura Mater. State of the Sinuses, Pacchionian bodies, Character of **Arachnoid,** Fluid seen upon opening the dura mater, Surface of Brain, Vascularity, Firmness of convolutions, Width of convolutions and of the sulci between.

The brain is to be removed by dividing the nerves at the points where they leave the dura mater. The tentorium cerebelli is to be divided with the point of the knife, and the medulla oblongata, with the vessels, are to be cut across as low as possible.

Brain. *Weight, General Vascularity, Consistence, Specific Gravity; its bulk.**

Remove hemispheres by horizontal slices; notice—

Extravasations of Blood, *Dilated Vessels,* **Tumours,** *Soft Patches, Cicatrices, Vascularity, Firmness, Moisture of White and Grey Matter.*

Lateral Ventricles. *Quantity of Fluid in them, Lining Membrane, Choroid Plexuses, Velum Interpositum, Fornix, &c.*

The corpora striata and optic thalami are to be removed gradually, in thin slices cut vertically, inclining outwards. Each slice should be carefully examined for cicatrices of clots.

Corpora Striata, *Pineal Body.* **Corpora Quadrigemina,** *Processus e cerebello ad testes.*

Pons Varolii, *or Mesocephale.*

Medulla oblongata. Surface, Section, *Fourth Ventricle.*

Cerebellum.

These parts are likewise to be removed by thin slices.

The laminæ of the vertebræ are to be sawn through or cut through with a proper instrument. The nerves are to be divided as they pass through the intervertebral foramina, and the spinal cord may be removed.

Vertebræ, Dura Mater. *Spinal Veins.*

Cerebro-spinal Fluid. *Arachnoid, Pia Mater, &c.*

Spinal Cord. *Weight, Dimensions, Consistence, &c.*

Sections of Cord. Roots of the Nerves.

* The bulk of an organ is ascertained by measuring the exact quantity of water it will displace.

The microscopic examination of the spinal cord is conducted according to the plan recommended by Mr. Lockhart Clarke, p. 22.

Examination of Eyes, Nose, Ears.

III. EXAMINATION OF THE THORAX, ABDOMEN, AND PELVIS.

An incision is to be made through the integuments, from a point three inches beneath the chin to the pubis. The linea alba being divided, the skin and muscles may be dissected from the thorax, and the abdomen laid open, by forming two longitudinal flaps. There is no necessity for cutting through the abdominal walls transversely. The cartilages of the ribs are to be divided with a strong knife, or with bone forceps, and the sterno-clavicular articulation cut through. The front of the sternum may now be removed, care being taken not to injure the large veins or pericardium.

Fluid in Pleura or Pericardium. Adhesions. The *quantity* of fluid present in a cavity should always be carefully measured.

Observe the position and relative size of the viscera, lungs, heart, liver, stomach, spleen, colon, small intestines, &c. Position and general appearance of tumours **in situ.**

Cut through the large vessels at the base of the neck and divide the trachea immediately below the cricoid cartilage, or, when permitted, dissect away the tongue from its attachment to the ramus of the jaw, draw it down, and remove it with the pharynx, œsophagus, larynx, &c. The larynx and pharynx being firmly grasped, the lungs are to be carefully torn away from their attachment to the spine. The large vessels and the œsophagus are to be divided immediately above the diaphragm. Often it will be found most convenient to remove a portion of the diaphragm attached to the pericardium. Lungs, heart, trachea, larynx, and œsophagus are then to be removed.

Lips. Fauces, Uvula, Tonsils, Teeth, Pharynx.

Tongue. Epiglottis, Glottis, Œdema, *Foreign bodies in the Larynx or Trachea.*

Larynx. *Trachea.*

Trachea and bronchi to be opened by an incision in front. Avoid wounding the œsophagus.

Lungs. *Colour, Consistence, Weight, Density.* Do they sink in water, or does any part of them sink?

Section. *Cavities*, Extravasation of Blood, Deposits in pulmonary tissue, cysts, &c.

Diaphragm.

The heart may now be separated from the lungs, by dividing the root of each close to the lung.

Position of Heart in Thorax. *Relations.*

Pericardium. External surface, internal surface.

Heart. *Adhesions in Pericardium*, *Size*, *Weight*, Fat about Heart, Capacity of Ventricles. Measure the quantity of fluid they will contain, and ascertain if the valves completely close the orifices, by pouring in water.

Open the right ventricle. By making an incision near the septum, and, by carrying another along the right edge, a **V**-shaped flap may be formed. Examine the tricuspid valves. Next pass the finger into the infundibulum and pulmonary artery, which is then to be laid open, by carrying the incision onwards between two of the valves. Dissect the pulmonary artery from the aorta.

The left ventricle is to be opened by an incision directed towards the aorta, commencing near the apex of the heart, a little to the left of the septum. The aorta is to be divided between two of the valves and the arch is to be slit open.

