THE MICROSCOPE,

IN

ITS APPLICATION

TO

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PRACTICAL MEDICINE.

BY

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SECOND EDITION.

WITH 270 WOODCUTS AND A COLOURED PLATE.



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WITH THE

AUTHOR'S

RESPECT AND ESTEEM.

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.

PREFACE

TO

THE FIRST EDITION.

A SHORT course of lectures, which was 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 with reference to 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.

The dimensions of all the drawings which are magnified with one of Powell's quarter of an inch object-glasses, can be readily ascertained by applying to them one of the scales figured in page 44, which represents divisions 1-1000th, 1-100th, &c. of an inch apart, magnified with the same power as the objects delineated.

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. Conwry Evans, the thanks of the author are also due for much kind assistance.

27, Carey Street,
4th April, 1854.

EXPLANATION OF THE PLATE.

All the objects, except figs. 6 and 10, are magnified 215 diameters.

1. Blood-crystals from the finger of a healthy man, treated with a drop of water.
2. Another specimen of human blood-crystals.
3. Crystals obtained by diluting putrid blood with a drop of water.
4. Crystals found among some clots which had been effused into a large hydatid cyst of the liver.* Two are seen to be situated within a large oil globule.
5. Guinea-pig's blood, crystallized, after the addition of a drop of water.
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* The liver from which these crystals were taken, was shown at the Pathological Society by Dr. Pollock, March, 1854

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THE

MICROSCOPE

IN ITS APPLICATION TO

PRACTICAL MEDICINE.

INTRODUCTION.

In the present work it is my wish to direct attention to that branch of microscopical investigation which has an important bearing upon the practice of medicine, upon the investigation of the healthy structures of the human body and the changes which these undergo in disease. Although no attempt will be made to describe very minutely the anatomy of the various tissues, it is nevertheless desirable to allude briefly to their most important anatomical characters. It is intended specially to consider the practical methods by which such investigations can be most successfully carried out, and the means at our disposal for *demonstrating* the minute structure of the various tissues, deposits, &c., with the characters of which it is important the practitioner should be acquainted.

My chief aim will therefore be, to endeavour to show *how* the structures are to be submitted to examination, but I

shall also attempt to describe briefly, *what* appearance they present under the microscope.

The question often occurs, whether an object should be examined while immersed in some fluid medium, or simply enclosed between two pieces of glass, without any previous preparation. Again, it will be inquired what liquid is best adapted to display the minute structure of the substance under examination, or in what manner can we hope to preserve most effectually the characters it possessed when recent, in order that it may be compared with other specimens at a subsequent period of time. The application of certain reagents may be necessary, either to dissolve substances which are accidentally present, or, perhaps, to render one element of the tissue more transparent, in order that the structure of another constituent may be better observed.

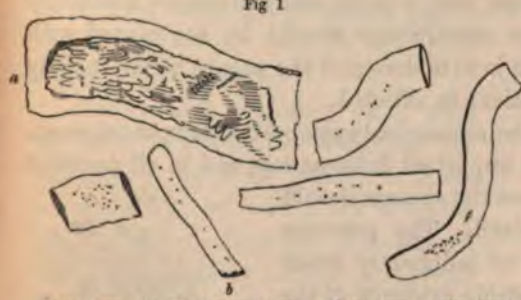
1. The value of the Microscope as a means of Diagnosis, &c.—To the practitioner, a familiar acquaintance with the microscopical characters of the tissues in health, and a knowledge of the way in which their structure is to be demonstrated, are essentially necessary. Without this, how can he expect to be able to investigate the changes which take place in certain textures in disease; or to make out the complicated structure of morbid growths? In the examination of urine and other secretions, he may fail to discover the presence of most important deposits, in consequence of not being acquainted with some very simple mechanical contrivance adapted for collecting them; and, in many instances, he may make an incorrect diagnosis in an obscure case of disease, in consequence of not knowing the best plan of submitting a substance to microscopical examination.

It is needless to discuss the vast importance of microscopical research in the study of anatomy and morbid anatomy, and hence its bearing upon *practical medicine*. We are dependent upon it for all advance in our knowledge of the changes taking place in the tissues in health and disease, and it affords the principal mode of ascertaining the

wonderful history of the changes which occur in the development and growth of morbid structures. In many instances, however, the microscope is of the greatest immediate use to the practitioner, and there are a number of cases the diagnosis of which is much facilitated, and often placed beyond all doubt, by its use. It may be well here to refer briefly to a few of those instances in which the microscope can be shown to have been of *direct* use to the practitioner in the diagnosis of disease, as well as in the study of morbid anatomy.

Diseases of the Kidney.—There is no class of diseases in which its powers have been more advantageously brought to bear by the practical physician, than in those of the kidney. By a microscopical examination of the urine, we are frequently enabled to ascertain the nature of morbid changes which are going on in the kidney, and even to distinguish, during life, the existence of certain well-defined pathological

Fig 1



Casts from the uriniferous tubes. *a*. Cast from a tube from which the epithelium has disappeared. *b*. Narrow cast from a tube to which the epithelium is abnormally adherent, ×215.

Fig. 2.



Casts of the uriniferous tubes containing free oil globules, and cells filled with fatty matter; from a case of fatty degeneration of the kidney, ×215.

conditions of that organ. The laborious researches of Dr. Johnson have shown us how, by the peculiar character of the casts (figs. 1, 2) of the uriniferous tubes, which are found in the urine, we can ascertain whether the epithelium be desquamating, or, on the other hand, if it presents no such tendency, but remains firmly attached to the basement membrane of the tube. If the epithelium be undergoing that peculiar change termed fatty degeneration, we shall

often be able to ascertain the fact by examining a specimen of the deposit by the microscope. So again, by the presence of certain other deposits, and a knowledge of the symptoms usually associated with them, the physician is enabled to direct his attention, as the case may be, to the existence of local changes, affecting some part of the genito-urinary mucous membrane; or to more general derangement connected with primary or secondary assimilation.

Fig. 3.



Casts from the uriniferous tubes. Some contain epithelium, others dark granular matter. The cells in the upper part of the figure are derived from the mucous membrane of the bladder, × 215.

The nature of some deposits can only be detected by using the microscope, and it is in many instances absolutely necessary that the practitioner should be acquainted with their presence if he is to understand the nature of the malady with which his patient is afflicted.

Sputum.—The microscopical examination of sputum sometimes affords most important information, and in all doubtful cases of chest disease the sputum should be carefully examined. The presence of small portions of pulmonary tissue affords incontrovertible evidence of the formation of a cavity, and the breaking down of the walls of the air cells.

Fig. 4.



Vomit containing Sarcinæ. *a.* Sarcinæ ventriculi. *b.* Starch granules partially dissolved and rendered transparent. *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.

Vomit.—The microscopical examination of the matters vomited in certain cases, has proved to us that minute fungi, originally discovered by Professor Goodsir, and named by him Sarcinæ Ventriculi (fig. 4), are met with in connection with retention of the food for a long period in the stomach, usually dependent

upon a contracted pylorus, and resulting either from thickening of the tissues, or due to the contraction of the cicatrix of an old ulcer. These remarkable cases occur much more frequently than was formerly supposed, and form an exceedingly interesting class of diseases. Such cases seldom recover. The patients complain of a peculiar burning sensation in the chest. The vomit usually ferments like yeast for an hour or two after it has been rejected, and often contains food which has been retained in the stomach for many days.

Fatty Degeneration. — Of late years, the remarkable changes which take place in some of the highly complex textures of the body, as well as in the most simple and elementary, in consequence of which their properties become changed, and their functions impaired, or altogether destroyed, have been undergoing careful investigation by a vast number of highly talented investigators.

Fig. 5.



Small artery from the brain with numerous oil globules deposited in its coats. The dark masses are aggregations of minute oil globules (granular or exudation corpuscles, inflammation globules). These are sometimes so numerous that they extend for a distance entirely round the vessel, much greater than its own diameter, × 215.

The recent discovery of a state of fatty degeneration affecting the arteries of the brain (fig. 5), in cases of apoplexy, by which the strength of their coats becomes deteriorated and their elasticity entirely destroyed, would lead to the inference that this disease is dependent rather upon complicated changes affecting nutrition, than upon the presence of a condition of plethora or hyperæmia, as was formerly supposed and acted upon.

The connection in many cases, though certainly not in all, between fatty degeneration of the margin of the cornea (arcus senilis) and corresponding changes taking place in the muscular tissue of the heart (fig. 6), in the cerebral vessels, and in many other textures of the body—as the investiga-

tions of Mr. Canton prove—must be regarded with great interest by every practitioner.

Tumours and Morbid Growths.—The microscope has frequently afforded important aid in the diagnosis of tumours, although after careful microscopical examination we have in certain cases not felt justified in assigning a particular name to the morbid growth in question. This has even been brought forward by some, as an argument against its employment altogether.

Fig 6.



Muscular fibre in a state of fatty degeneration.

It is in many cases quite impossible from a *microscopical examination alone* to pronounce decidedly as to the malignant or non-malignant nature of a particular tumour. On the other hand, not unfrequently this question has been positively and correctly answered in the affirmative or negative. It would surely not be right altogether to discard the use of an instrument which, although eminently useful in many instances, is not infallible.

For the discovery of Imposition, the microscope is invaluable. It almost necessarily follows that, in consequence

Fig. 7.



Globules of potato starch, × 215.

Fig. 8.



Oil globules from milk, × 215.

Fig. 9.



Fatty matter in a state of very minute division with corpuscles, from chylous urine, × 215.

of the frequency with which urine and other matters are subjected to minute investigation, patients sometimes resort to certain expedients to deceive the practitioner. Perhaps

flour, starch (fig. 7), sand, and milk are more frequently employed for this purpose than any other substances. The microscope will obviously enable any one who is familiar with their characters to detect the first three. If milk be added to urine, the mixture may very readily be mistaken for a specimen of the so-called chylous urine. Although a considerable quantity of fatty matter is present in both cases, this fatty matter exists in very different states. In milk, we find the oil globules (fig. 8), characteristic of this fluid, while, in true chylous urine not a single oil *globule* can be found, although the specimen may contain a large quantity of fatty matter in a molecular state (fig. 9).*

Larvæ of the Blow-fly in Urine.—A specimen of urine containing several bodies of about half an inch in length, and of a rounded form, was once sent to Dr. Todd for examination. The bodies in question looked not unlike the larvæ of some large fly, but, as it was confidently affirmed that they were passed from the urethra of a gentleman, the accuracy of this view was doubtful. Upon placing a portion of one of them under the microscope, *tracheæ* (the air-vessels characteristic of the class of insects) were observed in considerable number. This circumstance alone of course enabled me to assert positively that they were not entozoa, and that they could not have been passed in the manner stated. They were afterwards proved to be the larvæ of a fly.

Fig. 10.



Branches of tracheæ from larva of a large fly, found in urine, × 215.

Fungus Disease of the Bladder.—I have on two or three occasions been able to diagnose the existence of malignant disease of the bladder, in consequence of finding small portions of the morbid growth in the urine, which have been detached accidentally or brought away in the catheter. My

* "Archives of Medicine," No. I.

friend and colleague, Professor Fergusson, once asked me to examine some small pieces of what appeared to be clotted blood, which had been passed in the urine of a patient under his care. On submitting one or two fragments to examination, I found they were covered with a tolerably thick layer of epithelium, beneath which I thought I could discern a loop of capillary vessels. Upon treating the fragment with a little solution of soda, the epithelial cells and the outline of the capillary vessel with blood corpuscles in its interior, became very distinct. From these characters one was able to say that, from the internal surface of the bladder a ragged fungus growth projected. From this, serious hæmorrhage took place, and it was probable that the powers of the patient would soon be exhausted. Every one is familiar with the terrible nature of this class of diseases, and with the general characters which such morbid growths usually present. Many of them, after having commenced to grow, increase in size very rapidly, giving rise to the greatest suffering, and lead to a fatal termination within a few months. The diagnosis is often difficult, and the nature of the case for some time obscure. Any fragments or small clots which should be passed or withdrawn in the eye of the catheter, ought to be submitted to careful microscopical examination. Sometimes, in this way, we are able to decide upon the real nature of the case at a much earlier period of the disease than would be possible if the general symptoms were alone taken into consideration.

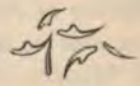
The claws of echinococci and portions of hydatid cysts

Fig. 11.



Echinococci. From the human subject, magnified 42 diameters.

Fig. 12.



Claws of Echinococci.

have on several occasions been discovered in vomit, sputum,

&c., upon submitting them to microscopical examination, proving beyond a doubt the existence of hydatids.

Substances passed by the Bowels.—If the practitioner have a good knowledge of the use of the microscope, he can often ascertain the nature of substances passed from the alimentary canal; and, by the aid of this instrument he is enabled at once to decide upon the nature and origin of substances, which, to the unaided eye, only present most doubtful characters. Considerable perplexity has arisen from the presence of bodies in the stools of patients, which afterwards proved to be portions of almonds, gooseberry skins, pieces of potato, the testa of the tamarind, husks of wheat, &c. Not many years ago the uredo of wheat was mistaken for, and described as, a peculiar fungus, to which it was supposed the phenomena observed in cases of cholera were due.

The yellow fibrous tissue of vessels which, unlike the other constituents of the food, have resisted the process of digestion, have been met with in the fæces, and mistaken for small intestinal worms, which they sometimes resemble when examined by the unaided eye. Upon being subjected to microscopical examination their true nature can always be discovered.

In Medico-legal Inquiries the microscope has often afforded important aid. The distinction between blood spots and red stains produced by fluids resembling blood in colour,—between human hair and that of animals,—and the detection of spermatozoa in cases of rape, need only be adduced as examples of the importance of the microscope in such investigations.*

For detecting Impurities in Food and Drugs the microscope has afforded important aid, and in chemical inquiries generally it is of the greatest use.

2. Arrangement of the Subject.—The different mechanical operations, the importance of examining various tissues, deposits from fluids, &c., the behaviour of these under the influence of chemical reagents, and other practical points

* "Illustrations of Urine, Urinary Deposits, and Calculi," page 48. "Archives of Medicine," Nos. I. and II.

bearing upon microscopical examination, will be especially dwelt upon in the following pages.

A general description of the instrument, and the various pieces of accessory apparatus, with directions for their employment, naturally forms the introduction to a work on the use of the microscope; but as this part of the subject is briefly discussed in a work recently published,* it will not be repeated here. For a description of all the beautiful instruments which have lately been invented I must refer the reader to the works enumerated in the note.†

The first part of the work will comprehend the consideration of the different practical operations which are of special importance to medical practitioners engaged in microscopical enquiries. This will include reference to the apparatus required, a description of the general plan of examining a specimen, the methods of drawing and measuring objects, of making minute dissections, the mode of injecting tissues, the examination of deposits from fluids, and the chemical examination of the solids and fluids with the help of the microscope.

The second part will comprise the various methods employed for the demonstration of tissues in a healthy and diseased state, morbid growths, the fluids and secretions of the body, animal and vegetable parasites, &c.

* "How to Work with the Microscope."

† Quekett on "The Microscope;" "The Microscope and its Revelations," by Dr. Carpenter; "The Microscope, its History, Construction, and Teachings," by Mr. Jabez Hogg; Hannover on "The Microscope;" Lardner on "The Microscope;" "Microscopical Journal." Those who read Dutch will find an excellent resumé of all the recent improvements in the microscope and accessory apparatus in the work of Professor Harting, just published, "De Nieuwste Verbeteringen van het Mikroskoop en zijn Gebruik sedert," 1858.

PART I.

THE APPARATUS NECESSARY FOR THE EXAMINATION OF OBJECTS OF INTEREST IN A CLINICAL POINT OF VIEW, OF THE PRACTICAL OPERATIONS REQUIRED FOR DEMONSTRATING OBJECTS, AND OF RECORDING THE APPEARANCES OBSERVED.

CHAPTER I.

Of the Apparatus necessary for Microscopical Examination.—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.—Of reducing Foreign Measurements to the English Inch.

In a practical work like the present it seems desirable, in the first place, to allude briefly to the kind of instrument and apparatus which the student will require to pursue clinical investigations. Under this head I propose only to include what is necessary; much which would be *advantageous* in special investigations is therefore omitted. It is unnecessary here to describe minutely the characters of the different pieces of apparatus, but their most important uses may be

gathered from the figures, and from the short explanation appended to each.*

MICROSCOPE AND ACCESSORY APPARATUS.

3. Microscope.—With large stage, firm tripod stand, coarse and fine adjustments, double mirror, and arrangement for inclining body; generally termed the *Student's Microscope*, which with two powers and bull's-eye condenser costs from five to ten guineas.† The general form of student's microscopes is shown in figs. 13, 14.

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.

5. The Diaphragm Plate.—Which should fit on beneath the stage, fig. 18.

6. The Bull's-eye Condenser.—A convenient form, is represented in fig. 16. It can be easily unscrewed and made to pack in a very small space. Fig. 17, represents a smaller one which is fitted into the stage of the student's microscope. The 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.

7. Achromatic Condenser.—Employed in the examination of objects by transmitted light. A simple plan of mounting as recommended by Professor Quekett, is represented in fig. 15.

8. Lamps for Artificial Illumination. — A small French moderator forms an excellent lamp for microscopical work.

* The instruments required in various branches of microscopical investigation, are described in "How to Work with the Microscope."

† Students' microscopes are now made by almost all microscope makers. Powell and Lealand, Ross, and Smith and Beck, are the best instrument makers, but the cheap instruments of Mr. Ladd, Mr. Matthews, Mr. Pillischer, and Mr. Salmon are worthy of special attention. To Mr. Salmon the credit of being one of the first to make a well-arranged cheap microscope is due.

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 strongly recommend the Argand gas lamp designed by Mr. Highley, fig. 19, but the purest artificial light is obtained from the camphine lamp of Messrs. Smith and Beck, fig. 20. All artificial lights are inferior to daylight, and every observer who can restrict himself to working by day should do so.

APPARATUS FOR DRAWING AND MEASURING OBJECTS, AND FOR ASCERTAINING THE MAGNIFYING POWER OF OBJECT GLASSES.

9. Neutral Tint Glass Reflector, fig. 21.—This fits on the eye-piece, the microscope being arranged horizontally, as in fig. 82.

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

11. Stage Micrometers *divided into* 100*ths and* 1000*ths of an inch.* These are represented magnified by different powers, in figs. 22, 23.

INSTRUMENTS AND APPARATUS FOR GENERAL PURPOSES.

12. Wire Retort Stand for supporting watch-glasses, &c., figs. 24, 25.

13. Tripod Wire Stands, figs. 26, 28.

14. Spirit Lamp, fig. 25.

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, fig. 30.

21. Scissars, ordinary form, and a small pair with curved blades, figs. 32, 33.

22. Needles, mounted in handles, for dissecting, fig. 31.

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, fig. 29.

24. Glass Dishes, of various sizes, from an inch to two inches in depth, for dissecting under water, fig. 39.

25. Loaded Corks, fig. 40.

26. Fine Pins.

27. Saw, with fine teeth, for cutting thin sections of bone and other hard tissues, fig. 35.

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.

31. Spirits and Water.

32. Glycerine.

33. Gelatine and Glycerine.

34. Solution of Naphtha and Creosote.

35. Chromic Acid.

36. Turpentine.

37. Canada Balsam.

38. Cells of various sizes, figs. 41—54.

39. Small Glass Shades, *to protect recently mounted preparations from dust,* fig. 36.

FOR THE SEPARATION OF DEPOSITS FROM FLUIDS.

40. Conical Glasses, figs. 65, 68.

41. Pipettes, figs. 66, 67.

42. Wash-bottle, fig. 64.

43. Animalcule Cage, fig. 53.

FOR MAKING INJECTIONS.

44. Injecting Syringe, holding from half an ounce to an ounce, fig. 60.

45. Pipes of various sizes, figs. 55, 56.

46. Corks for stopping the pipes, fig. 63.

47. Needle for passing the thread round the vessel, fig. 61.

48. Bull's-nose Forceps, for stopping vessels which have been divided, fig. 58.

49. For making Blue Injection.—*Ferrocyanide of potassium.* *"Muriated tincture of iron."* *Glycerine* and *spirits of wine* for preparing the *Prussian blue injecting fluid* (page 67).

CHEMICAL ANALYSIS IN MICROSCOPICAL INVESTIGATION.

50. Platinum Foil.

51. Test Tubes and Rack, fig. 71.

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, figs. 69, 70.

57. Wire Triangles, tripods, figs. 26, 28.

58. Small Retort Stand, fig. 24.

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. They are also furnished by most instrument makers.

STUDENTS' MICROSCOPE.

Fig. 13.



This instrument is now made by Mr. Salmon with a double pillar, which is preferable to the simple hinge joint originally used.

STUDENTS' MICROSCOPE.

Fig. 14.



Microscope designed by Mr. Highley, and made by Mr. Ladd.

Accessory Apparatus.

Fig. 15.



Achromatic Condenser, consisting of a French combination mounted in a simple tube and focussed with a lever motion, as suggested by Professor Quekett.

Fig. 16.



Bull's-eye Condenser, for condensing a st on objects.

Fig. 18.



Stage of students microscope. The diaphragm is indicated by the dotted lines It is fitted on beneath the stage. The stage should be at least three and a half inches from back to front, and two and three quarter inches from side to side.

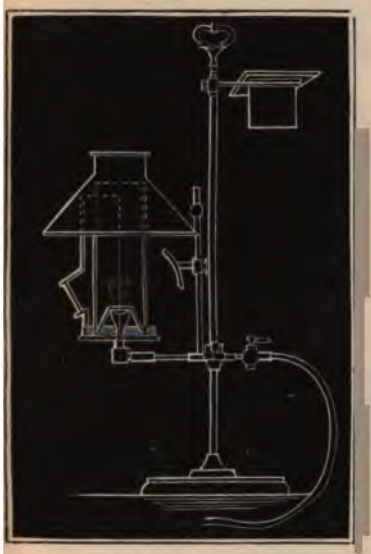
Fig. 17.



Bull's-eye condensor, to fit on to th

Lamps. Instruments for Measuring Objects, &c.

Fig. 19.



Mr. Highley's Gas Lamp for the Microscope.

Fig. 20.



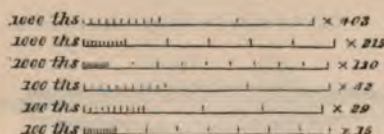
Camphine Lamp of Messrs. Smith and Beck.

Fig. 21.



Neutral tint Glass Reflector.

Fig. 22.



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

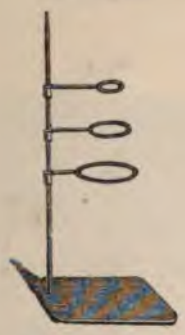
Fig. 23.



Stage Micrometer, divided to thousands of an inch. Magnified 215 times.

Instruments for General Purposes.

Fig. 24.



Small Wire Retort Stand, to support watch-glasses, &c.

Fig 25.



Spirit Lamp, to which a wire stand is attached for supporting watch-glasses, &c. This can be removed.

Fig. 26.



Tripod Wire Stand for supporting objects.

Fig. 27.



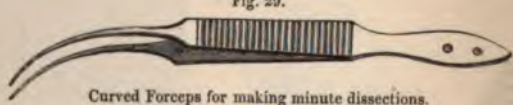
Plate Glass Stage for placing the glass slide upon, when acids or corrosive liquids are examined.

Fig. 28.



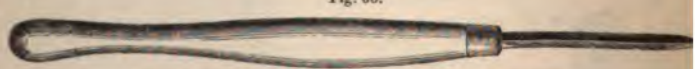
Porcelain Basin on tripod wire stand.

Fig. 29.



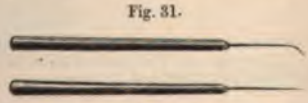
Curved Forceps for making minute dissections.

Fig. 30.



Double-edged Scalpel for cutting thin sections of soft tissues.

Fig. 31.



Needles fixed in handles for dissecting.

Fig. 32.



Curved Scissars for cutting thin sections of tissues.

Fig. 33.



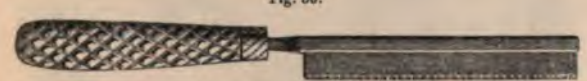
Fine Straight Scissars for dissecting.

Fig. 34.



Forceps for removal of small portions of viscid Sputum, for microscopical examination

Fig. 35.



Saw for cutting thin sections of bone and other hard tissues

Fig. 36.



Glass Shades for keeping preparations in process of examination or mounting, from the dust.

Cements. Dissecting under Water, &c.

Fig. 37.



Tin Pot for holding Canada balsam. This can be warmed if desired.

Fig. 38.



Glass Bottle for containing different cements.

Fig. 39.



Arrangement for dissecting objects under water. The bull's-eye condenser is larger than those represented in figs. 16 and 17.

Fig. 40.



Loaded Cork for pinning objects upon for the purpose of dissection.

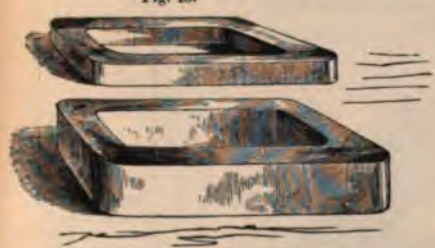
Cells for Examining and Preserving Microscopical Specimens.

Fig. 41. Fig. 42.

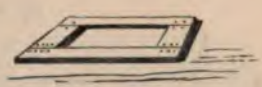


Small Cells for preserving injections and other opaque preparations.

Fig. 43. Fig. 44.



Larger Cells for preserving opaque preparations.



Cell, made by cutting a piece out of the centre of a portion of plate glass. The corners are marked so that the corresponding strips may be made to fit accurately, when cemented with marine glue to the glass slide.

Fig. 45. Fig. 46.



Thinner Glass Cells, made by grinding out the centre from a piece of plate glass. All these cells are fixed to strips of plate glass by marine glue.

Fig. 47.



Brass Plate, heated by Spirit Lamp, for warming slides when it is required to cement to them one of the above cells with the aid of marine glue. This is also required in mounting objects in Canada balsam.

Cells for Examining and Preserving Microscopical Specimens.

Fig. 48.



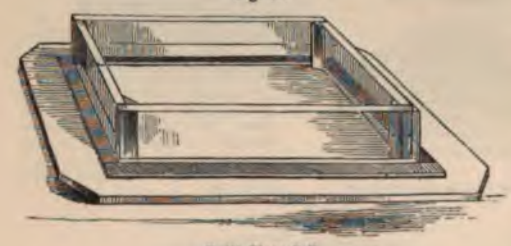
Glass Cell, made by bending a strip of glass in the blowpipe flame.

Fig. 52.



Thin glass Cell, for examining deposits from fluids, mounting preparations in fluid, &c.

Fig. 49.



Built Glass Cell.

Fig. 50.



Glass Cell, obtained by grinding a concavity on the surface of a piece of thick plate glass.

Fig. 53.



'Animalcule Cage' (made by Messrs. Powell and Lealand), for examining deposits from fluids.

Fig. 51.



This drawing shows the manner in which the thin glass, after having been breathed upon, is allowed to fall upon the surface of a preparation immersed in fluid.

Fig. 54.



This figure shows the manner in which cells are made of Brunswick black by means of Mr. Shadbolt's apparatus.

Apparatus for Injecting.

Fig. 55.



Stopcock and Injecting Pipe, which fit on to the Syringe, fig. 60.

Fig. 56.



Fig. 57.



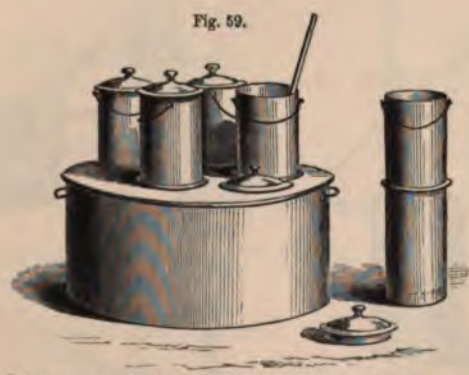
Performing the Operation of Injecting.

Fig. 58.



Bull's-nose Forceps for stopping vessels from which injection is escaping.

Fig. 59.



Injecting Can for heating size. It is also used as a water bath, for drying objects, or for conducting evaporation, when the cans are removed.

Fig. 60.



Small Syringe used for injecting.

Fig. 61.



Needle for passing thread round a vessel which is to be tied upon the pipe

Fig. 62.



Section of piston of injecting syringe, showing the manner in which the leather is applied.

Fig. 63.



Corks for stopping pipes when the syringe not provided with a stopcock is refilled with injection.

Apparatus for Collecting Deposits, Testing, &c.

Fig. 64.



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.

Fig. 65.



Conical Glass, for allowing deposits from fluids to subside. The drawing shows the manner in which a portion of the deposit is to be removed with the pipette.

Fig. 66. Fig. 67.



Pipettes for removing deposits from fluids.

Fig. 68.



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

Fig. 69.



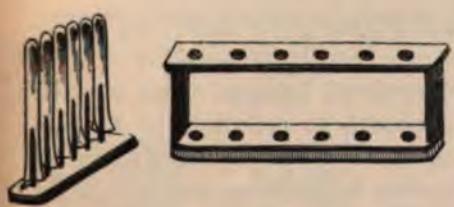
Bulb, with capillary orifice, for testing small quantities of matter.

Fig. 70.



Small Tube, with capillary orifice.

Fig. 71.



Test Tubes, Rack, and Drainer.

Fig. 72.



Retort Stand, Funnel, and Glass, arranged for filtering.

Of Examining Objects.

Although it is not within the limits of the present work to describe fully the anatomy of healthy and morbid tissues, I shall attempt to give a short account of the healthy and morbid appearance of those textures which most frequently engage the attention of the physician; and shall, as far as

possible, enter fully into the various methods at our disposal for demonstrating the anatomy of healthy and diseased structures. 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 standard 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.

Fig. 73.



Fig. 74.



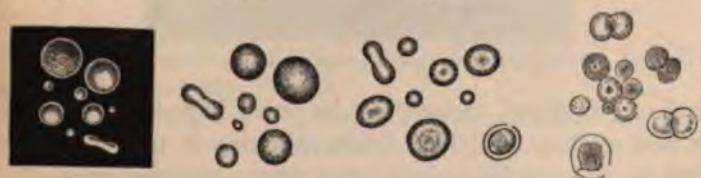
These figures show the different appearance of an object when viewed by reflected and transmitted light. Crystals of oxalate of lime, fig. 73 by reflected, and fig. 74 by transmitted light.

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). Figs. 79 and 80 show the mode of arrangement of the instrument and light for the two methods of examination; but for further information, the reader is referred to "How to Work with the Microscope." 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 serum, glycerine, or other solution, is then added,

and the whole covered with a clean square 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 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. 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

Fig. 75. Fig. 76. Fig. 77. Fig. 78.



These figures show the different appearance of the same object viewed by reflected and transmitted light, and in different media.
Carbonate of lime from horses' urine; fig. 75, as seen by reflected light; fig. 76, by transmitted light in air; fig. 77, in water; fig. 78 in Canada balsam.

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 than 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

Fig. 79.

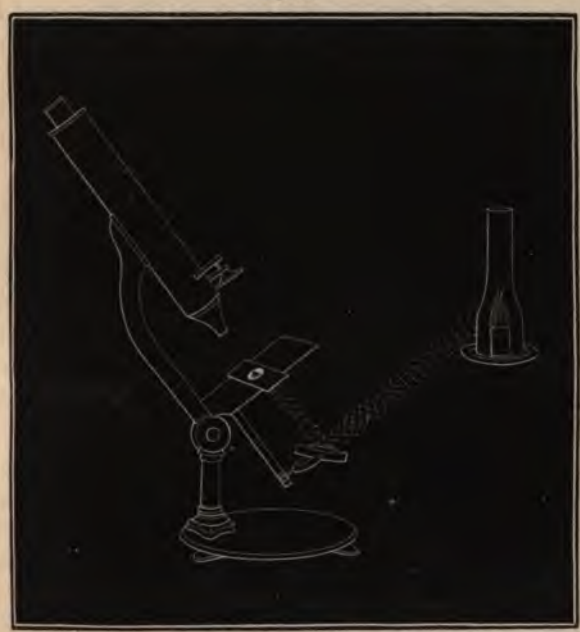


Arrangement for examining objects by Reflected Light.

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, allow-

ance must always be made for this great transparency of the fibrous tissue. The composition and method of using dif-

Fig. 80.



Arrangement for examining objects by Transmitted Light.

ferent preservative solutions, are fully discussed in "How to Work with the Microscope," and, therefore, need not be again referred to here in detail.

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 alone, but must trust 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 avoid drawing most erroneous conclusions; and those who cannot, or are unwilling to make such a sacrifice, 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 advantage of the best tuition, is hardly so likely to become a useful, earnest labourer in this field of inquiry, as 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 deter-

mination 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.

Every observation should be carefully recorded in a note-book at the time it is made, and drawings made if necessary. It is very important that when descriptions of appearances are added, the language used should be as simple as possible, and the use of technical terms, unless the meaning has been very accurately defined, should be avoided.

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 careful they may be, cannot possibly 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 already discussed in the work above alluded to, it is so important that I consider it necessary to repeat it 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*, fig. 81, 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. The disc is smaller than the aperture of the pupil, and the pencil can at the same time be seen very well as it traces the image apparently thrown down upon the paper beneath.

Fig. 81.



Steel Disc placed at an angle of 45°, to fit on to the eye-piece of the microscope.

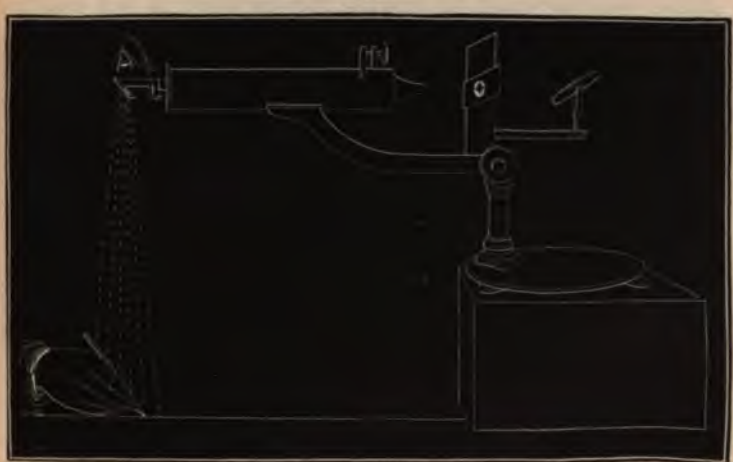
77. Neutral Tint Glass Reflector. — The simplest and cheapest reflector for microscopical drawing, consists of a

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. This is also arranged at an angle of 45° with the eye-glass, and the draughtsman can very easily follow his pencil upon the paper.

In order to use these instruments, the microscope is arranged horizontally, and the paper placed on the table, fig. 82.

It is important, however, in using these instruments, to arrange the light 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 pre-

Fig. 82.



cisely the same as from the object to the eye-piece, for otherwise the size of the object delineated will be altered.

In fig. 82, the microscope is arranged for copying an object in the manner just described. 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 by proceeding in the manner described in page 44.

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 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 upon the prepared block, 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 reproduced by 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 fac-simile 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 is a very transparent paper, obtained by soaking tissue paper in some oily material, and allowing it to dry.

Retransfer Paper consists of transfer paper, upon one side of which a fine red or black powder has been rubbed, which adheres to the paper pretty firmly, but which, at the same time, may be made to adhere to another surface by firm pressure.

Wood blocks are *prepared* by rubbing a little dry carbonate of lead and brick dust moistened with water upon the surface, and allowing a very little to dry on. In this way a smooth white surface is obtained, admirably adapted for receiving the most delicate drawing. It is well to moisten the white lead with a little gum water, which makes it adhere firmly to the surface.

79. Of obtaining Lithographs of Microscopical Drawings.—I think it desirable to give a few directions for drawing on stone, as I believe there are many observers who would willingly give up the necessary time required to place their work on the stone, who could not afford to employ a lithographic artist. I have myself made many drawings in this manner, and with the help of a boy who could at first draw but little, have been able to publish numerous drawings, which are very accurate copies of the objects, although in execution will not bear comparison with artists' work.*

Drawing on Transfer Paper.—If the drawing does not contain much very minute work, it may be drawn on properly prepared transfer paper with lead pencil, direct from the microscope (page 35). 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

* "Illustrations of Urine, Urinary Deposits, and Calculi." The "Archives of Medicine."

chalk. The latter plan, however, is not well adapted for making transfer drawings. The drawing is then to be sent to the lithographic printer, where it is damped, placed downwards on a dry stone, and after being subjected to firm pressure, the paper may be peeled off, leaving the preparation, with the drawing, on the stone. The latter is removed with water, the drawing properly set, and then the printing ink applied with the roller.

Drawing on the Stone.—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. When much shading is required, and extreme delicacy of outline is unnecessary, the outline is first made on paper, and the drawing retraced on the stone in the manner designated in page 36; the outline may then be traced with ink, a pen, or very fine sable hair brush, being used for the purpose; the shading is to be given with chalk. The chalk is to be very finely pointed by cutting downwards, the point being uppermost (as in pointing an ordinary chalk crayon), and held in a handle made out of a common quill. The lines are to be made very gently, repeating the strokes frequently with a light hand, when depth of colour is required, rather than by leaning heavily so as to remove a considerable quantity of chalk at once, and deposit it upon the stone. When chalk shading is employed, a finely *grained* stone is required.

Of Engraving on Stone.—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. The stone must be finely polished, and it is well to have it tinted with a little infusion of logwood, or to cover it with a thin layer of lamp black, which enables the draughtsman to see his strokes better. The outline of the drawing is traced as before, and then the lines scratched upon the stone with a very fine point. A needle point, previously hardened by being heated

red hot and suddenly dipped in cold water, inserted into a strong handle, or a diamond point, may be used. I generally use an etching needle; the point requires to be sharpened from time to time upon a hone. The dark parts are shaded by lines placed very close together, or cross shading may be adopted, or the tint may be given by dots, as in copper-plate engravings. Generally it is better to try to obtain the appearance of texture by copying, as nearly as possible, the character of the shading of the object itself. The thickness of the line in the print will depend upon the width of the line, without reference to the depth to which it extends into the stone. It is desirable to make two or three narrow lines near to each other, instead of one wide one, when a thick line is required. After all the lines have been scratched, the stone is sent to the lithographic printer, who will obtain impressions from it. The oily material only adheres to the rough scratches, and subsequently when the stone is wetted, the ink only attaches itself to the oily parts. Plate I. and II. are examples of engraving on stone.

Transfer Paper is prepared for the purpose, that which was made of India paper, I found answered exceedingly well.*

Lithographic Ink.—The ink may be obtained in the fluid state, but it is better to use the solid ink, a little of which is rubbed up with water when required.†

Lithographic chalk may be obtained of different degrees of hardness,—it can always be made much harder by melting it and rolling it into sticks.

The stones are sold by the pound. It is desirable to obtain stones large enough to hold four octavo pages of

* To be obtained of Messrs. Harrison and Sons, St. Martin's Lane.