Examine auricles and large veins, clots in heart, state of the walls of the cavities, interior of heart, size of *auriculo-ventricular orifice of right side*, *size of orifice of pulmonary artery*, **tricuspid valve, semilunar valves of pulmonary artery**, *auriculo-ventricular opening of left side*, **aortic orifice, mitral and semilunar valves,** ascertain how many fingers are admitted through the valvular orifices in the heart.

Aorta. *Its diameter*, character of coats, hardness, dilatation, aneurisms.

Pulmonary Arteries. Clot.

Coronary Arteries.

Note any points, with reference to the viscera, while they remain in situ. Remove liver with stomach and intestines, spleen, &c. Carefully tear the colon away from its attachments, and divide the rectum at its commencement in the sigmoid flexure. In this dissection be careful not to injure the genito-urinary organs.

Œsophagus.

Peritoneum generally.

Mesenteric Glands.

Stomach. Size, *Contents*, Condition of Mucous Membrane, Muscular Coat, Pylorus.

Next the common biliary duct is to be examined. The duodenum may be opened and probes passed into the gall and pancreatic ducts, which may then be traced in their course from the glands to the intestines.

Coats of Gall and Pancreatic Ducts. Mucous Membrane, Gall stones, Pancreatic Concretions.

Mesentery. Surface. Nerves and vessels. Glands.

Separate the small intestines from the mesentery, and afterwards slit them up with scissars, close to their *mesenteric attachment*, in order to avoid dividing Peyer's patches. The mucous surface is to be carefully washed by a gentle stream of water.

Duodenum. *Valvulæ conniventes*, Vascularity, **Brunner's Glands.**

Brunner's glands are situated in the submucous areolar tissue, and must be exposed by inverting the duodenum upon a loaded cork under water, when, the serous and muscular coats having been removed, the glands are observed, and may be isolated, by dissecting away the areolar tissue.

Jejunum, Ileum. Valvulæ conniventes, Vascularity, *Peyer's patches*, Solitary glands.

Cœcum. *Ileocœcal valve*, *Appendix Vermiformis.*

Colon. Condition of Muscular Coat, *Solitary Glands.*

Rectum. *Hæmorrhoids.*

Liver. Adhesions, *Bulk*, *Weight*, *Density*, *Hardness*, Colour, *Capsule*, *Portal Canals.*

Structure of Substance of the Organ. *Congestion of Portal or Hepatic Capillaries.*

A thin section of the liver should be placed upon a piece of glass and held up to the light, when the minute branches of the portal vein may be seen at the circumference of each lobule and the little twig of the hepatic vein in the centre. This is often divided in making the section.

Gall Bladder.

Bile. Colour, Reaction, Density, Microscopical characters.

Spleen. *Size*, *Weight*, Colour, Consistence.

Pancreas.

The kidneys, with the ureters, bladder, and lower part of the rectum should be removed together. In the male the testicles and penis (without cutting the skin) can be taken out at the same time. In the female, the ovaries, uterus, and Fallopian tubes may be removed with the kidneys and bladder, and each organ examined separately.

Suprarenal bodies. *Size, weight, structure.*
Kidneys. *Capsule,* Surface when capsule removed, Size, Weight, *Cortical structure, Medulla, Pelvis of Kidney, Ureter.*
Bladder. Contents of Bladder.
Male. *Urethra, Penis, Prostate,* vesiculæ, seminales, *Testicles.*
Female. *Urethra, Vagina, Hymen, Uterus, Ovaries, Breasts.*
Large Arteries and Veins of the Abdomen. *Coats, Coagula.*
Ganglia and Plexuses of Sympathetic.

IV. EXAMINATION OF THE LIMBS.

Size, *Form, Muscles, Nerves, Joints, Bones.*

Appearances resulting from Post-Mortem Change.

The walls of the large vessels and other structures are often stained from lying in contact with the blood. This post-mortem change must not be mistaken for *inflammation* or *congestion* occurring during life. In congestion the distended capillaries can always be distinguished by the aid of a lens. There are also many changes in texture, resulting from infiltration of serum ; and of colour, depending upon the action of gases set free after death, and upon other causes, which must be carefully noted and not mistaken for the results of morbid processes.

MICROSCOPICAL EXAMINATION.

The specimen to be examined must be immersed in fluid. As a general rule, glycerine of various strengths will be found most useful. The tendency of glycerine to render tissues too transparent may, in great measure, be counteracted by the addition of a little alcohol or chromic acid. Morbid specimens often undergo change more rapidly than healthy tissues. It is therefore of the utmost importance that the examination should be proceeded with as soon as possible. Thin sections of tissues are easily made with a thin double-edged knife. In making thin sections, the knife must be wetted with water or glycerine. It will be convenient to keep a few glass slides, with thin glass ready for making rough microscopical examinations, in the post-mortem room. The examination may be readily effected by using the clinical pocket microscope, represented in pl. I.