† The apparatus, ink, chalk, &c. alluded to, can be obtained of Messrs. Waterlow, Messrs. Hughes and Kimber, Red Lion Court, Fleet Street, and most lithographers. It is only due to Messrs. Harrison, of St. Martin's Lane, that I should thank them for the kindness they have always displayed in assisting me in carrying out this and many other plans of producing drawings. Without the important help they and their workmen have afforded me on all occasions, my efforts would probably have failed, as I had no knowledge of practical lithography.

drawings, as the expense of working a stone of this size is little more than that only large enough to contain one.*

* It will, I know, be said that these processes take much time, and after all are of a nature which an intelligent draughtsman can perform, and 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, nevertheless I cannot but feel that if I had been prevented from having the drawings made at home, not one of the pages illustrating my works would have been published. I remember how much I needed at one time the little information given here—and I therefore gladly communicate it, imperfect as it is, in case there may be others in the same situation as myself. Now, I believe that it is 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. Neither is it possible that any one man can make himself fully conversant with all the beautiful minutiæ in every branch of microscopic inquiry. It is true that Mr. Tuffen West and one or two other gentlemen have taken up this kind of drawing and engraving, and have produced most beautiful results. I believe Mr. West's success to be due to the interest he takes in the subject, and to his being himself a practical observer.

There are many drawings of microscopic objects which ought to be published, and although these may be of little interest to persons generally, are absolutely required by those who are working at special subjects. Now, however rich a man may be, it is doubtful if a large sum of money should be spent in employing artists to do work which, however well skilled they may be, they cannot do so truthfully as the observer himself, unless they had devoted the same attention to the subject. Few have time or inclination to do this. There is not the same question about our own time. Whatever is worth doing at all, is worth an expenditure of time, is worth doing well—though it may involve some sacrifice on our part—and is worth recording. Whatever is observed is worth copying, provided it has not been correctly copied before. It would, I think, be quite possible for many to learn the process of drawing on stone, and thus engrave many drawings of great use which would not otherwise be published.

Very much yet remains to be done in representing microscopic texture faithfully. Photography has done much, and will, doubtless, 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.

All advance in our knowledge of structure, as well as of the minute changes incessantly going on in living organisms, doubtless depends, in great measure, 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.

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

80. On Measuring the Diameter of Objects.*—Instead of alluding to the dimensions of an object in the text, it is

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 meaning which different persons attach to words and phrases, introduces another difficulty in our attempt to collate and deduce inferences from the observations which have been made.

Take for instance the structure of tumors. Although we possess observations without end, we are not yet able to group them under general heads, nor are we acquainted with their mode of origin, or conversant with the changes which take place in their anatomical elements at different periods of their growth. Much difficulty has arisen from the attempts to assign definite names to various growths, while the precise characters included under any particular term, have never been properly defined—and it is doubtful if this can be done, except by a nomenclature, the complex nature of which would be fatal to its introduction. Now surely our knowledge on these and other subjects would have been much more extensive and more accurate, if instead of long descriptions, we had been furnished with sketches of the morbid growth, its dimensions and weight, the length of time it had been growing, and a few general points in the history of the case, with accurate drawings of the minute structure of the tumor. It is true that all persons cannot draw well, but a very little patience will enable any one to copy a microscopical specimen, and an accurate copy, although it be very badly executed, has an aspect of truth which is unmistakeable, while a drawing which is offspring of the imagination instead of a simple copy of nature, bears the mark of untruth in every line, however elaborate and unexceptionable its execution may be. Errors of observation are, I believe, much more easily detected in a drawing than in verbal description. A mistake or misinterpretation expressed in a drawing can, and at length must be, corrected by subsequent observation, while ill-observed or misinterpreted facts, cloaked in obscure language, may be propagated for years, and no matter how false they are, it may be very difficult to refute them. I would, therefore, urge upon every one the importance of making drawings at whatever cost of time and labour; it is worth any sacrifice to do really good work, and if every observer could but record a few accurate observations during his life, the united labour would indeed be productive of great results.

I would also strongly urge upon observers the importance of at once agreeing upon some general plan of delineating objects, so that our observations may be useful to each other, while the task of those who will hereafter have to arrange and deduce conclusions from our work, will be much facilitated. The value of the beautiful drawings in the Pathological Society's transactions, would be greatly increased if a scale of 100ths or 1000ths of an inch were appended to them, and the magnifying power of the object glass stated. This would not have added five minutes to the time required for the task, while it would have rendered the drawings comparable with each other. In some, the magnifying power is not even mentioned, and in others there is reason to believe it is wrongly stated.

Every one who copies an object should state the magnifying power of the

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

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 readily ascertained. 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 comparing the representation of the same object delineated by different observers, it will be often found that great confusion has been produced in consequence of the magnifying power of the object-glass not having been accurately ascertained, and an object said to be magnified the same number of times by two authorities, is not unfrequently represented much larger by one than by the other. This discrepancy in most cases arises from the magnifying power of the glasses not having been accurately ascertained in the first instance.

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

The plan of appending to every microscopical drawing a scale magnified in the same degree as the object represented, supersedes the necessity of giving measurements in the text, while it is free from any of the objections above referred to. With very little trouble, every one can prepare scales for himself.

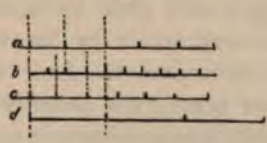
combination of lenses he employed, and should append a scale magnified by the same combination, page 44.

Let it not be supposed that I am insensible to my own shortcomings in these and many other matters. I am conscious that every drawing I have published might have been, and ought to have been—better,—and I can only hope that the desire for seeing our work useful to each other and to our successors, as well as to ourselves, will be received as a sufficient apology for the remarks in this long note, which can hardly have escaped the charge of presumption.

To carry out this, it is necessary to ascertain the magnifying power of every object-glass, and to be provided with a stage micrometer divided into 100ths and 1000ths of an inch.

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, fig. 82. The neutral tint glass-reflector is fitted to the extremity of the eye-piece, and the light carefully adjusted so as to render the micrometer lines distinctly visible. Care must, however, be taken that

Fig. 83.



a. 1000ths of an inch magnified 200 times.
b. Inch scale divided into tenths.
c. 1000ths of an inch magnified 130 times.
d. 100ths of an inch magnified 40 times.
Each magnified 1000th of an inch covers two-tenths, or one-fifth of an inch, therefore the glass magnifies 200 times, for $\frac{1}{1000} \times 200 =$ two-tenths, or one-fifth of an inch. Each 100th of an inch covers four-tenths of an inch, therefore the glass magnifies 40 times for $\frac{1}{100} \times 40 =$ four-tenths.

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, forty diameters; and so on, each tenth of an inch corresponding to a magnifying power of ten times. This will be understood by referring to fig. 83.

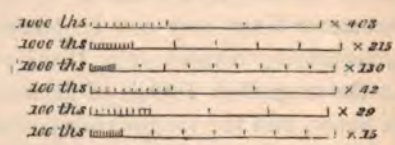
If we wish to ascertain the magnifying power of one of the higher object-glasses, a micrometer divided into 1000ths of an inch should be employed instead of the one

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.

In order to apply this plan to microscopical drawings generally, the following seems to be the simplest method of proceeding, and saves much trouble. Scales are carefully drawn upon gummed paper; the magnifying power, and the micrometer employed being written against them as represented in fig. 84. If a number are drawn together, one of the rows can be cut off and appended to the paper upon which the drawing, magnified in the same degree, has been made. This is the plan I have followed in all the drawings which illustrate my observations, and the scales have been

Fig. 84.



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

copied in the wood-cuts and plates. All magnifying glasses of the same focus do not magnify in precisely the same degree, so that it is necessary for every observer to ascertain for himself, the magnifying power of his lenses. Little tables may be readily constructed in the manner I have described.

In order to make an accurate microscopical drawing, the image of the object is carefully traced on paper with the aid of the glass-reflector, and afterwards finished by the aid of the eye alone (page 35). In order to obtain the size accurately, care must be taken that the distance between the reflector and the paper is the same as that between the former and the object-glass. The drawing having been finished, one of the scales made as above-described may be gummed on in one corner of the paper.

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. The accompanying table of Dr. Robertson's will be found of great use in making these calculations.*

* "Edinburgh Monthly Journal of Science," January, 1852.

To convert—	1	2	3	4	5	6	7	8	9	
1. British inches into Millimetres.....	25·39954	50·79908	76·19862	101·5982	126·9977	152·3972	177·7968	203·1963	228·5959	Millimetres.
2. Do. Old Paris Lines...	11·25936	22·51872	33·77808	45·03744	56·29680	67·55616	78·81552	90·07488	101·33424	Paris Lines.
3. Do. { Rhineland or Prussian Lines }	11·65275	23·30550	34·95824	46·61099	58·26384	69·91649	81·56923	93·22198	104·87473	Prussian Lines.
4. Millimetres into British Inches.....	·03937079	·07874158	·11811237	·15748316	·19685395	·23622474	·27559553	·31496632	·35433711	British Inches.
5. Do. Old Paris Lines...	·44329	·88658	1·32987	1·77316	2·21645	2·65974	3·10303	3·54632	3·98961	Paris Lines.
6. Do. { Rhineland or Prussian Lines }	·45878	·01756	1·37633	1·83511	2·29389	2·75267	3·21145	3·67022	4·12900	Prussian Lines.
7. Old Paris Lines into British Inches	·088815	·177630	·266445	·355260	·444075	·532890	·621705	·710520	·799335	British Inches.
8. Do. Millimetres.....	2·25586	4·51172	6·76758	9·02344	11·27930	13·53516	15·79102	18·04688	20·30274	Millimetres.
9. Do. { Rhineland or Prussian Lines }	1·03494	2·00988	3·10482	4·13976	5·17469	6·20963	7·24457	8·27951	9·31445	Prussian Lines.
10. Rhineland or Prussian Lines into British Inches.....	·085817	·171633	·25745	·343267	·429083	·51490	·600717	·686532	·77235	British Inches.
11. Do. Millimetres.....	2·179704	4·359408	6·539112	8·718816	10·89852	13·07822	15·25793	17·43763	19·61734	Millimetres.
12. Do. Old Paris Lines...	·9662407	1·9324814	2·8987221	3·8649628	4·8312034	5·7974441	6·7636848	7·7299255	8·6961662	Paris Lines.

Illustrations of Use of the above Table.

I.—EXAMPLE.

Given 245·9003 Paris Lines. Required the value in British Inches.

By line seven of Table—

Old Paris Lines.		British Inches.
200	=	17·7630
+ 40	=	3·55260
+ 5	=	·444075
+ ·9	=	·0799335
+ ·0003	=	·0000266445
		21·8396351445 British In.

II.—EXAMPLE.

Given ·00215 Millimetres. Required the value in British Inches.

By line four of Table

Millimetres.		British Inches.
·002	=	·00007874158
+ ·0001	=	·000003937079
+ ·00005	=	·0000019685395
		·0000846471985 British In.

III.—EXAMPLE.

Where extreme exactitude is not required, only one or two decimal places need be used. Thus—

Given 21·8396 British Inches. Required the value in Paris Lines.

By line two of Table—

British Inches.		Paris Lines.
20	=	225·19
+ 1	=	11·26
+ ·8	=	9·01
+ ·04	=	·45
		245·91 Paris Lines *very nearly*.

Data, from which the Table has been calculated, extracted from Mr. Woolhouse's Table in the "Encyc. Metropolitana."—British foot = 1. Metre = 3·2808992. Old Paris foot = 1·06578. Rhineland or Prussian foot = 1·0298.

CHAPTER II.

Methods of Examining Tissues.—Preliminary Operations.—Of Hardening Tissues.—Of Cutting Thin Sections of Soft Tissues.—Instruments.—Of Dissecting under Water.—Of Injecting.—Examination of Deposits from Fluids, and of their Preservation.

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 cannot be effected 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 permit of being cut with a knife.

By simply drying a tissue we are sometimes able to make out a point in its structure, which had entirely eluded our observation when it was examined in a recent state, and there are other processes of practical importance in the demonstration of minute structures, which will be considered.

PRELIMINARY OPERATION IN EXAMINING TISSUES.

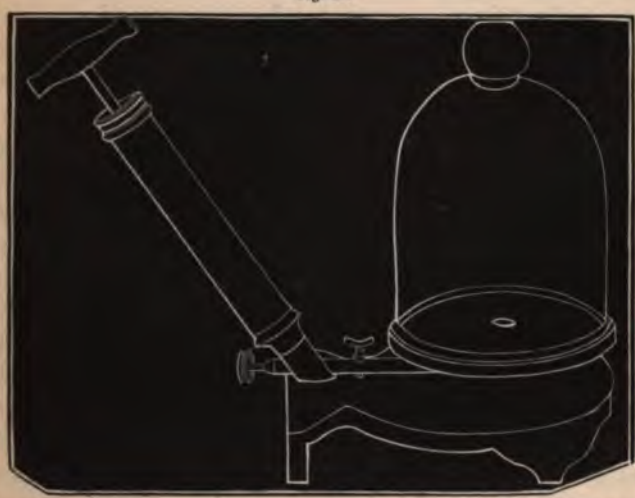
85. Of Hardening Tissues by Boiling. — This operation is often of great service in enabling us to demonstrate the structure of a tissue. For instance, the fibres of which the crystalline lens is composed, are best shown after boiling the lens in water. The branched muscular fibres in the tongue of the 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 examined, as well as that 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 character of the tissues which remain. In these operations the wash-bottle, fig. 64, 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*.

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

Fig. 85.



Small Air Pump, for drying objects at the ordinary temperature, for mounting in Canada balsam, &c. Made by Mr. Matthews.

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, 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, and supported on a piece of coarse wire gauze over sulphuric acid. The process is expedited by exhausting the air, which may be readily effected in the small hand air pump, fig. 85.

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 obtained in this manner. The ignition should be performed in a small platinum capsule, supported on a tripod (figs. 26, 27), 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. Thus, the addition of a little

alcohol often demonstrates the presence of a membrane where none could be seen previously. Chromic acid exerts a similar effect in rendering perfectly transparent structures composed of an albuminous substance, granular, and often demonstrates an arrangement of the tissue which was before invisible. 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 sesquichloride of iron, &c., effect a very important alteration in many perfectly transparent tissues.

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, if the structure be allowed to soak in it for some little time.

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. 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.

The chief value of *acetic acid* in rendering tissues transparent, is due to its power of dissolving earthy salts, such as phosphate and carbonate of lime, and rendering transparent certain forms of albuminous matters, especially the granular matter which exists within the cell wall in many instances. Acetic acid also causes white fibrous tissue to swell up and become perfectly clear, while all traces of its fibrous appear-

ance is lost. On all varieties of yellow elastic tissue, however, it exerts no action.

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 imbedded in it, which are known to be soluble in acetic acid. In such a case alkalies are 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.

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. Alcohol, and various saline solutions, as alum, bichloride of mercury, arsenious acid, &c., render most tissues too granular and opaque for microscopical 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, 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 many fatty substances. 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. By mixing together some of these solutions, having opposite properties, compound fluids may be obtained, which will exert different effects upon tissues according to the proportion of the different constituents they contain. 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 beautiful 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 inquiry, although he himself had but only commenced his researches. Dr. Lenhossek, of Vienna, has adopted Mr. Lockhart Clarke's plan, and has made some very beautiful specimens, which he exhibited in London a short time since.*

* These are now 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 are required to have.

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 occur to the mind of every practical observer, according to the properties which he desires it 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 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 third month, is given in fig. 87, and in fig. 86 one about the end of the second month is represented. The first was prepared four years ago (1853–4), and perfectly 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.*

Fig. 86.



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.

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

* "On the Anatomy of the Liver," page 2.

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. This plan was first used by Mr. Lockhart Clarke, for the preservation of his specimens of the spinal cord, and has been subsequently adopted by Dr. Lenhossek. Thus, although Canada balsam does not possess the

Fig. 87.



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.

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 under ordinary circumstances do not possess the property of wetting them.

To Cut Thin Sections.

31. 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 the success which attends his investigations mainly depend. The harder and more complicated the tissue may be, the more important is it to obtain a section of extreme tenuity, for otherwise 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 each other, as to prevent the possibility of any one being defined clearly, although the tissue is tolerably transparent.

Cutting a thin section of a soft tissue may at first sight appear a very simple process, but it will be found to require some skill on the part of the operator. 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 motion 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 [illegible] which the preparation is immersed.

The most important instruments for making thin sections of soft tissues are the following: scissars of different sizes, figs. 32, 33, Valentin's knife, figs. 88, 89, double-edged scalpels, fig. 30, or lancets mounted in handles, and a few other instruments, such as forceps, fig. 29, and needles of different sizes, fig. 31, mounted in handles, are often required in demonstrating minute structure. Tissues which have been hardened are 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.

92. Instruments for Cutting Thin Sections of Soft Tissues.—*Double-edged Scalpel.*—For cutting thin sections, a knife of the form represented in fig. 30, 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.

Common Lancets mounted in handles will be convenient for cutting 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 form for this purpose, is that shown in fig. 32. When only very small portions of a tissue are required for examination, they will be removed with scissars more easily than with any other instrument.

93. 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

Fig. 88.



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 employed; 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. 88. The best form of Valentin's knife that I have made use of, is that represented in fig. 89, which

Fig. 89.



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, which renders it much cheaper, without in any way impairing its usefulness. The knife may now be purchased from 10*s*. 6*d*. to 12*s*. 6*d*.

94. Of the Use of the Compressorium.—Not unfrequently it is 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, fig. 90, which consists simply of a mechanical arrangement, by which we are enabled to apply a certain amount of pressure, which can be increased or diminished at pleasure, and regulated at will, upon the thin glass covering an object. The compressorium consists of a flat piece of brass, with a small ledge on

Fig. 90.



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. A compressorium, made at the suggestion of my friend, Dr. Branson, also possesses this advantage, but the slide is held in its position by springs, an arrangement which

is not so simple as the ledge of brass in the instrument just described. The compressorium is made by Messrs. Powell and Lealand. 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 this consistence, are, in the first place, cut into thin slices with a saw, fig. 35. 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. The method of preparing sections of teeth, hair, nails, and other hard tissues, is described in page 55 of "How to Work with the Microscope."

Of Making Dissections.

96. Of Dissecting under Water. — Minute dissections of 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, figs. 48, 49, make very good troughs for dissecting in, but small circular vessels are made for the purpose.

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 then cut 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, fig. 40.

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

Fig. 91.



Small Spring Scissars, for making minute dissections.

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 this 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. 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 fig. 39.

Tablets upon which Dissections may be Pinned out.— Many preparations require to be arranged in a particular position, previous to 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 easily be 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 of many tissues are not distinguishable as such, in preparations examined in the ordinary way. By looking at uninjected preparations, 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 are often collapsed, and in the manipulation necessary for preparing a microscopical specimen, are inevitably pressed and somewhat stretched and torn. In such a specimen the vessels cannot be distinguished from a form of fibrous or connective tissue, which is very common, and in not a few instances, have been so described. In investigating the anatomy of morbid growths, still greater confusion has arisen from the same cause, and it is hardly to be expected that we shall be able to ascertain the nature

of these, 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, determined. It is obviously impossible to ascertain these points without 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 substance, for this would prevent the possibility of the surrounding structures being seen at the same time. For investigations, therefore, of this class, the materials usually 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 structures are invariably altered or destroyed by this process. In such preparations, vessels occupying very different positions all appear on the same plane, and it is impossible to distinguish if a particular branch is really continuous with another, or if the apparent continuity results merely from one lying exactly in front of 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 the use of injections 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. 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 can tissues be so surely subjected to the action of these, as by injecting them into channels from which their absorption is imme-

fluate, while all parts of the tissue are acted upon by a solution of uniform strength?

In order to inject satisfactorily the most minute vessels of a tissue, and at the same time to demonstrate their relation to adjacent structures, one 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 tissue indiscriminately, and would thus prevent the vessels from being distinguished from other textures. Though insoluble, the particles of which the colouring matter is composed must 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 amount of 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 fine 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 for some time. It should be cheap and readily prepared.

The injected specimens must permit of examination with a power of at least 200 diameters.

97. Prussian Blue Injecting Fluid. — 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, 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. 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 studies. 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, but is removed by alkalies. Capillaries thus injected may be examined by the eighth of an inch object-glass.*

In using this fluid, it is not even necessary that the pipe should be tied in the vessel, but when this cannot be effected readily, the injection may be driven as the pipe lies loosely

* "Archives of Medicine," No. I.

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. A quantity of injecting fluid is lost in the process, but as the expense of making the fluid is very little, it is immaterial.

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

Composition of the Prussian Blue Fluid for Making Transparent Injections:—

Glycerine	1 ounce.
Wood naphtha, or pyroacetic spirit	1½ drachms.
Spirits of wine	1 ounce.
Ferrocyanide of potassium	12 grains.
Tincture of sesquichloride of iron	1 drachm.
Water	4 ounces.

The ferrocyanide of potassium is to be dissolved in one ounce of the water, and the tincture of sesquichloride 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 sesquichloride of iron is recommended because it can always be obtained of uniform strength. It is generally called the *muriated tincture of iron*, and may always be purchased of druggists.

98. 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 hydrochloride acid ..	½ ounce.
Glycerine	1 „
Alcohol	2 drachms.
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.

99. Of practising the Operation of Injecting.—The student will find that the process of injection will be learned after a few trials, and although in the first attempts he should fail altogether, I would earnestly recommend him not to give up the attempt, as this mode of investigation is of the greatest 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 clean and in working order, with pipes, stopcock, and corks, figs. 55, 56, 60, 63.

One or two scalpels, fig. 30.

Two or three pair of sharp scissars, figs. 32, 33.

Dissecting forceps, fig. 29.

Bull's-nose forceps, fig. 58.

Curved needle, threaded with silk or thread, the thickness of the latter depending upon the size of the vessel to be tied, fig. 61.

Wash-bottle, fig. 64.

Injecting fluid in a small vessel.

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, and the thread seized with 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 being first forced into the wide part of the pipe so as to prevent the possibility of any air being included, fig. 57.

The pipe and syringe being still held with the left hand, the piston is slowly and gently forced down with a slightly screwing movement with the right, 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 branches into which the pipe is to be inserted, must be carefully dissected out in the first instance. When the trunk is small, much difficulty will occur 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. 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 considerably, and soon water transudes into the follicles of the gland, and passes along the ducts, which, in consequence, become so much distended as to be easily found; while at the same time, they are completely washed out, and any epithelium or secretion which would interfere with the course of the injection, removed. An opening can readily be made in the wall, a pipe inserted, and the tube tied over it. Next, 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 in the most favourable state for receiving injection. A pipe may frequently be inserted into a small lymphatic vessel 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. In consequence of the capillaries lying on different planes, being completely filled, the whole looks of a uniform colour, and cannot be distinguished from a mass of extravasation. With the Prussian blue fluid, 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. 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.

101. Of Impregnating Tissues with Preservative and other Solutions, by the process of Injecting.—The process of injection may be employed for other purposes than 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 dwelt upon (page 51). 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 immersed. In the ordinary manner in which tissues are prepared, especially if they be very thick, the fluid in which they are placed is a long time penetrating 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, it is found that decomposition has commenced before the preservative solution has permeated every part of the structure. Now all these inconveniences may be avoided by injecting the vessels of the part 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 surrounded 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 also makes the tissues transparent, and at the same time acts the part of a preservative solution.

By acting in this manner, many fallacies are guarded against. Uninjected and contracted capillaries have often been mistaken for a form of fibrous tissue; the loop-like arrangement of vessels in some textures has produced an appearance which has been mistaken for epithelial cells; and 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 epithelium in either of the above localities. 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, gives diagrams of it still adhering to partially injected vessels.* The delicate epithelium existing in the minute gall ducts, is not unfrequently found still adhering to the basement membrane, not only after they have been thoroughly washed out with water forced through them in one direction, but injected with fluid in an opposite one.

Examination of Deposits from Fluids, and of their Preservation.

The most important pieces of apparatus required in the examination of deposits which subside from fluids, are the following:—Test tubes, fig. 71; pipettes of different sizes, conical glasses, wash-bottle, fig. 64; watch-glasses, funnels for filtering, fig. 72; and cells in which the deposit may be subjected to microscopical examination, figs. 52, 53.

102. 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

* Dr. Isaacs, in a paper on the Anatomy and Physiology of the Kidney, published in the Transactions of the New York Academy of Medicine, 1857.

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 figs. 24, 25, and in this manner exposed to the action of the lamp.

103. Pipettes.—The pipettes required in microscopical examination 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, for instance, we shall want a pipette of very small calibre. On the other hand, if the deposit be very thick and viscid, the pipette must be wide, 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.*

It is convenient to have a sort of collar to the pipette, about two inches from the top, which will prevent the finger and thumb from slipping when the instrument is used, figs. 66, 67. Occasionally a pipette, the end of which is slightly bent round, fig. 67, 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.

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 fore-finger, while the middle finger and thumb are placed on either side of the tube immediately below the ring.

Various other forms of pipettes have been employed, but the above will be found most useful to the microscopical

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

observer. A small pipette with a narrow opening is convenient for removing any superfluous liquid which may escape outside the thin glass cover when preparations are being mounted in fluids and preserved in cells.

104. Conical Glasses. — Glasses of the shape figured in figs. 92, 93 are the most convenient vessels in which to place fluids holding certain substances in suspension, which we wish to examine. After the fluid has been allowed to stand for some time, the deposit collects in the narrow portion of the glass,

Fig. 92.



Glass, suggested by Dr. Budd, for taking specific gravities, and for obtaining deposits.

Fig. 93.



Conical Glass, for allowing deposits from fluids to subside. The drawing shows the manner in which a portion of the deposit is to be removed with the pipette.

and however small in quantity, 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 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. A

useful glass for allowing deposits to collect in, is repre-
d in fig. 92. It was designed by Dr. Budd, and is of
use in examining urine and other fluids, as the specific
ty may be taken, and the specimen allowed to stand in
same glass without the trouble of transferring it to
her vessel. This must be done, if the ordinary upright
e employed for taking the specific gravity.

05. Wash-Bottle.—This simple piece of apparatus, which
dinarily used by chemists, is of great use to the micro-
ical observer. He will find it most convenient for wash-
away the parenchymatous part of tissues in order to
the more fibrous portions, removing epithelium from
surface of membranes, &c. It is employed by the
ist chiefly for washing precipitates on filters, &c.

The wash-bottle is made with an ordinary bottle or glass
, having a moderately wide mouth. Two tubes bent, as
n in fig. 64, are accurately fitted into a cork adapted
he neck of the bottle. Upon nearly filling the bottle
water, and blowing through the shorter tube, the fluid
be projected from the capillary orifice of the longer
in the form of a fine jet, which may be directed upon
desired point.

06. Funnels; Filtering.—The funnels required in micro-

Fig. 94.

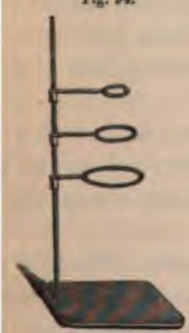


Fig. 95



Retort Stand, Funnel, and Glass, arranged for filtering.

ical examination are very small. Those of about two or
e 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, fig. 95, or upon a tripod. The filtering paper may be obtained already cut in packets

Fig. 96.



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

of circular pieces of any size required. One of these is folded in the manner shown in fig. 96, 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. The funnel is conveniently supported on the small stand represented in figs. 94, 95.

107. 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.

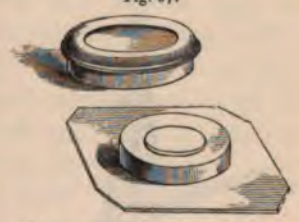
The muslin may be tied over a glass or funnel with a piece of thread, or it may be conveniently fixed in its place by one of the vulcanized India-rubber rings commonly sold at stationers' shops.

108. Cells for the Examination of Deposits.—The thin glass cell, fig. 52, will be found a very convenient form for the examination of deposits from fluids, especially when they exist only in small quantity. 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, I have been in the habit of using the animalcule cage, fig. 97.

109. 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 a very thin stratum only may in this manner be examined.

Fig. 97.



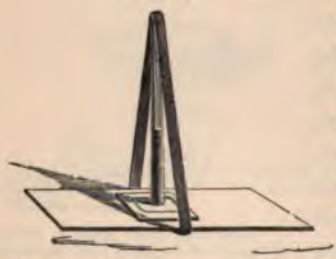
'Animalcule Cage' (made by Messrs. Powell and Lealand), for examining deposits from fluids.

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. 93. If the forefinger be now raised very slightly, but not completely 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 then 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 orifice, 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 be collected in a small drop upon the glass slide, which may be removed and examined in the usual way.

Fig. 98.



This figure shows the manner in which a trace of deposit may be collected from a fluid for examination.

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 with 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, fig. 98.

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, 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.

113. 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, a short time being allowed for the subsidence of the densest particles; the fluid is poured off into another vessel. After a short time 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.

CHAPTER III.

Of the Chemical and Microscopical Examination of the Solids and Fluids of the Animal Body.—Apparatus.—Microscope for Examining Substances Immersed in Corrosive Liquids.—Method of Examining Objects at a High Temperature.—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 in the Expired Air.—Of Removing Stains from the Hands.

114. Importance of Chemical Analysis in Microscopical Investigation.—By microscopical examination alone we are enabled very readily to distinguish with certainty the nature and origin of many substances; but amorphous particles are very often met with, the nature of which it is impossible to ascertain by microscopical examination alone. In such cases, it is necessary to study the effect of certain reagents upon the doubtful substance, and thus ascertain its chemical composition. Although by the microscope we can say that such a texture is granular, fibrous, opaque, perfectly clear, &c., we learn in such an examination nothing more of its nature. Since these appearances are manifested by several different materials, it is necessary to resort to a chemical examination to discover the nature of the substance to which the microscopical characters are due. If the composition of any body having well-defined microscopical characters has been once made out, by resorting simply to microscopical examination we are enabled to recognize it whenever we meet with i

afterwards. Some bodies always produce well-recognized crystals when treated with a certain chemical reagent, and we know that although there may be in nature other crystals of a different composition, but of precisely the same form, these latter could not be produced under the same circumstances as the former; hence in such a case we may feel as confident of the nature of the substance as if an ultimate analysis were made of it.

In almost every branch of microscopical enquiry, the greatest assistance is derived from the use of chemical reagents.

By an acquaintance with the behaviour of certain substances with particular chemical reagents, and the application of this knowledge 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 compounds in the animal frame with the greatest certainty, which would 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, and the examination of crystalline forms in the microscope, 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 these processes undergo when influenced by circumstances interfering with or counteracting healthy actions. Such considerations cannot but be of the deepest interest to us as practitioners of medicine; and in the various forms of disease which are constantly being brought under our notice, we have opportunities of studying the course of morbid actions, which it is our duty to investigate and know more of in the hope that they may be modified, prevented, or cured.

The laboratory is a most 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, essential parts of his studies.

The works of Vogel, Schmidt, Scherer, Hœfle, and others, which have been published within the last ten or twelve years, have done much to advance this branch of investigation; while those of Golding Bird, Schwann, Robin and Verdeil, Lehmann, and Gorup-Besanez, 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 principle upon which such examinations are 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 them so nearly in refractive properties,

* "Anleitung zum Gebr. des Mikroskopes zur Zooch. Anal. u. zur Microscop. Chemisch. Untersuch," Dr. Julius Vogel, 1841. "Chemische und Mikroskopische Untersuchungen zür Pathologie," Dr. J. J. Scherer, Heidelberg, 1843. "Entwurf: einer Allg. Untersuchungsmethode der Safte 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 Chemie Anatomique et Physiologique," Robin et Verdeil. "Urinary Deposits," Dr. Golding Bird, new edition by Dr. Birkett, 1857. Bowman's "Medical Chemistry." "Anleitung zür Zoochemische Analyse," Gorup-Besanez.

in form, and in general appearance, as to have led to mistakes with reference to their nature. The application of a drop of ether has no effect whatever upon the latter, but instantly dissolves the former. Sometimes the oil globule is covered with a membrane which prevents the action of ether upon it, in which case 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. 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 reagent 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 which has led to much discussion, in consequence of the solubility or insolubility of the globules in ether not having been clearly proved in certain instances, which have been hastily set down as cases of fatty degeneration.

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

Preliminary Operations. — 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.

115. 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 has 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.).

116. 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

* 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," page 481.

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 from 1030 to 1052. The specific gravity of the solutions may be ascertained by the specific gravity bottle, by the urinometer, or by the aid of the little glass bulbs, fig. 99. The specific gravity bottle affords the most satisfactory results.

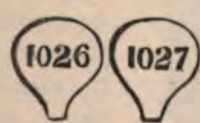
Several glasses are nearly filled with the solutions from different bottles, and arranged in regular order. The piece of tissue is thrown into one, and, if it sinks, it must be placed in the fluid of the next higher specific gravity, and so on, until it neither sinks towards the bottom nor rises to the 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 density as itself.

The soluble substances employed for making the solutions may be sugar, various salts, glycerine, and other compounds, 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.*

117. Specific Gravity—Liquids.

First. By the converse of the last operation, namely, by placing little glass bulbs, the specific gravity of which is

Fig. 99.



Little Glass Bulbs, which indicate the specific gravity of fluids.

marked upon them, fig. 99, into 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

* *Vide* paragraph on the Brain, chapter vi.

of the fluid. This method is not 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, fig. 100. If they are equal, as in A, the instrument may at once be pronounced as incorrect, without resorting to an experiment. The degrees at the lower part of the 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 the margin. In fig. 101, representing a dense fluid, the stem is of course almost entirely above the surface of the liquid, but in fig. 102, a fluid, 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. 102. Hence it is necessary that this should be allowed for in graduating the instru-

Fig. 100.



Urinometers. A, an imperfect instrument, in which the degrees on the stem are equally divided. B, a good instrument, in which they gradually diminish from above downwards, to counteract the increased pressure when much of the stem is above the surface of the liquid.

Fig. 101. Fig. 102.



These figures show the different positions of the Urinometer in fluids of high (fig. 101) and low specific gravity (fig. 102).

ment, and the degrees at the lower part of the scale must be shorter than those at its upper part.

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, fig. 103. 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.

Fig. 103.



Specific Gravity Bottle, with tubulated stopper and counterpoise.

118. Evaporation and Drying.—The evaporation of animal fluids, and the desiccation of animal solids, must always be conducted over a water-bath, otherwise there is great danger of decomposition occurring. For operations upon small quantities, the water-bath represented in fig. 104 will suffice, or the cans of the injecting apparatus, fig. 59, 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, fig. 28.

Fig. 104.



Small Water-bath with basin.

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. 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 conducted in vacuo over sulphuric acid. Drying is one of the most important and difficult operations to be performed in physiological chemistry.

Fig. 105.



Rings for Water-bath, when very small basins or watch-glasses are employed. These may be obtained of any size.

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 which 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, fig. 26. It may be removed from the lamp with the aid of an old pair of forceps.

Apparatus.

120. The chemical apparatus which is necessary in the

course of 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, § 104. Apparatus for taking specific gravities, §§ 116, 117. Test-tubes of various sizes, arranged on a stand, fig. 71. Spirit-lamps, with various supports, fig. 25, or, where gas is laid on, the gas-lamp, fig. 19. Small porcelain basins, watch-glasses; a simple water-bath, fig. 104, or the injecting can, fig. 59, may be used, if several evaporations are to be conducted at once. A small platinum capsule, a strip of platinum foil, a blow-pipe, pipettes, figs. 66, 67, and glass stirring rods, with a box of reagents in small bottles, fig. 110, 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 preparations which require to be immersed in strong acid, in the ordinary microscope, 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, in consequence of the vapour which rises, condensing on the object-glass, and rendering the object invisible.

These inconveniences are entirely obviated by the ingenious microscope invented some years ago by Dr. Lawrence Smith, of Louisville, United States. This was made by M. Nachet, of Paris, and has been described as Nachet's chemical microscope.*

The inverted chemical microscope is represented in fig. 106, in which also the form and position of the prism are shown.

By this arrangement the object-glass is always kept

* In the first edition of this work I much regret having inadvertently omitted Dr. Smith's name as the inventor of this instrument. To him is certainly due the merit of its invention. Dr. Smith's paper on the subject, will be found in the "American Journal of Science," second series, Vol. xiv., 1852.

perfectly clear, while of course the definition of objects not in any way interfered with. In order to adapt t instrument to drawing the outline of objects with the gl

Fig. 106.



Inverted Microscope of Dr. Lawrence Smith. *a.* Tube of microscope, with ey *b.* Object-glass on a box which contains a prism resembling that marked *g*. *c.* Stage, wi upon it. *d.* Support on which polarizing apparatus, or condenser, may be placed *e.* *f.* Screw, which elevates or depresses the stage in focussing. *g.* Prism, showing the di in which the rays of light passing through it are refracted. *h.* Position of achromatic glass.

reflector, § 76, it would only be necessary to have the fixed at a right angle with the axis of the object-glass small mirror, arranged at an angle of 45°, might be stituted for a prism.

122. Of Examining Substances which require a Temperature for Observation.—By placing a brass plate the stage of the instrument just described, and allowing end to project over the edge, so that it may be conveni heated by a spirit-lamp, any substance may be kept upon a glass slide, while being subjected to microsc examination. When a high temperature is necessary, I adopted the plan represented in fig. 107. A square c

rranged to lie flat upon the stage of the microscope. lamp is placed at its lower opening, while the heated pes from the upper end. At that part where the

Fig. 107.



s for examining objects while exposed to the action of a high temperature. The ugh which the heated air passes, is made of thin copper, without being soldered. re perforated, the lower one being filled up with a piece of glass, while over the g, the slide with the object is placed.

de is to be placed, the lower wall of the tube is d of glass, while at the upper part is an opening lows the heated air to come into actual contact with slide.

Reagents.

reagents necessary are not very numerous; they e perfectly pure. Of the greater number only very required; but of alcohol, ether, and one or two t is necessary to have a moderate quantity.

reagents should be kept in stoppered bottles of about city of two ounces.

Alcohol. — Alcohol of different strengths will be for the purpose of dissolving certain substances, separating them from other constituents, which are in this reagent.

Alcohol should always be diluted with distilled water, it is better to prepare a considerable quantity at a time. is convenient to have two or three bottles which will h about two quarts each. The strength of each should written upon a label attached to the bottle.

The importance of alcohol, as a preservative solution, been already referred to.

Within the last few years, the Government has permit the use of methylated alcohol, which pays no duty. It n only be used for various purposes in the arts, chemi processes, &c. It answers admirably for preserving ana mical preparations, and is a great boon to all engaged putting up large specimens. Any person wishing to use t alcohol, must in the first instance make application to t Board of Inland Revenue, Somerset House, for permissi His application must be accompanied with the names of t respectable householders, who are willing to serve as bo that the applicant only uses the spirit for the purposes sta in his application. The probable quantity required annua must also be mentioned. It may be obtained at the pr of 5*s*. 6*d*. per gallon, sixty degrees over proof, of Mess Lightly and Simon, and of other distillers, in quantit of not less than ten gallons at a time.

124. Ether. — An ounce or two of ether will be qu sufficient for microscopical purposes. It should be kept in stoppered bottle, provided with a glass cap, to prevent loss evaporation. A little should also be kept in one of th small glass bottles with capillary orifices, § 138, for the co venience of applying to cells containing highly refracti globules, resembling oil, &c., under the microscope.

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

126. Sulphuric Acid is sometimes required undiluted, but small bottle of diluted acid (one of acid to five of water) hould also be at hand. The pure colourless acid should lways be procured;—it is to be purchased for about 1*s.* 6*d.* 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 equired.

128. Acetic Acid.—Two specimens of acetic acid will be ound convenient. One, a solution of the strongest acid hich can be procured; the other, containing about twenty er cent. This is prepared by dissolving one part of the trongest liquid acid, or of the pure *glacial acetic acid* in ve of water. The glacial acetic acid is now commonly mployed for photographical purposes, and can, therefore, be ery readily obtained.

129. Chromic Acid is usually required very dilute. For ne purpose of hardening tissues, a watery solution of a raw colour will be found strong enough. It is easily repared by dissolving a little of the crystallized chromic id in distilled water.