NAMES AND ADDRESSES OF MICROSCOPE MAKERS AND OTHERS USEFUL TO MICROSCOPICAL OBSERVERS.

BRITISH MICROSCOPE MAKERS.

Baker, 44, High Holborn, London.
Bryson, Princes-street, Edinburgh.
Collins, Charles, 77, Great Titchfield-street, Oxford-street.
Crouch, H. and W., Regent's Canal, Commercial-road, London.
Dancer, 43, Cross-street, Manchester.
Field, Birmingham.
Highley, S., Green-street, Leicester-square, London.
King, Bristol.
Ladd, W., Beak-street, Regent-street, London.
Murray and Heath, 43, Piccadilly, London.
Parkes and Son, St. Mary's-row, Birmingham.
Pillischer, 88, New Bond-street, London.
Powell and Lealand, 170, Euston-road, London.
Ross, 2, Featherstone-buildings, London.
Salmon, 100, Fenchurch-street, London.
Smith, Beck, and Beck, Cornhill, London.

FOREIGN MICROSCOPE MAKERS.

Amici, Modena.
Bénèche, Berlin, Tempelhofer Strasse, 7.
Brunner, Paris.
Chevalier, Paris.
Hartnack and Oberhäuser, Place Dauphine, 21, Paris.
Hasert, B., Eisenach.
Kellner, Wetzlar.
Merz, G. and S., Munich.
Mirand, A., senr., Paris.
Nachet, Rue St.-Severin, 17, Paris.
Ploesl, S., Vienna.
Schröder, Hamburg, Holländischer Brook, 31.
Schiek, F. W., Berlin, Halle'sche Str., 15.
Zeis, C., Jena.

Most of the microscope makers furnish cabinets and boxes for objects, apparatus and instruments required by the microscopist.

MAKERS OF CUTTING AND OTHER INSTRUMENTS REQUIRED BY MICROSCOPISTS.

Matthews, Portugal-street, Lincoln's-inn.
Weedon, Hart-street, Bloomsbury.
Weiss and Son, 62, Strand.

PREPARERS OF MICROSCOPIC OBJECTS.

Barnett, J. E., Whitehall-street, Tottenham.
Hett, A., 4, Albion-grove, Islington.
Hudson and Sons, Greenwich.
Norman, J., 178, City-road, London, E.C.
Topping, C.M., 11, Loader's-terrace, Manor-road, Bermondsey.
Webb, H., George-street, Balsall-heath, Birmingham.

Collections of objects of various kinds may be obtained of almost all the microscope makers.

MATERIALS AND APPARATUS FOR MOUNTING OBJECTS.

Claudet and Houghton, 89, High Holborn (for thin glass only).
Crouch, Regent's Canal, Commercial-road, London.
Griffin, 119, Bunhill-row, London.
Highley, Green-street, Leicester-square, London.
King, G., 190, Great Portland-street, W.
Matthews, Portugal-street, Lincoln's-inn, London.
Norman, 178, City-road, London, E.C.
Smith, Beck, and Beck, Cornhill, London.

ARTISTS. DRAUGHTSMEN.

Aldous, Mr. W. Lens, 47, Liverpool-street, King's Cross.
Dr. Westmacott, King's College, London.
West, Mr. Tuffen, W. West, Hatton-garden.

WOOD ENGRAVERS.

Hart, Mr., 33A, Red Lion-square, E.C.
Malden, Mr., Hart-street, Bloomsbury.
Powell, Miss, 170, Euston-road, N.W.
Ruffle, Mr., 17, Princes-road, Kennington.

PRINTERS. LITHOGRAPHIC AND PHOTOGRAPHIC PRINTERS.

Adlard, 22½, Bartholomew-close.
Blanchard and Sons, Millbank-street.
Brooks, V., Lithographic Printer, Photographic Lithography, 1, Chandos-street, Covent-garden.
Harrison and Sons, St. Martin's-lane.
Toovey, Photographic Lithographer.
West, W., Hatton-garden, E.C.

LITHOGRAPHIC STONES—DIAMONDS FOR ENGRAVING, AND OTHER APPARATUS USED IN LITHOGRAPHY.

Hughes and Kimber, West Harding-street, E.C.
Stoer Brothers, Vulcan Wharf, 16, Earl-street, Blackfriars, London.

APPARATUS FOR DRAWING, ENGRAVING, &c.

PENCILS, COLOURS, TRACING PAPER, &c.

Brodie, Long Acre, and other Artists' Colourmen.

WOOD BLOCKS

May be obtained of Mr. Williamson, Picket's-place, Strand ; and of Mr. Wells, Bouverie-street, Fleet-street.

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