The crystallized acid may be prepared by decomposing 00 measures of a saturated solution of bichromate of otassa, by the addition of 120 to 150 measures of pure ncentrated sulphuric acid. As the mixture becomes cool, ystals of chromic acid are deposited, which should be dried d well pressed on a porous tile, by which means the eater part of the sulphuric acid is removed, and the ystals obtained nearly pure.

130. Solution of Potash should be kept of two or three fferent degrees of strength. One, the strongest which can obtained; another, made by mixing one part of the strong id with three or four of water; and a solution consisting one part of liquor potassæ to eight or ten of water, will found of a useful strength for the examination of mar eparations.

131. Solution of Soda is generally required very dil

It may be made by mixing one part of the strong solution of the shops with five or six of water; but this, for many purposes, will require to be still further diluted. Or, about twenty-five grains of the fused soda may be dissolved in an ounce of distilled water.

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. The precipitated sulphate of baryta being 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. — 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 phosphate are with great difficulty soluble

in acetic acid, hence the necessity of first adding nitric acid, as above directed.

136. Iodine Solutions.—An aqueous solution is easily prepared, by dissolving a few grains of iodine in some distilled water, until it acquires a brownish-yellow colour. A solution of iodine is sometimes useful for colouring certain substances which are so transparent as to be scarcely distinguishable upon microscopical examination. In the examination of many such structures, great assistance will be obtained from the use of coloured solutions; for delicate textures, like the cell wall and basement membrane, &c., can be better distinguished when a faint tint is communicated to them, than when perfectly colourless. A very dilute solution of carmine and ammonia is the best fluid for this purpose. It is curious, that in some instances the nucleus absorbs a much greater quantity of the colouring matter than other parts of the cell.* When a membrane is to be made more distinct, it may be immersed in a little Prussian blue fluid, the minute particles of which adhere to it, and enable us to trace its outline clearly.

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). For testing bodies suspected to consist of starch, the following solution is recommended by Professor Schultz. 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

* This plan was originally employed by Welcker, but it has also been adopted by Gerlach and Dr. Harley, in certain investigations.—"Henle und Pfeuffer's Zeitschrift," Vol. viii., page 230.

measure), three grains of iodine dissolved, with the aid of six grains of iodide of potassium, in the smallest possible quantity of water, are to be added.* 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.

Method of Applying Tests to Substances intended for Microscopical Examination.

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 we usually require only a small drop of a solution, 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 a second time, without being first well washed in water,—for if this be not scrupulously attended to, there is great danger of conveying some of the substance intended for examination into the test bottle, in which case the whole contents would be spoiled.

Without great care in all our manipulations, there will be much danger of removing a portion of one substance from a glass slide and carrying it to a deposit which is subsequently examined;—a result which might lead to great inconvenience and very serious mistakes. Claws of echinococci, and other minute bodies, in themselves highly characteristic, may thus be transported, and find their way into deposits in which we should not expect their presence; and

* Busk on "Starch Granules."—(Transactions of the Microscopical Society, new series, Vol. i., page 67).

from such an accident we might be led to infer, very erroneously, the existence of hydatids, although the presence of the claws of the echinococci really resulted from accident. Accidents of this kind can always be avoided, by not allowing the drop of the reagent 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 in the microscope covered with a vast number of starch granules, which have been introduced from without. Usually they are derived from the squares of thin glass which are commonly kept in a little starch powder to prevent fracture.

An intimate friend showed me one day some microscopic preparations which contained 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. For all such delicate operations, the specimens should be carefully protected by glass shades.

138. Tests kept in Glass Bulbs with Capillary Orifices.—By far the most convenient method with which I am acquainted, of applying chemical reagents to minute quantities of matter, consists in allowing a drop 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.

With this view 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, fig. 108. These bulbs were easily filled, by expanding the air within them, by the heat of a spirit-lamp, and then inverting them in a small vessel containing the solution which was to be introduced. As the bulb cooled,

Fig. 108.



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

Fig. 109.



Small Tube, with capillary orifice.

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 some of the fluid can afterwards be expelled by the heat of the hand when the bulb is inverted. The bulbs containing the strong acids and alkalies should be furnished with glass caps, but gutta percha will be sufficient for the other tests. When it is required to expel a drop of the solution, the bulb is taken in the hand, and the air in the interior being expanded by the warmth, a small quantity of the solution is forced out.

Mr. Highley has had some small bottles made of the form shown in the accompanying figure, fig. 109. These apped 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, fig. 110. 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, which runs down the sides when the cap is removed. They may be obtained of Mr. Matthews.

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.

Fig. 110.



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

Fig. 110*a*.



Pipette serving as the stopper to the bottle. *a*. Vulcanized India-rubber, by pressing which fluid may be expelled from the tube. *b*. Ground to fit the neck of the bottle. *c*. Orifice.

139. Capillary Tubes with India-rubber tied over the Top.—Dr. Lawrence Smith, of Louisiana, 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, fig. 110*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.

140. Application of the Reagent to Minute Quantities of Matter.—With the aid of the bulbs 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 the smallest 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 a 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 sub-

jected to microscopical examination. *Phosphate of lime* occurs as a granular amorphous sediment, while the ammoniaco-magnesian, or triple phosphate, is usually found crystallized in a beautiful stellar form,* or as minute prismatic crystals.

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 clearly enough. In some instances, however, advantage is derived from subjecting the specimen to microscopical examination, when the formation of the 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 this occurrence, however, must always be borne in mind, and the fallacy carefully guarded against.

Sometimes in testing a deposit for carbonates, the effervescence which is produced upon the addition of the acid,

* Illustrations of Urine, Urinary Deposits, and Calculi, Plate IX., fig. 2.

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.

142. Effects of Acids. — 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 character 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.

143. Acetic Acid.— Acetic acid is one of the most useful reagents to the microscopical observer. It 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 pre-

viously rendered transparent by acetic acid, they again contract, and the outline becomes distinct. In some cases, however, the cell wall 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 pus-globules is discussed in a subsequent chapter.

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

144. 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.

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. This is one of the processes employed for obtaining these beautiful objects, from guano.

145. Sulphuric Acid.—Hydrochloric Acid.—The pure concentrated 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 as to 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.

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.

146. Effects of Alkalies.—The action of alkalies, even hen cold in a very dilute state, is to dissolve most animal xtures. Cell-membranes are frequently almost instantly ssolved, while the nucleus appears to be altered but slightly.

Alkalies are also employed for dissolving certain crystal-ne substances which are occasionally found in animal tissues, uch, for instance, as deposits of alkaline urates, which are ot unfrequently met with in the form of considerable eposits in the tissues of gouty persons.

147. Potash and Soda.—The action of potash and soda on animal structures is very similar. Both dissolve sub-nces of an albuminous nature, but the effect of soda is ore gradual, and it has been found that for most purposes microscopical research, this reagent possesses advantages er potash.

The solution of potash is the ordinary *liquor potassæ* of e pharmacopœia, and the solution of soda is prepared in the ne manner. These solutions may be diluted with water to e required strength. Potash and soda are employed where issue is to be rendered more transparent for the purpose of monstrating the arrangement of the nerves or other ana-nical elements not soluble in this reagent. Soda is more ployed than potash, for although it renders tissues perfectly nsparent, it does not dissolve them so readily as the latter.

These reagents dissolve the layer of epithelium covering ucous membranes, or render it perfectly transparent, so at the arrangement of the structures beneath the basement mbrane can be easily demonstrated. In investigating the mination of the nerves and vessels in papillæ and other uctures, they are very valuable, especially the latter.

For the purpose above mentioned, the alkalies should be uted with water. The changes are expedited by the plication of heat, which, however, must not be too great, fear of complete solution taking place. Where the uctures are hard and dry, they may be warmed with the gent in an ordinary test tube, a plan which is much commended by Kölliker.

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 page 73. 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 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 crys-

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

talline state. The addition of water in some cases causes the most rapid crystallization, especially when the crystallizable material is contained in a cell, as when water is added to blood, in order to obtain blood crystals. Instead of water, in other instances, it becomes necessary to add alcohol, in which fluid the crystals may be much less soluble than in water.

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.

149. Influence of other 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 octohedral 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 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, 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 (fig. 111). Crystals of several salts may be made in the same simple manner, and from an attentive examination of them, much may be learned. Phosphate of soda, phosphates of soda and ammonia, sulphates of potash and soda, muriate of ammonia,

Fig. 111.



Cubes of chloride of sodium, obtained by concentrating a solution of common salt, × 215.

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 polarized light* 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. Their behaviour 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.

Fig. 112.



Chloride of ammonium evaporated very rapidly, and crystallized in crosslets.

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, fig. 112.

153. Of Measuring the Angles of Crystals.—The goniometer is employed in the measurement of the angles of crystals. Although not much used in this country at present, it is

* "How to Work with the Microscope."

tant briefly to refer to its construction, as in some ches it is desirable that the angles of the crystals l be carefully measured. Crystals which nearly resemble other in their general form, and even in size, will be to exhibit differences in the measurement of their .

ıe simplest method of measuring the angles of micro- crystals is that of Schmidt. The goniometer consists ositive eye-piece, which is so arranged as to be easily

Fig. 113.



Goniometer for measuring the angles of crystals in the Microscope. Made by Messrs. Powell and Lealand. Altered from Schmidt's Goniometer.

d within a large and accurately-graduated circle. s the focus of the eye-piece a single cobweb is drawn; o the upper part is attached a vernier. The crystals placed in the field of the microscope, and care being that they lie perfectly flat, the vernier is brought to nd then the whole apparatus turned until the line is l with one face of the crystal; the framework bearing bweb with the vernier is now rotated until the cobweb es parallel with the next face of the crystal, and the r of degrees which it has traversed may then be tely read off. In using this instrument, care must be

taken that the crystals are placed perfectly flat, otherwise a wrong estimate of the angle will be made.

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 description of his apparatus will be found in Mr. Quekett's treatise, but the cobweb goniometer just referred to, will, I believe, be found to answer all the purposes for which this instrument is required by the physiological or pathological observer. For special crystallometrical investigations, however, a more elaborate apparatus becomes necessary.*

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 must be preserved 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-

* See also a paper by Mr. Highley in the fourth volume of the "Quarterly Journal of Microscopical Science," page 77.

' blood which have been preserved for upwards of three
's in this medium.

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

135. Urea.—Traces of urea in an animal fluid may always
letected by the crystalline characters of the nitrate of
. Upon adding a drop of nitric acid to a drop of cold
centrated urine, or other solution containing urea, placed
n a glass slide, a crystalline precipitate of nitrate of urea
immediately take place. Upon covering this with a
e of thin glass, and subjecting it to microscopical exam-
ion, the characteristic rhomboidal plates will be observed.
.114 represents the appearance of nitrate of urea examined

Fig. 114.



Crystals of nitrate of urea. *a*. Crystals tained from urine. *b*. Crystals of pure rate of urea, × 215.

Fig. 115.



Crystals of oxalate of urea, obtained by adding oxalic acid to concentrated urine, × 215.

a quarter of an inch object-glass, at *a* are shown some
tals 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. 115, 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 "Illustrations of Urine, Urinary Deposits and Calculi," pages 56, 58, 60, Plates II., III., IV.

Fig. 116.



Crystals of urea, obtained by evaporating a solution slowly. The dark oval bodies are spaces in the crystals, × 215.

In examining solid organs for urea, the fresh tissue may be broken up, and treated with several portions of hot water, the solution filtered from coagulated matters, and evaporated,

en the residue may be extracted with alcohol, as before cribed.

Oxalate of Urea is easily prepared by adding crystals of lic acid to a concentrated solution of urea, or to urine evaated to the consistence of syrup. As the mixture becomes d, numerous crystals of oxalate of urea form, fig. 115.

Crystals of pure urea, obtained by decomposing a solution the oxalate of urea with chalk, and carefully evaporating filtered liquid, are shown in fig. 116. The cavities repreted in many of the crystals contain fluid. Urea may also obtained in a nearly pure form by adding ether, in which is only slightly soluble, to the fluid which contains it.* ea may be determined, quantitatively, by weighing the rate and calculating the proportion of urea it contains, by composing it with solution of chlorinated soda and estiting the volume of nitrogen according to the method Dr. Davy,† or by Liebig's process.‡

156. Creatine—Creatinine.—Creatine exists in very small antity in muscular fibre. Traces of it are also present in ine, in which fluid it was discovered by Liebig. According Dr. Gregory, it is most readily prepared from the flesh of e cod fish; from twenty-five pounds of which, in one expeent, he obtained 164 grains of creae. From crodile's flesh I obtained very readily; two pounds yielded more an seventeen grains of pure creatine. e flesh is to be chopped in small pieces, well kneaded with water. After all fluid has been expressed by powerful ssure, it is very carefully raised to the ling-point, and the coagulated matter moved by filtration. The phosphatic ts are precipitated by caustic baryta. The solution must

Fig. 117.



Warty granules of the chloride of zinc compound, × 215.

* A plan recommended by Dr. Marcet.
† "Dublin Hospital Gazette," June 1st, 1855; "Archives of Medicine," i, page 144.
‡ *Vide* a paper by Dr. von Bose, "Archives of Medicine," Vol. i. page 34.

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

Fig. 118.



Crystals of creatine.

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 fig. 118, and those of creatinine in fig. 119, which have been copied from M. Robin's Atlas.

I have obtained crystals of creatine and creatinine 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 twenty-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, fig. 117. 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

Fig. 119.



Crystals of creatinine.

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 last year.*

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.

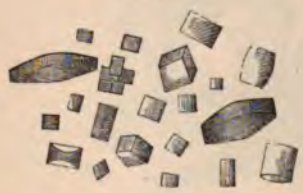
In order to ascertain if an amorphous or other deposit contain uric acid, or a urate, we must treat it with a few drops of potash, which will dissolve any of the acid that may be present. This alkaline solution is to be decomposed with excess of acetic acid, and, after the mixture has been allowed to stand for twenty-four hours or longer, any deposit that may have formed, is to be subjected to microscopical

* For drawings of crystals, of creatine, creatinine, and the chloride of zinc compound from urine, *vide* "Illustrations of Urine, Urinary Deposits, and Calculi;" "Urine," Plate VII.

examination. The microscopic crystals of uric acid, obtained in this manner, are usually in the form of rhombic tablets, figs. 120, 121, but sometimes they assume the form of six-sided plates.

Uric acid is soluble in alkaline fluids, and is usually present in serum, in combination with an alkali; hence we

Fig. 120.



Crystals of uric acid from urine, × 215.

Fig. 121.



Crystals of uric acid in forms in which they are often deposited from alkaline solutions, after adding excess of acid, × 215.

shall be able to detect it in aqueous extracts, if it existed originally in the fluids. All that is necessary is to concentrate the solution, and then add excess of acetic acid.

Dr. Garrod* 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,

* "Medico-Chirurgical Transactions," Vol. xxxi.

hosphates, &c.), and then causing the crystals of uric acid o be precipitated by the addition of excess of acid. To ome specimens he may add hydrochloric, to others, acetic or itric acids, &c. Upon examining the crystals obtained by hese various processes in the microscope, he will notice a reat variety of forms, but, upon careful examination, it will e found that most of them are mere modifications of the ame form, and that a connection between them may be raced in many instances.*

158. Hippuric Acid is separated from its salts by the addi-ion of a stronger acid (as hydrochloric acid) and the crystals hich are deposited may be subjected to microscopical xamination in the usual manner. Hippuric acid should lways be sought for in animal fluids which are quite fresh, s it undergoes de-omposition very apidly, and becomes ntirely converted into enzoic acid. The nicroscopical charac-ers of these two acids re very distinct. Benzoic acid crystal-izes in scales, while the crystals of hippuric acid occur in the form of beautiful prisms, fig. 122, 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.

Fig. 122.



Crystals of hippuric acid, after Robin and Verdeil.

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

* "Illustrations of the Constituents of Urine, Urinary Deposits, and Calculi," page 15, Plates IV. to VIII.

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 three or four cases of confirmed diabetes in which the urine contained a very large quantity of uric acid. My friend, Dr. Murchison, tells me that he has also observed it. Indeed, in this country at least, I suspect 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.†

Its presence 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.

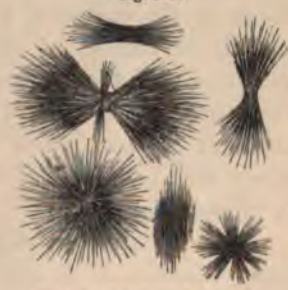
In order to detect the presence of lactic acid in animal fluids, Lehmann proceeds as follows: the fluid is evaporated carefully over a water-bath, and the residue extracted with

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

† 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.

alcohol. After the separation of some of the salts by evaporating this alcoholic solution, and allowing them to crystallize 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, fig. 123, 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

Fig. 123.



Crystals of lactate of lime.

Fig. 124.



Crystals of lactate of copper.

Fig. 125.



Lactate of zinc.

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, fig. 124. 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, fig. 125. The microscopical characters of the salts of lactic acid are well shown in the excellent atlas of plates of Dr. Funke, of Leipzig, a work which will be found of the greatest value to the student in animal chemistry.*

160. Pulmonic or Pneumic Acid. — This acid has been lately discovered in the lung tissue, by Verdeil.† It is prepared as follows: perfectly fresh calves' lung is cut into

Fig. 126.



Crystals of pulmonic acid, obtained from calves' lung, × 215.

Fig. 127.



Pulmonic acid, after Robin and Verdeil.

small pieces, and extracted with tepid water. It is well pressed, in order to remove all the liquid. The fluid is

* Cavendish Society, 1853.

† According to Cloëtta, Verdeil's pulmonic acid consists principally of taurine.

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 fig. 126 were obtained. It is probable, however, that these do not consist of one simple substance.

161. 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

Fig. 128.



Crystals of margarine, after Robin and Verdeil.

consequence of being composed of dense aggregations of minute crystals, fig. 128. Almost the whole of the oily fat remains in solution in the alcohol.

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.

Margarine crystallizes from its solutions in tufts composed of somewhat wavy, minute, acicular crystals, or in

separate, free, short crystals, which are usually somewhat curved.

Margaric acid also crystallizes in minute tufts composed of very small and much-curved crystals, fig. 130.

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

Fig. 129.



Crystals of stearic acid, after Robin and Verdeil.

Fig. 130.



Crystals of margaric acid.

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 in the majority of instances. The characters of stearic acid under the microscope are shown in fig. 129, and those of margaric acid in fig. 130. These figures were taken from the excellent atlas of plates by Robin and Verdeil.*

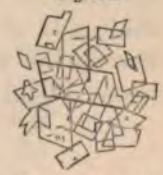
These crystalline fatty matters are not unfrequently met with in morbid growths, and very commonly in various fluids and solids of the body. In vomited matters, masses of

* "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.

rystalline fat are very often observed, and in vomit con-ining sarcinæ, stellar crystalline fatty masses are very equently present.

Cholesterine is a non-saponifiable fat, and occurs in many tuations in the human body. A small uantity of cholesterine is always present in ile, and the colourless gall-stones consist most entirely of this substance. It may e extracted from many of the tissues in a ate of health; I have even obtained it om the healthy crystalline lens of the eye. n disease it often occurs in serous fluids, pecially in the serum of ovarian and other serous cysts, nd occasionally in the fluid of hydrocele.

Fig. 131.



Cholesterine, crystallized from an alcoholic solution, × 215.

Cholesterine may always be recognized by its crystal-ne form, fig. 131, and may sually be obtained by the slow vaporation of alcoholic solu-ons; but where only mere aces of this substance are esent, it is necessary to re-ove the other fatty matters efore the cholesterine can be btained in the crystalline ate. By boiling with water nd oxide of lead, the sapo-ifiable fats form a plaster, nd the cholesterine is dis-lved by treating the latter ith dilute alcohol, from which lution it may be obtained in a crystalline form by sub-quent evaporation.

Fig. 132.



Non-crystalline flakes of seroline. Robin and Verdeil.

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

162. Excretine. — This substance was discovered by

Dr. Marcet a few years ago. It is only present in human fœces. 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

Fig. 133.



Crystals obtained by evaporating an alcoholic solution of excretine. Prepared by Dr. Marcet.

* "Phil. Trans." 1857, page 403. "Archives of Medicine," No. II., April, 1858.

few non-crystalline globules are obtained, but this stallize if re-dissolved in alcohol and exposed to the

Marcet has ascertained the composition of excretine follows:*

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

nic weight is 578, assuming that an equivalent one equivalent of sulphur.

Crystallizable Substance from the Blood.—This beau- pound is held in solution in the red blood-corpuscles nd animals. It was first examined by Funke, and ds by Kunde.† The subject has lately been very investigated by Lehmann.‡ In the "Medical d Gazette" for 1852, will be found a very interest- r on the subject by Dr. Parkes.§ The various forms rystals are well delineated by Dr. Funke.‖ The portant crystals are figured in Plate I.

e crystals are very readily obtained by diluting blood e fluid. A drop of blood may be placed upon a glass d after the addition of a drop of water, alcohol, or e whole should be lightly covered with thin glass. or a small piece of thin paper or wood, may be etween the glasses, in order that a stratum of fluid ent thickness may be retained. It is preferable to brinated blood. Often the corpuscles and a little ay be removed from the clot by firm pressure, and

l. Trans.," 1857.
rt. inaug. Lips. 1851 (O. Funke). Zeitschrift. f. rat. Med. N. F.

rbuch d. Physiolog. Chemie," Vol. i., second edition, 1853. Bei. Gesel. d. Wiss, 1852–1853.
lso a paper on "Albuminous Crystallization," by Dr. Sieveking, in h and Foreign Medico-Chirurgical Review," for October, 1853, in excellent woodcuts of blood-crystals are given.
ndish Society, 1853.

from this, very perfect crystals may frequently be obtained. The blood-corpuscles become ruptured by endosmosis, their contents escape, and crystallize as the solution gradually becomes concentrated by spontaneous evaporation which goes on at the edges. The time which elapses before crystallization takes place, varies from an hour to several hours, or days, in different specimens of blood. Crystals may also be obtained in a similar manner 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, while six-sided tables are formed in the blood of the squirrel, mouse, and some others. 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). Frog's blood cannot be made to crystallize, in consequence of the density of the cell membrane, but Professor Lehmann tells me he has obtained crystals readily from the blood of the Italian lizard.* The 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.

Guinea-pig's blood crystallizes in the course of half an hour, or even sooner, if it be diluted with a little water or

* Teichmann has 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.

I have seen crystals form in Guinea-pig's blood
the addition of any fluid, and without any evapora-
ıtever. Dog's blood also crystallizes in the course
rt time upon the addition of a little alcohol. Human
ystallizes after the addition of water, slowly, if only
ıoved from the body, but more rapidly if the blood
quite fresh. The crystals shown in Plate I, were
by diluting a drop of fresh blood from the finger,
rop of distilled water; and after covering the mixture
ı glass, the slide was placed in a light place. Crystal-
commenced about forty hours after the addition of
this specimen of blood.

ıann has discovered a process by which large quan-
blood crystals may be prepared. This consists in
oxygen and carbonic acid through the blood which
diluted with much water. The blood which answers
hat of the dog and Guinea-pig, but as far as I know,
ıas obtained crystals from the blood of the ox or
This depends probably upon the membranes of the
rpuscles being less readily ruptured than those of
imals. The following plan yielded an abundant
of crystals from the blood of the dog and Guinea-
ıe defibrinated blood was diluted with half its
ır with an equal volume of water. Sometimes it was
in the case of dog's blood, to add a little alcohol
until rupture of the corpuscles had taken place,
n always be ascertained by microscopical examina-
ırough the solution, oxygen was passed for a quarter
ın hour, and then carbonic acid was transmitted
the same fluid during half the time that the oxygen
passed. In the course of an hour, or longer, an
precipitate, consisting entirely of blood crystals,
uced. This was separated by filtration, and dried.
ystals are required quite pure, they must be re-dis-
water until the mixture has a specific gravity of
1004 and 1002, and then alcohol must be added
specific gravity is reduced to 0970. Crystals will be

deposited in a few hours. It is often exceedingly difficult to obtain pure crystals after resolution in water.

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. 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.*

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 four years.†

164. 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 eva-

* Henle and Pfeuffer's "Zeitschrift," Vol. VIII, page 141.

† The following references to papers on blood crystallization, in addition to those given in page 129, 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 197. Remak in "Müller's Archiv.," 1851, page 481. Funke "Zeitschr. 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, "Zeitschr. f. rat. Med N. F.," III, p. 375, VIII, page 141.

ited to dryness over the water-bath, and the dry residue dered and extracted with absolute alcohol; the dark n alcoholic solution is quickly filtered into a small flask ottle, and then ether is gradually added until the white ipitate at first formed ceases to be re-dissolved upon ation. Care should be taken to add the ether very lually, for otherwise a bulky amorphous precipitate rs, which does not become crystalline. The bottle is to lightly corked, and allowed to stand in a still place. er a few days, stellar masses of beautiful and almost ourless crystals appear; these increase until tufts of a

Fig. 134.



Crystallized bile, obtained by treating perfectly dried bile with anhydrous alcohol, and adding gradually to the alcoholic solution. The small crystals in the left hand corner are drawn natural size.

siderable size are produced. The crystals may be sub- ed to microscopical examination, immersed in a drop the solution in which they were produced, and are beau- l objects; or they may be carefully washed with alcohol, which a tenth of its bulk of ether has been added, and idly dried in vacuo.*

* An excellent paper "On the Constitution and Physiology of the Bile," Dr. Jno. C. Dalton, junr., will be found in the American "Journal of the ical Sciences," for October, 1857. The method of crystallizing the bile is described.

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.

Fig. 135.



Glycocholic acid, prepared by decomposing glycocholate of lead with sulphuretted hydrogen and allowing the filtered solution to stand for some days.

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.

165. 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 lately been thoroughly investigated by Dr. Richardson, who has added very much to our knowledge. His

researches, which lead to the conclusion that the escape of ammonia from the blood is the cause of its coagulation, 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 Dr. Reade and recommended by Dr. Richardson. An ordinary glass microscope 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. In typhus fever and many other low conditions of the system, a very considerable excess of ammonia may be detected in the breath, but in health traces are always to be found. Dr. Richardson found

Fig. 136.



Crystals of chloride of ammonium, obtained by breathing for several minutes upon a glass slide moistened by hydrochloric acid. The individual was in good health at the time.

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

but one exception to this, in the case of a gentleman who lived entirely on vegetable food. It 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.

166. Removing Stains from the Hands. — It is at least convenient to many that stains, which can hardly be avoided in microscopical inquiries, should be removed from the fingers, and a few directions are therefore added on this head.

Brunswick black may be removed from the hands by washing them with a little turpentine, or by rubbing them with lard or oil, which may afterwards be removed by soap and water.

Marine glue may generally be peeled off, or it can be dissolved with a little ether or naphtha.

Chromate of lead.—In using this substance for injection, the fingers often become stained with a very deep yellow colour, which cannot be removed by ordinary washing. The application of a little hydrochloric acid at once dissolves the yellow precipitate. The hands should be plunged into water immediately after the stain has disappeared.

The *Prussian blue fluid* can generally be removed by soap and water alone, but if any difficulty be experienced, the colour can always be destroyed by washing the hands in a little dilute potash.

Sealing-wax varnish, and other varnishes soluble in spirits of wine, can always be removed by the application of a little spirit.

Lime and India-rubber cement can be removed by lard or oil and subsequent washing.

Canada balsam can always be dissolved by a little turpentine or ether.

PART II.

OF DEMONSTRATING THE MICROSCOPICAL CHARACTERS OF TISSUES IN HEALTH AND DISEASE, OF MORBID GROWTHS AND DEPOSITS, OF THE FLUID PRODUCTS OF 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.—Of Different Forms of Cells.—Epithelium.—False Cells.—Demonstration of Cell Structures.—Of the use of Carmine in Demonstrating the Nucleus 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 structures 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 necessary that he should describe in detail what he understands by it. Considerable difficulty is always felt by learners in consequence of different writers employing the same term in a different sense, and much confusion and difference of opinion has arisen in consequence of sufficient care not having been

taken in using appropriate terms. It is hoped that the reader will not too hastily glance over the next few pages, as it has been attempted to affix a definite meaning to many words which are used freely in a subsequent part of the 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 development of *granules, globules, cells,* or *fibres.* It may be so great as to obscure completely the natural structure of the tissue, even although a very thin stratum or section 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 tissue 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 to which the opacity is due.

Many highly refracting fluids are used in microscopical examination. The most important are—syrup, glycerine, oil, turpentine, or Canada balsam. For the methods of employing these, the reader is referred to "How to Work with the Microscope," and for the effects of chemical reagents to page 104 of the present work.

Granules, Globules, Cells, Fibres, and *Membranes* may be met with in the interstices of any texture, may occupy the position of the original structure, or may be suspended in a fluid. It is, therefore, very important to define the meaning of these terms, and they should never be used for describing morbid changes, unless the observer is quite satisfied he is

using the words in the sense in which they are generally employed. Should he feel doubtful if the characters of the object are properly described by the word he uses, a note of interrogation should be placed after it, or the sense in which he uses the phrase should be fully explained in a note.

167. 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, or upon electrical disturbance. This movement occurs alike in particles of organic and inorganic matter. It was discovered by Robert Brown, and termed *molecular motion*, and 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 whenever fine particles of matter are suspended in a fluid.

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. It is therefore necessary to resort to chemical examination. 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 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, 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.

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 the cell wall

Fig. 137.



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.

Fig. 138.



Globules, *a*, and granules, *b*, enclosed in cells.

Fig. 139.



Granules of urate of ammonia.

very readily. 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.

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 liquid, 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. 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, however, such granules are very abundant. 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, in the cells constituting the deeper layer of the epidermis, 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 and newt, and fishes. The dark granules often found in sputum forming irregular masses, or inclosed in a membrane, appear to consist in many cases merely of blacks which are inspired, but in others probably of pigmentary matter separated from the organism in the lung itself.

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 of phosphate, they dissolve without effervescence, and the clear acid solution yields with ammonia a precipitate, in a *granular state* if composed of phosphate of lime; *crystallized* if consisting

* For the method of applying the test, see page 103. 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.

of triple phosphate. Doubtless many other substances are deposited in tissues in a granular state, than those I have alluded to. Patient and exact investigation of such a subject is important, and must lead to increased knowledge of the nature of morbid changes at present but little understood.

168. 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 refractive power of the material of which it is composed and that of the surrounding medium. If, both being colourless and the globules spherical or nearly so, exactly correspond in refractive power, the globule is invisible, but if they differ in this property, the outline of the globule appears dark and well-defined while its centre is 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

Fig. 140.



Air bubbles of various sizes in water, × 215.

Fig 141.



Milk globules, × 215.

Fig. 142.



Casts of the uriniferous tubes containing free oil globules, and cells filled with fatty matter; from a case of fatty degeneration of the kidney.

in water is distinct and well-defined, but the outline of an air bubble in water is very much wider than that of the oil globule, figs. 140 and 141. It is very important that the observer should be quite familiar with the appearance of oil globules and air bubbles under different powers of the micro-

If the globule be suspected to consist of an earthy
l, it must be tested with chemical reagents. Phos-
of lime is readily dissolved by acids, without effer-
e, and may thus be very easily distinguished from
atter, while the latter is dissolved by ether, which
action whatever on the former.

siderable confusion has been introduced with reference
terms "granule," "molecule," and "globule," and
e writers the two former have been used in the
ense as "globule." The word "globule" should be
ted to a body which has a distinct circular outline,
clear bright centre; while by "granule" is under-
a minute particle of no determinate form. The
is, therefore, synonymous with the word "molecule."
ms to me very important that in describing these, we
d carefully distinguish the mere molecule or granule
the well-defined globule. We can discover the form
globule without difficulty, but are quite unable to ascer-
that of a granule or molecule.

il globules may be easily obtained for examination by
ng a few drops of oil in a bottle of weak gum water, or

g. 143.



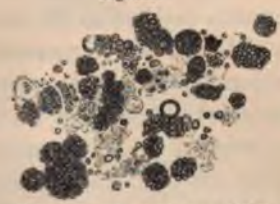
ules, free,
ed in cells,

Fig. 144.



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.

Fig. 145.



Collections of minute oil globules, the so-called inflammation corpuscles, granular corpuscles, compound granular corpuscles, or "granular cells," × 215.

of milk, in which they exist ready formed of all sizes,
e placed under the microscope.

obules composed of Fatty Matter are so frequently met
n the healthy organism and in morbid conditions, that
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. The nuclei of many cells seem to be composed of a minute round globule like an oil globule. 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, in 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. The deposition of oil globules seems to be constant wherever a tissue ceases to discharge its office, either as the natural course of events, or in consequence of a morbid process having been set up. The deposition 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 the tissue. It would seem that in health this oily matter is very rapidly absorbed, but that in some conditions of the system its removal is impossible. So also the proper office 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, and the system vigorous, absorption of the degenerated tissue may occur;

but if the powers be reduced, the process continues, the function of organs necessary to life becomes deranged, and death ultimately results. It is in such conditions of system that maladies, from which healthy men would recover, and trifling surgical operations, so very frequently prove fatal.

It is important to bear in mind that some forms of fungi somewhat 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, while it dissolves the oil. The

Fig. 146. Fig. 147.



Fig. 146.—Globules of earthy matter from the cerebellum, from a case of insanity. These consisted principally of carbonate of lime. *a*. Small collection. *b*. Four larger ones. *c*. Globule resembling corpus amylaceum. *d*. Collection of globules incorporated together, following the course of a vessel.

Fig. 147.—Globules of earthy matter, from the choroid plexuses of a case of 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 situated external to the capillary wall. *b*. Outline of a capillary loop. *c*. Large globule external to capillary. *d*. Small collections inclosed in membranous structure. *e*. Large and small globule inclosed in a membranous envelope. The mode of formation of these will be understood by reference to *a*, *b*, *c*. *f*. Globules acted upon by hydrochloric acid, showing the earthy matter almost entirely dissolved, leaving a certain quantity of organic material which had been deposited with it.

outline of small oil globules is thicker, in proportion, than large ones; but that of fungi is the same in all cases. Generally, oil globules in a specimen vary very much in size, while the cells of fungi are nearly all of the same size, or at least there is a limit which none surpass.

Globules composed of an Albuminous Material are often

of very large size; they are found in many morbid products, in serous fluid from cysts, 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*.

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, contain a large quantity of carbonate of lime, while those which occur in the urine of the horse and of rodent animals, 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. 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 composed. This is often seen when the highly refracting matter has been dissolved out by a chemical reagent. Calculi will be alluded to in a subsequent part of the work.

169. *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. Corpora amylacea 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.† The best

* 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.

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 amalycea or of their effects, nothing is known.

170. Cells.—A cell consists of a perfectly closed sac containing certain contents. The most important structure within the cell wall in most instances, is the nucleus, upon which the multiplication of the cell, and many important changes taking place during the period of its life, depend. It must be borne in mind, however, that in some cells, as the human blood corpuscles, a nucleus is not to be demonstrated. Within the nucleus there usually exists a quantity of granular matter amongst which is seen a clear bright spot, in many instances not to be distinguished in appearance from a minute oil globule. This is the nucleolus.

The cell wall is composed of an exceedingly thin membrane, which is sometimes clear and transparent, and sometimes granular. This membrane, although containing no visible pores, is permeable to fluids and gases.

The cell contents are various. They differ no less in their physical characters, than in their chemical properties and vital 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 it is formed may not be prone to alteration, and the structure may retain its primitive cell-form unchanged for ages.

In all tissues the cells cannot be separated from each other, or from the intercellular material in which they lie, as separate and individual structures, neither can any distinction be made between the cell wall and the substance which intervenes between contiguous cells. Indeed the cavity of the cells might be regarded as little spaces existing throughout the material, of which the so-called cell wall and intercellular substance are composed. To the entire contents of this cavity or cell (where it can be removed as an independent structure), Professor Huxley gives the name of

endoplast, and to the walls of the cavity, or cell wall, that of *periplast*. It is not possible here to offer any remarks upon the various opinions entertained with reference to the mode of growth and development of cell structures. For a full account of Professor Huxley's views upon this subject, the reader is referred to his paper in the "Medico-Chirurgical Review."*

171. Of the Different Forms of Cells. — As cells differ in their vital and physical properties and in the duration of their existence, so also, they may be distinguished according to the offices they perform, or they may 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 *candate* cells, some of which are very complicated, 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 seems to be that of forming merely a protective covering to delicate structures placed beneath them; cells which have the power of selecting from the blood proper pabulum for the nutrition or growth of the material in which they lie; 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 the nervous 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

* "Medico-Chirurgical Review," Vol. xii., page 285, 1853.

growths, which differ essentially from the cells of healthy tissues, of the origin and mode of growth of which we are in almost total ignorance.

Although it is not possible to decide as to the function of a cell from its anatomical characters, it is impossible not to observe a certain correspondence between the forms and offices of cells.

All cells possess the power of multiplying in number, of selecting certain materials from the blood 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. But the power of multiplying with wonderful rapidity seems peculiar to some, while the most striking character of others is their power of selecting and converting certain substances into the constituents of the secretions. Some seem destined to absorb large quantities of matter and pass it onwards into channels adapted to receive it, while not a few appear to serve only the purpose of a protecting covering to delicate parts beneath. The cell which possesses a remarkable power of multiplication, though assuming a great variety of forms, is distinguished for the distinctness and number of its nuclei (cancer cells). The *secreting cell* by its more or less spherical, or polyhedral form and granular contents (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, by its flattened form and imbricated or tessellated arrangement (squamous epithelium of skin, mucous membrane of mouth, œsophagus, vagina, &c., tessellated epithelium covering the surfaces of serous membranes, &c.). All these cells possess the different properties alluded to, but in some, one predominates, while others are distinguished for manifesting another power in an exalted degree.

Perhaps one of the simplest forms of cells in the body is the blood corpuscle. This 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, they burst, and their contents escape. Upon this physical change, and the solubility of the crystallizable material within in water, depends the success of the process for crystallizing the hemato-globulin of the blood, described in a former page. Their cellular character, and the fluid nature of their contents are therefore considered to be proved. The cell wall and cell cavity, however, are not so easily demonstrated in all cases, and I believe that many structures which are now called *cells*, will be shown to consist of masses of material arranged in shapes like cells, but not invested with any membranous envelope. There are many instances in which certain materials are deposited round the nucleus, and not invested with any covering whatever. In this case the nucleus seems to be situated within a cell, while really it has attracted substances which are gradually deposited around it and perhaps altered by its influence, though they are not inclosed within any membrane whatever. 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. This subject will be again alluded to in its proper place.

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 [illegible] into the air tubes during inspiration, which by 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 there is reason for believing that even the *liver-cell* is nothing more than the aggregation of material round a nucleus. I have not been able to demonstrate the existence of a cell wall.* 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 and not exceed this. This will be probably explained by further observation. The whole subject is of the greatest interest, and our views of "cell formation," and the growth and development of structures, are undergoing a gradual but very material alteration. In fact it is probable that

* "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.

before long the whole "cell theory" will be greatly changed. Bearing upon this question in an important degree, are the researches of Mr. Rainey on the deposition of calcareous material in shell, bone, &c., to which the reader is referred.*

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 under their respective heads, and it is, therefore, unnecessary to discuss their characters in this place.

172. Epithelium.—The term epithelium (*επι, 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 variety 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.

173. 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.† .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.

* "Medico-Chirurgical Review," Vol. xx., page 451.

† "Illustrations of the Use of the Microscope in Medicine," Sputum, Plate I., fig. 2.

Vagina.—The scaly epithelium from the vagina is composed of very large, irregular, and often ragged cells, fig. 148. In consequence of the flattened character of the cells of scaly epithelium, portions of them will often be found folded upon

Fig. 148.



Large cells of scaly epithelium, from the vagina.

Fig. 149.



Epithelium, from the bladder. *a.* Large cells from the *trigone*. *b.* Columnar cells lining mucous follicles. *c.* From the fundus.

each other, and creased, as it were, in various directions. The cells of the epidermis, as well as those of nail and hair, present modifications of scaly epithelium.

174. 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 black 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, fig. 150, also present more or less of this character. The nucleus of the cell is usually distinct and well-developed.

175. 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 demon-

strated in the convoluted portion of the tubes of the kidney, fig. 151, in the sweat glands, in the secreting tubes of the stomach, in the follicles of the pancreas, in the liver, &c.

Fig. 150. Fig. 151. Fig. 152.



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.

176. 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, fig. 152, is of this variety. In the evacuations of cholera, the sheaths of the villi will often be found entire, an excellent opportunity for the examination of the arrangement of this variety of epithelium is afforded.

Upon examining a cell of columnar epithelium from the intestine, it will often be observed that at its summit the cell wall is considerably thickened. 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 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

pithelium. I have not been able to satisfy myself perfectly s to the existence of distinct pores, but I believe that Kölliker's statements are correct. The yolk membrane (zona ellucida) of many insects, mollusks, and fishes, and probably also of mammalian animals, is perforated by a single pening, or by a vast number of minute pores, through hich the spermatozoa pass, to reach the yolk within.*

177. Ciliated Epithelium.—There are two principal varieties f ciliated epithelium, the one consisting of small cells of early the same length and breadth, and the other, of the rismatic or cylindrical form. Ciliated epithelium may lways be obtained for demonstration from the back part f the frog's mouth, or from the branchiæ (the beard) of an yster or mussel. The cells must be moistened with some f the mucus taken from the same surface, or with some f the fluid in the shell surrounding the animal, or with a ttle clear serum. If water be added, the movement soon lops, in consequence of endosmosis taking place. In examining ciliary movement, it is often advantageous to place he smallest quantity of lampblack or carmine with the cells, o that the direction of the current produced by the cilia an be clearly demonstrated by the movement communicated o the insoluble particles.

In the human subject, ciliated epithelium is found in the ollowing situations:—On the surface of the ventricles of the rain and on the choroid plexuses; on the mucous membrane f the nose and its sinuses; on the upper and posterior art of the soft palate, and in the Eustachian tube; in the avity of the tympanum; on the membrane lining the rontal and sphenoidal sinuses; on the inner surface of the achrymal 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

* See "Micropyle," Todd and Bowman's Physiology, Vol. ii., page 569.

beautiful specimen of ciliated epithelium from the lining membrane of a large ovarian cyst. 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.

178. False Cells.—Under this head I would include all those structures which resemble, and indeed often cannot be distinguished from, true cells, but which possess no proper cell wall. Many cell-like structures consist of granular material, oil globules, or even perfectly transparent albuminous matter aggregated together sometimes around a nucleus, but in many instances this structure is altogether absent. Not uncommonly, viscid matter is deposited external to the mass, and thus a sort of cell wall is ultimately 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 changes, and in some instances is doubtless due to the attraction of gravitation. Professor E. H. Weber has shown that when solutions of resinous substances are made to take place 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, are produced.* Indeed cell-like bodies are very often formed in fluids out of the body. I have very frequently observed them in solutions of organic fluids undergoing evaporation. Although the solution was at first perfectly clear and free from any solid particles whatever, as evapora-

* 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.

tion 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. 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. 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, it may ever afterwards be impossible to correct.

179. 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 interior, endosmosis will occur, in consequence of which, distension will take place, and in many instances the rupture of the cell wall will result. On the other hand, if the density of the external medium be greater than that of the fluid in the interior of the cells, exosmose of the contents of the latter will occur, and the cell will become collapsed and shrunken. 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

* "Aleurone."—"Annales des Sciences Naturelles," 1857, page 348.

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 yet no chemical action upon the cells. Albumen, sugar, gum, and glycerine, are the most advantageous substances for this purpose. The effect is often as well produced by a viscid solution as by one of high specific gravity. Glycerine, from its highly refractive properties, is sometimes inadmissible, in which case, the 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 cellular structures. A solution of albumen, however, must be used perfectly fresh.

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 will be found to keep very well in the naphtha and creosote solution, or in a dilute solution of chromic acid.

180. Of the Use of Carmine in Demonstrating the Nuclei of Cells.—Different plans for demonstrating the nucleus 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. I must not omit, however, to call attention to the value of a mode of investigation which has been employed of late years. This consists in soaking the structure to be investigated, in a very dilute solution of carmine and ammonia. It is very curious that even for long after the removal of the cells from the body, the nucleus seems to possess the power of attracting the coloured material, and will be found very much more deeply coloured than other parts of the cell. This striking alteration of the nucleus seems to show that it still retains the power of attraction at a time long after its death has taken place, at least according to our present notions of the period at which this occurs. The whole subject is full of interest, and well worthy of patient and attentive study. Dr. Harley was kind enough to give me a beautiful specimen of the cells of the suprarenal capsules prepared in this manner, which displays the nuclei very satisfactorily.

The plan of colouring tissues by imbibition, was first adopted by Dr. Welcker, in his researches on elastic fibres and muscle.* It is only necessary to add to a little carmine a few drops of ammonia, when a very dark red solution is produced. This is thickened with a little gum, and diluted with water. The lower part of the tissue to be coloured, is placed in the solution, which gradually rises by imbibition into that part above the surface of the fluid. The coloured material is always deposited in the nuclei in greater quantity than in other parts of the texture, so that these are of a dark red colour, while the rest of the cell and surrounding textures are only slightly tinged of a delicate pink colour.

* Henle and Pfeuffer's "Zeitschrift," N. F. Vol. viii., p. 225.

181. 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 doubtful how far these are apparent or real, and 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. At the same time, the term *fibre* in the minds of most, has a definite meaning attached to it. 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 Plate II.

Whenever we observe lines parallel to each other, much curved, or interlacing in every direction, whatever their length may be, we speak of this as a *fibrous material*, and say that the tissue has a *fibrous texture*. White and yellow fibrous tissue are represented in figs. 155, 156.

182. Of the manner in which Fibrous Appearance may be produced.—The "*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. 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. The delicate material existing between the basement membrane of a gland tube or follicle, and the capillary vessels, is often spoken of as a "*fibrous matrix*," 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 improperly, be termed *fibrous*.

183. 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. 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 Mr. Bowman in his well-known article "*Mucous Membrane*," in the "Cyclopædia of Anatomy and Physiology," published in the year 1845. Since the appearance of this article, but little has been added to our knowledge of the intimate structure and arrangement of this widely-distributed tissue.

Basement membrane is a perfectly clear transparent, and apparently structureless membrane often of extreme tenuity, so thin, that its thickness cannot be measured, though it is certainly less than the 1-20,000th of an inch. This structure, although it contains no holes, permits fluid to pass through it.

Perhaps the best organ for examining the characters 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.

In disease this membrane is liable to undergo great alteration. It may increase 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 fluids, 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 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 demonstrated by Mr. Rainey. 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 arranged together, a *conglomerate gland*, like the salivary, pancreatic, or mammary gland, is formed.

In all these cases the basement membrane is the structure to which the form of the gland is due. Take a tubular gland like the kidney for example: we may remove the whole of the epithelium from the interior, and a simple tube of basement membrane remains. This membrane always intervenes between the epithelium and the capillary vessels, 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. Its properties may become so altered, that it will allow a fluid to pass through which it retains in the healthy state,—or the transmission of a fluid which in the normal state takes place with the greatest rapidity, may be entirely prevented by an alteration in its structure; it is often many times its natural thickness; it is granular instead of being perfectly transparent; it may be striated, or numerous oil globules may be deposited in or upon it.

Fig. 153.



a. Basement membrane of uriniferous tube. The epithelium has been removed. *b*. Uriniferous tube, showing outline of basement membrane, with epithelium *in situ* in its interior. *c*. Single epithelium cell, × 215.

It is therefore very important to be able to demonstrate this structure in health, and to be familiar with its appearance. It can always be seen in the uriniferous tubes of the kidney and in most glands, but in some, its tenuity is such

that it is demonstrated with great difficulty, and in many places it cannot be obtained as a distinct membrane at all.

184. Capillaries.—The capillaries are tubes composed of delicate membrane in 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 disintegration of the tissues must pass in the contrary direction. At definite intervals, often on alternate sides of the tube, are situated the nuclei, but whether these take part in the changes alluded to, or are

Fig. 154.



Capillary vessels from the Malpighian tuft of the human kidney, which had been injected with dilute Prussian blue injection, showing nuclei connected with their walls. *a*. A few coils separated from the rest of the tuft. *b*. A portion of a loop somewhat compressed, showing the nuclei a little flattened. *c*. Tissue which connects the coils with each other, and thus preserves the globular form of the tuft even when entirely separated from the kidney. *d*. A small portion of a capillary pressed as much as possible, showing the thickness of the capillary wall at the point of reduplication, *e*. × 403.

simply concerned in the nutrition of the capillary itself, is unknown. From the great number of these nuclei in some capillaries set apart for a special purpose, as in those of the Malpighian tuft of the kidney, one would be led to infer that they perform an important office.

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 each other, and the various structures of which 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 nutrition 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. The liver is one of the most vascular organs, and every part of each secreting cell is within 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 1-10,000th 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 (*vide* page 67).

The changes taking place in the tissues, capillary vessels, and blood, in the early stages of inflammation, have lately been carefully investigated by Mr. Lister, whose paper lately read before the Royal Society should be consulted.*

* "On the Early Stages of Inflammation," by Joseph Lister, M.R.C.S., &c. "Proceedings of the Royal Society," June 18th, 1857.

CHAPTER V.

Of Demonstrating the Anatomy of the Tissues, and the changes they undergo in Disease.—Areolar Tissue.—White and Yellow Fibrous Tissue.—Adipose Tissue.—Cartilage.—Bone.—Bony Tumours.—Myeloid.—Vessels.—Atheromatous and Calcareous Deposits in Arteries.—Muscular Fibre.—Fatty Degeneration of Muscle.—Unstriped Muscle.—Nerves.—Mucous Membrane.—Serous and Synovial Membranes.

185. Areolar Tissue can always be obtained from beneath the skin, and mucous membranes, or from the external coat of the arteries. In some situations it is lax and very abundant. It may be blown up with air, and dried to show the areolæ or spaces in which it is disposed. If the vessels be injected with plain size, the areolæ become distended with it, and when cold, very thin sections may be easily cut which show the arrangement of the fibres in the most beautiful manner. It consists of two elementary tissues—the *white fibrous* tissue and the *yellow fibrous* or *elastic* tissue. It is frequently associated with adipose tissue, but beneath the skin of the eyelids and scrotum, and in some other situations, it exists free from fat. The medulla, or marrow of bones, is an example of adipose tissue without any traces of areolar tissue.

186. White Fibrous Tissue can be readily obtained free from the yellow element in tendons and many fasciæ. In the former, its fibres are slightly wavy, but parallel to each other. It can be split up indefinitely, and does not appear to be composed of minute fibres. This fibrous appearance

is destroyed by the action of acetic acid and alkalies, and is rendered less distinct if the tissue be soaked in glycerine. Upon the addition of water, the tissue resumes its ordinary appearance. White fibrous tissue is very opaque, and in

Fig. 155.



White fibrous tissue unravelled, from a tendon.

Fig. 156.



Yellow fibrous tissue, the fibres of which have been unravelled, from the ligamentum nuchæ of a sheep.

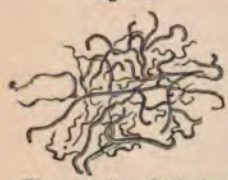
order to demonstrate its characters well, it is desirable to cut a very thin section, unravel it with needles, and subject it to moderate pressure under the thin glass.

187. Yellow Fibrous Tissue may be obtained, perfectly free from the white fibrous element, from the ligamentum nuchæ of any animal, from arteries, or from the elastic ligament to which the retraction of the claw in the cat and other feline animals is due. It consists of circular fibres disposed to curl up very much, and not easily broken or destroyed by the action of reagents. In areolar tissue the fibres are very long and branching, after the manner of a network; in the ligamentum nuchæ they are parallel to each other: in the *longitudinal* fibrous coat of the arteries they are parallel and extremely delicate; in the *circular* coat they are coarse, and the material is often disposed in ragged laminæ rather than in distinct fibres.

The yellow fibrous tissue in the ligamentum nuchæ of the giraffe exhibits transverse striæ (Quekett), and, according to Mr. Brooke, a somewhat similar appearance is sometimes observed in the fibres which have escaped digestion and are found in the fœces.

Yellow fibrous tissue resists decomposition. It is with difficulty acted upon by the strongest chemical reagents, neither is it dissolved by the gastric juice. It is often broken up into small shreds in the alimentary canal without undergoing complete solution. In children these fragments of yellow elastic tissue have been frequently mistaken for thread worms, from which their microscopical characters would at once distinguish them.

Fig. 157.



Fibres of yellow elastic tissue, from the scrotum of a man, operated on by Mr. Fergusson. In this case the areolar tissue had undergone considerable hypertrophy, × 215.

The *development* of these tissues may be studied in almost any embryo. For the investigation of the arrangement of the cells of development, glycerine, with a few drops of acetic acid, will be found the most advantageous solution.

Many tumours and morbid growths are composed of a modification of areolar tissue. Both the white and yellow element, are, however, in most cases coarser than in healthy areolar tissue. Such growths are often very firm and unyielding, with few vessels distributed to them. The investigation is conducted in the same manner as in examining the healthy textures.

188. Adipose Tissue.—Adipose tissue may be examined by cutting off a thin section, and placing it with a little water between two pieces of glass, care being taken not to allow the thin glass cover to press upon it. The surface of one of the smallest collection of fat cells which can be found, should be subjected to examination as an opaque object.

The mesentery of small animals is the best place for obtaining good specimens of adipose tissue,—and being protected by the transparent peritoneal covering, the relations

and form of the fat vesicles are not altered. In this situation, too, the nucleus of the vesicle may often be demonstrated, and cells in every stage of growth can easily be found. Such a preparation, the vessels of which have been previously injected with Prussian blue fluid, will afford an opportunity of demonstrating all the peculiarities of adipose tissue. Near the ovary of the newt and many other batrachia, there exists small collections of adipose tissue. The vesicles are much shrunken during the spring, when the ova are increasing in size, and at this time the nucleus is beautifully distinct in each vesicle. The nuclei of the cells may also be seen very distinctly, especially in starved fat cells, after treatment with a little acetic acid.

Frequently the more solid portion of the contents consisting of margarine and margaric acid, will crystallize on

Fig. 158.



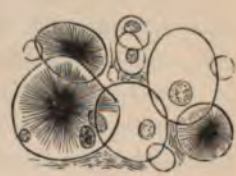
Adipose tissue, with vessels injected, from the capsule of the kidney of the dog. × 130.

Fig. 159.



Large fat vesicles, with crystals of margarine, from a large tumour connected with the testicle, removed by Mr. Fergusson, × 130.

Fig. 160.



Adipose tissue, from the abdominal cavity of a newt, near the situation of the ovary. The nuclei of many of the fat vesicles are unusually distinct, × 215.

the surface of the more oily fat in small acicular crystals, which radiate from a centre forming a star-like mass, fig. 159.*

* See also Todd and Bowman's "Physiological Anatomy."

Adipose tissue should be examined by low as well as by high powers (a two inch, or an inch, and a quarter of an inch object-glass), and by reflected as well as transmitted light.

Fat cells are not unfrequently found degenerated in emaciated subjects, the fat having much diminished in quantity, and the greater part of the cell being occupied with a serous fluid, which, however, exists in very small proportion in a state of health. Under these circumstances the nucleus is often very distinct. The cell may also be in a shrivelled condition, and of a more irregular or angular form. The fluid in its interior has been found to contain granular matter with many small oil globules.

189. Cartilage.—The characters of cartilage are very easily demonstrated. A thin section may be placed in water or glycerine. Specimens should be taken from the larynx, trachea, the ear, the ribs, the articular cartilage of joints, and the fibro-cartilage between the vertebræ and in other situations. The ear of the mouse affords the best example of cartilage consisting almost entirely of cells. The thin part in the upper extremity of the cartilage is very favourable for studying the nutrition and mode of growth of the cells, the intercellular substance or matrix being very small in quantity in this variety of membraniform cartilage. Specimens of cartilage keep very well in dilute spirit and water, creosote fluid, and many other solutions, but on the whole I prefer glycerine as a medium for their preservation.

In preparing sections of articular cartilage, a strong knife should be used, in order that a small portion of the subjacent bone may be obtained in connection with it. In disease, fat globules are often found in considerable number in the cartilage cells. In certain cases of degeneration of the margin of the cornea, *arcus senilis*, the change is associated with fatty degeneration of the muscles, cartilages of the ribs, larynx and other tissues, as my friend Mr. Canton has recently shown.

Morbid growths, closely resembling ordinary cartilage in structure, were first described by Müller under the term

enchondroma. They are most frequently connected with the bones of the extremities, but are occasionally developed in glands and soft parts. In their general characters and minute structure they closely resemble cartilage, but the arrangement and number of cells vary greatly in different specimens of the morbid growth.

In the *pulpy degeneration* of cartilage, the softening seems to be due to an increased growth of the cells. Professor Goodsir showed that the cells were augmented considerably in size, and contained a number of smaller ones in their interior. The different stages through which these cells pass in their development, have been well described by Redfern.*

190. Bone.—Sections of bone are obtained in the manner alluded to in page 61. It is desirable to make sections of the whole extent of the compact tissue. The observer will notice in thin sections, even of young bones, spaces of very different sizes, resulting from dividing a number of tubes (Haversian canals) in which the vessels, which are distributed to the compact tissue, run. Now it appears from the beautiful researches of Messrs. Tomes and De Morgan, that this solid, hard, compact tissue is perpetually undergoing removal and repair. An Haversian canal increases in diameter by the gradual absorption of the concentric lamellæ of bone which surround it, and after a time, a large space is formed, (Haversian space). When this space has reached a certain size, new bone is deposited, commencing at the circumference and gradually proceeding towards the centre, until the space has regained its small size and is again converted into a narrow canal. The *interstitial laminæ* upon this view are very readily accounted for. They are, doubtless, the remains of old Haversian systems only partially absorded.†

The growth of bone is investigated in young animals by mixing madder with their food. In a very short time (even a few days) the madder, which has an affinity for phosphate

* "On Anormal Nutrition in the Human Articular Cartilages," 1852.
† "Phil. Trans.," 1853.

of lime, is deposited in those parts of the bone nearest to the vascular surface. Young pigs are the best animals for experiments of this kind.

The arrangement of the vessels may be investigated in the bones of an animal which has been injected with Prussian blue fluid. It is well to add an excess of hydrochloric acid to the solution. After the injection is complete, the bone may be soaked in dilute hydrochloric acid (one of acid to five of water), to dissolve out the earthy matter, when the soft tissue which remains can be readily cut into thin sections in various directions with a sharp knife.

Not unfrequently the vessels of bone are found distended with blood, thus producing a natural injection. It is difficult to cut and grind the section thin enough for examination without altering the masses of dried blood, but with care this may be effected. My friend Mr. White has given me some beautiful sections of the antler of the stag, in which all the vessels of the Haversian canals still retain blood.

Sections of bone may be preserved dry, in aqueous fluids, or in Canada balsam. The dark appearance of the lacunæ in sections of dried bone is entirely due to their containing air. Their apparent solidity led Purkinje, their discoverer, to call them *bone corpuscles*, but their true nature is easily proved by treating the section with a little turpentine, which insinuates itself into the canaliculi and fills the lacunæ, driving out the air before it. The bone then appears perfectly clear, and it is exceedingly difficult to make out lacunæ at all. If the bone be dried, it regains its former appearance.

If a thin section of bone be immersed in thick balsam, the lacunæ still retain their dark appearance, in consequence of the balsam being too viscid to penetrate the canaliculi and expel the air.

191. Examination of Osseous Tumours and Bone-like Structures.—Sections of bony tumours, which have the structure of true bone, and of the hard plates, such as those frequently deposited in arteries, which are merely masses of calcareous matter deposited in a lamellar form, may be

obtained in the same way as sections of bone. Good sections of tumours which have partly an osseous, and partly a fibrous or fibro-cartilaginous consistence, are very difficult to make; but a thin section may generally be removed with a strong knife, in such a manner as to cut through both the fibrous and ossified portion, if the latter is not very hard and abundant. The facility of this operation is sometimes increased by drying the tumour, and after removing a section, re-moistening it with water.

In examining growths of this description, we may dissolve out the ossific matter with hydrochloric acid, in the same way as in investigations on bone and teeth.*

192. Myeloid.—This term was applied by Mr. Paget to a soft, pulpy growth which probably has its origin in the bone itself. 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 nucleated cells which were originally described by Professor Kölliker, and are found in the medullary cavity of fœtal bones, and to a less extent even in adults.

Myeloid tumours are more common in connection with

Fig. 161.



Myeloid cells from a soft tumour at the lower end of the shaft of the femur, × 220. From a drawing by Mr. Hulke.

the jaw-bones, and certain forms of *epulis* have a myeloid structure. Mr. Paget has described such tumours connected

* On the examination of hard tissues, reference may be made to the following works:—Kölliker, op. cit.; Paragraphs at the end of each article on the

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.†

193. Examination of Vessels.—The smaller vessels may be examined entire, and present beautiful objects for microscopical observation. A portion of the mesentery of a child, or of one of the lower animals, or a small piece of the pia mater may be selected; or one of the smaller arteries of the brain may be freed from cerebral matter by gentle washing in water, and placed in the microscope, with the usual precautions. If the specimen be treated with a drop of acetic acid, the nuclei of the contractile fibre cells, and, in some cases, also those of the epithelial cells, on the lining membrane are brought into view.

In order to make out the fibre-cells of the contractile coat described by Kölliker, a little care is necessary. To effect this object it is better to take an artery of moderate size, which is not quite fresh, but at the same time in which decomposition has not commenced. The artery is to be slit up, and its inner part removed by careful scraping. Small portions of the subjacent elastic tissue are then to be removed, carefully torn up by the aid of fine needles upon a glass slide, moistened with a little water, and placed in the microscope with the usual precautions. The spindle-shaped or muscular fibre cells are also to be obtained from the veins. The vein from which they may be most readily procured is the renal vein. Many of the fibre cells contain distinct nuclei, which are rendered very clear upon the addition of a little acetic acid.

Preparation of Specimens; Quekett, op. cit.; Todd and Bowman, op. cit.; Strausdurkheim, op. cit.; and articles in the "Cyclopædia of Anatomy and Physiology."

* "Transactions of the Medico-Chirurgical Society," 1856.

† "On Tumours connected with Bones."—(Archives of Medicine, No. II., page 104, and Plate 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.

I have obtained beautiful specimens of the muscular fibre cells arranged circularly round the arteries by injecting the vessels with plain size, and gradually increasing the force so as to distend them as much as possible without rupture. In this manner the cells are, as it were, gradually unravelled. When cold, thin sections may be very easily made in various directions, and even isolated fibre cells can be obtained. The arrangement of the muscular fibre cells in the smaller vessels, has lately been carefully investigated by Mr. Lister, to whose researches, published in the "Transactions of the Royal Society," the reader is referred.*

194. Small Vessels of the Kidney.—A thin section of the cortical substance of the kidney often displays the minute vessels very well. The examination of the vessels in this organ is of especial interest, because they are known to undergo important alterations which could not be detected unless the observer were previously well acquainted with their appearance in health. If a section of a healthy kidney is to be examined, with the view of observing the characters of the minute vessels, it will be better to wash the preparation previously in water, or with the wash-bottle, fig. 64, in order to remove as much as possible of the epithelium of the renal tubes. Upon the addition of a drop of acetic acid the vessels are at once brought into view. It will now be noticed that the coats of the veins everywhere appear to be very thin, being represented only by a defined line on each side of the vessel, while the arteries are at once recognized by the greater thickness of their walls, and by the distinct arrangement of the nuclei of the circular and longitudinal fibres. All these points may, however, be observed much more satisfactorily in sections removed from a specimen which has been injected with Prussian blue fluid.

The coats of a healthy Malpighian artery appear to be about the fifth or sixth part of the total diameter of the vessel, but in disease the vascular wall may have increased

* "Transactions Royal Society of Edinburgh," Vol. xxi., Part iv., 1857.

in thickness to such an extent as even to equal in width the canal itself, and to be as much as one-third of the diameter of the vessel. The most perfect specimens of this morbid condition are to be obtained from the small contracted kidneys of intemperate persons. This change is described by Dr. Johnson,* to whom I am indebted for the advantage of having seen many excellent examples of it. Fig. 162 represents the appearance of a portion of a Malpighian artery considerably thickened, but not to such a degree as often occurs. The thickening of the walls is well shown in injected specimens.

Fig. 162.



Small artery from the kidney, taken from a case of chronic nephritis, showing increased thickness of the coats, × 215.

195. Minute Vessels of the Brain and other Organs.—A knowledge of the appearance of the minute arteries of the brain in a state of health is especially important to the morbid anatomist, because in disease these vessels are not unfrequently found to have undergone a very important change, which must necessarily much interfere with the discharge of their functions. In cases of white softening of the brain, this change is very common; indeed in such instances it is, I believe, rarely absent. If we tear away some of the smaller vessels from the softened portion, and after washing them in water, place them in the microscope, we shall often find at short intervals, collections of minute oil globules, easily distinguished by their high refracting power, fig. 163. These may form small aggregations of globules at short intervals, or may extend entirely round the vessel for some distance. With regard to the exact position of the granules or globules connected with the capillaries, much difference of opinion has been expressed. Some hold that they are situated upon the internal surface of the wall of the vessels, others consider them to be in its substance, while many contend that they are always external to the vessel. Professor Bennett regards them as originating in an

* "Diseases of the Kidney," 1852, page 229.

exudation, and therefore situated external to the vessels. *Still*, in many cases the matter is certainly within the substance of the wall, and in others probably upon its external surface.* Frequently small collections are found on opposite sides of the tubes, alternating with each other, and appearing to occupy the position of the nuclei of the development cells of the vessels. This condition has been termed fatty degeneration of the vessels, and is probably very similar to the corresponding change in muscular fibre. Fig. 164 repre-

Fig. 163.



Portions of small artery, and capillary vessels from the brain, with oil granules and globules in their coats, × 215.

Fig. 164.



Small artery and portions of capillary vessels, from the brain in health, × 215.

sents the characters of an artery from a healthy brain, magnified in the same degree as fig. 163; the different diameter of the vessel in various points is due to the unequal pressure of the thin glass cover. In many cases of white softening, the small arteries of the brain are entirely surrounded by spherical aggregations of small oil globules which sometimes extend around the vessel to a distance equal to twice its entire diameter. In such a case it is clearly impossible that the cerebral tissue can be properly nourished. In some instances

* On this subject, Mr. Paget's "Surgical Pathology," Vol. i., should be consulted, as well as Professor Bennett's "Clinical Lectures," second edition, 1858.

there can be little doubt that the passage of the blood through a vessel is prevented by its tube being plugged up with a portion of fibrinous matter. In consequence of this obstruction, the nervous tissue suffers in nutrition, the vessels degenerate, and other changes result.* The mode of investigating the arrangements of the capillaries by injection has been already discussed (page 69).

It is probable that as the investigation of the minute anatomy of the tissues in disease advances, morbid changes will be found to pervade the capillary vessels of many organs of the body. Thus, the vessels of the retina and choroid are frequently affected so that their walls become softened and undergo small dilatations at various intervals, in which the blood seems to collect; and after a time it becomes stagnant. At length disintegration of the small clots commences. The changes which occur in the capillaries of the papillæ of the skin, of the villi, of the liver, kidney, and other glandular organs, are well worthy of attentive study.

196. Atheromatous and Calcareous Deposits in Arteries.—The atheromatous deposit, so common in the larger vessels in disease, usually contains numerous oil globules, with granular matter, partly fatty and partly albuminous, aggregations of minute fat globules, and much cholesterine, fig. 131, which appears to have gradually crystallized out, having been originally deposited in a state of solution in the oil. Cholesterine is always found dissolved in the oily fat in cases of fatty degeneration of various organs. Its presence may always be detected by treating the fatty matter with alcohol and allowing the filtered solution to stand in a cool place, when the crystals gradually make their appearance. This crystallization of cholesterine having taken place, may possibly exert an influence on the still further deposition of atheromatous matter, and so lead to the accumulation of the large quantity often met with. Besides atheromatous deposit, plates of calcareous matter, resembling bone to the unaided

* See a paper by Dr. Kirkes in the thirty-fifth volume of the "Transactions of the Medico-Chirurgical Society," 1852.

eye, are often found in the coats of arteries, sometimes forming an entire ring, completely surrounding the vessel. In some cases fibrous patches are found in the coats of arteries. They are seldom or ever the seat of deposition of calcareous matter, while the atheromatous material is often gradually replaced by hard plates or laminæ, consisting entirely of earthy salts, and to the unaided eye exactly resembling bone. These never contain Haversian canals or lacunæ.

197. Examination of Lymphatic Vessels. — The arrangement of lymphatic vessels may be shown by artificial injection. In consequence, however, of the valves opening towards the large trunks and preventing the flow of fluid from these towards the smaller vessels, there is considerable difficulty in making good artificial injections. Occasionally when blood-vessels are injected, rupture occurs and extravasation into the lymphatic vessels takes place. The lymphatics are often injected in attempts to inject the ducts of the liver, and sometimes by making a small opening into the areolar tissue beneath the skin or mucous membrane, the injection enters the lymphatics. In all these cases, however, only the trunks of the vessels can be displayed, and no injection passes into the smallest tubes. Formerly the lymphatics were injected with mercury, but although this process was well adapted for displaying the course of the larger trunks, the great distension produced rendered it impossible to ascertain the arrangement of the smaller vessels, even supposing them to be injected,—but the mercury seldom penetrated into the smallest branches. Opaque injections are not adapted for showing the smaller lymphatic vessels, especially as the large trunks are always much distended. The use of transparent injections affords more satisfactory results, and with the Prussian blue fluid I have prepared some very good specimens. Many attempts will probably be unsuccessful, but sometimes sufficient of the fluid may be made to pass the valves to inject the smallest branches, when the pipe has been inserted into a large trunk. If the vessels of the part be injected with water, much

of the fluid will return by the lymphatics, the trunks of which become distended and rendered so large that a pipe may be very easily inserted into one of them. After a time, the water may be absorbed by cloths, and the injection forced into the empty vessels. In some instances it runs freely, and beautiful injections, even of the smallest branches, may be readily obtained. This plan, however, does not succeed in every case in which it is tried. Occasionally the lymphatics are distended with granular matter and oil globules to so great an extent, that their arrangement can be made out without any preparation.

198. Examination of Muscular Fibre.— For a description of the minute anatomy of muscular fibre, I must refer to the various works on physiology and minute anatomy; and especially to the well-known papers of Mr. Bowman in the "Philosophical Transactions,"* and to the articles "Muscle," and "Muscular Motion," in the "Cyclopædia of Anatomy and Physiology."

Two forms of muscular fibre have been described, the *striped* or *voluntary fibre*, or *muscular fibre of animal life*, and the *unstriped*, *involuntary*, or *muscular fibre of organic life*, the characters of which will be presently referred to. Both forms possess inherent contractility, and each is stimulated to contract by simple irritation, as may be proved by direct experiment under the microscope. The voluntary muscle alone is under the direct control of the will, while the involuntary fibre performs its functions altogether independently of volition.

Striped muscular fibre may be obtained from the voluntary muscles of man or any animals. If specimens be taken from the members of the different vertebrate classes, certain characteristic peculiarities will be met with, and the muscular fibre of the crustacea, mollusca, and insects, differs from the muscles of the higher animals in many important particulars.

In order to subject a portion of muscular fibre to

* "Phil. Trans.," 1840, 1841.

microscopical examination, it is only necessary to remove a small piece with a sharp knife or a pair of scissars. After tearing it up with needles, and moistening it with a drop of water, the thin glass cover may be placed on it, and the specimen examined with different powers. The transverse striæ will often be rendered very distinct after the fibre has been allowed to macerate for some time in glycerine.

The general arrangement and form of the fibres in voluntary muscles is well shown in a transverse section of the pectoral muscle of a teal (*Querquedula crecca*), which has been put upon the stretch, and allowed to become perfectly dry. A section cut as thin as possible, may be re-moistened with water, and examined in the usual manner. The position of the vessels, their relation to the fibres, and the character of the capillary network are easily demonstrated in specimens which have been injected with transparent Prussian blue or carmine injection.

199. Sarcolemma.—The fibre of the skate, as Mr. Bowman has shown, is remarkably well adapted for showing the sarcolemma, as the sarcous matter may be ruptured while the investing membrane remains entire, and may be thus easily demonstrated. A few of the long fibres from the fin may be spread out upon a piece of glass with the aid of needles, and in this operation it will often be found that the rupture of the sarcous matter in the interior has taken place.

200. Branched Muscular Fibres.—Several modifications of striped muscle have been described of late years, and it is desirable to consider the best methods of demonstrating a few of the most important of these. Branched muscular fibres have been found in the heart, but they are not very easily demonstrated. Fibres of this nature may, however, be shown to exist in great abundance in the tongue of the frog (as was pointed out by Kölliker), from which organ they may generally be obtained as follows: the tongue is to be separated from the animal, and boiled for a few moments in water; the mucous membrane is cautiously dissected off from

a small portion, and a few minute pieces are to be carefully snipped off with scissars, from the edge of the tongue, just beneath the mucous membrane. These are to be torn with very delicate needles, and then examined with a quarter of an inch object-glass. In this manner very perfect fibres may generally be found; but care must be taken not to boil the tongue for too long a time, in which case the fibres become too brittle to admit of separation. These branched fibres are very beautiful objects. In good specimens they are seen to ramify after the manner of the branches of a tree, gradually becoming thinner, until each terminates in a delicate extremity, which is of a tendinous nature, and is incorporated with the sub-mucous areolar tissue or *corium*. The transverse striæ may be observed in the thinnest branches, but cease some distance from the terminal extremity of the fibre. Branched fibres also exist in the upper lip of the rat.*

The gradual tapering of the muscular fibres of the tongue towards their small tendons which are inserted into the corium, has been well described by Dr. Hyde Salter.†

201. Preparation of Muscular Fibre for Microscopical Examination.—The transverse striæ may usually be demonstrated upon a piece of fresh muscular fibre, and are often seen very distinctly in a portion of ordinary voluntary muscle that has been boiled. The ultimate fibrillæ are well displayed in the muscles of many of the lower cartilaginous fishes, especially the lamprey. The mode of cleavage can be very satisfactorily determined, and the "ultimate sarcous particles" separated from each other. I have often obtained most beautiful specimens of muscular fibre from the back of the tongue, a few hours after a meal, of which meat has formed a portion. The fibrillæ often separate readily from each other in a portion of muscle which has been macerated in a solution of chromic acid.

* Huxley; "British and Foreign Medico-Chirurgical Review," 1853. No. XXIV., page 313.

† Article "Tongue," Dr. Todd's "Cyclopædia of Anatomy and Physiology."

Amongst the matters vomited by patients suffering from certain affections of the stomach, beautiful specimens of striped muscular fibre may often be found; and in the evacuations of cholera patients, such specimens were almost constantly observed. In the stomach, the fibres sometimes break up into the discs described by Bowman (Frerichs), and I have obtained these discs produced by transverse cleavage, by macerating the muscles of a fœtus for a long time in strong acetic acid.

The thin, narrow, muscular bands, immediately under the skin of frogs and other small animals, will be found to exhibit well the general anatomy of voluntary muscle. The muscular fibre of the eel splits up readily into its ultimate particles; and beautiful preparations exhibiting the fibrillæ, have been obtained by Mr. Lealand from the pig. Sections of muscle in various directions may be made from muscles which have been boiled, or hardened in spirit, bichloride of mercury, or chromic acid. The reagents of the greatest use in investigating the structure of muscular fibre, are a dilute solution of caustic soda, and acetic acid, which are employed more particularly in investigating the arrangement of the nuclei. Preparations of muscular fibre may be preserved moist in glycerine, glycerine jelly,* chromic acid, or solution of creosote, or they may be dried and mounted in Canada balsam.

202. Examination of Muscular Fibre in a state of Fatty Degeneration.—This most interesting subject was originally investigated by Vicq. D'Azyr. Lately it has received the attention of many observers, both in England and also on the Continent. The paper of Dr. Quain,† contains a most excellent account of fatty degeneration of muscular fibre.

The muscular fibres of the heart very commonly undergo this change, and it is frequently well marked in the musculi papillares, to which the tendinous cords of the auriculo-ventricular valve are attached. Almost any muscles which

* "How to Work with the Microscope," page 37.
† "Medico-Chirurgical Transactions," Vol. xxxiii.

have long been out of use, as happens in many cases of paralysis, and in numerous forms of club-foot, will be found to exhibit it also.

Dr. Meryon mentions the case of four brothers in whom all the muscles of the body lost their contractile power. In these families the females were unaffected.*

Sometimes there is not the slightest appearance of transverse striæ on the fibre, which appears to be composed of rows of minute and highly refracting globules of oil. Professor Paget has shown that the nuclei of muscular fibres in a state of fatty degeneration, were very often absent. In other specimens, no distinct globules can be seen, but the whole fibre appears made up of granular matter. Fig. 165 represents two elementary fibres in a state of fatty degeneration from one of the papillary muscles of the mitral valve. It must, however, be borne in mind, that fibres in a state of commencing decomposition exhibit, in a slight degree, this granular appearance.

Fig. 165.



Muscular fibres, from a musculus papillaris in a state of fatty degeneration, × 215.

The examination is conducted in a similar manner to that of healthy muscle; very small pieces may be cut off with scissars, and torn up carefully with very fine needles. The addition of acetic acid causes the oil globules to become more distinct. The oily nature, both of the globules and granules, may be proved by the addition of a drop of ether, which dissolves them; and upon the evaporation of this ethereal solution, a globule of oil remains behind, which will be found to leave a greasy stain when rubbed upon a piece of clean glass. This reagent also enables us to distinguish between globules of oil and globules of phosphate of lime, which often much resemble each other in form, colour, and refractive properties.

Not unfrequently fibres of muscles become converted into

* "Medico-Chirurgical Transactions," Vol. xxxv., page 73.

fibrous tissue, a change which is also particularly common in the small papillary muscles of the heart. By carefully tearing up a fragment with needles, the fibrous structure can be clearly made out.

203. Examination of Unstriped Muscle. — Involuntary, smooth, or non-striated muscular fibre may be obtained from various situations, both in man and also in the lower animals. These fibres are most abundant in the alimentary canal, the uterus, the bladder, the ducts of glands generally, and large vessels, but they are also found dispersed amongst fibrous tissue in certain situations, particularly in the skin. There are also bundles of pale muscles connected with the hair bulbs, which may be demonstrated very readily. The elongated cells, of which this form of muscle is composed, are also to be demonstrated in the small arteries and veins, as well as in the trabecular tissue of the spleen, and corpora cavernosa penis, the urethra, &c. Involuntary muscle, which has hitherto been described as consisting of flattened bands, has been demonstrated by Professor Kölliker to consist of the elongated cells just referred to. The contractile fibre cells have been arranged in three classes:—1. Short, rounded, or flattened cells, somewhat resembling epithelium. 2. Flattened bands, with fringed edges. 3. Long rounded or fusiform fibres, slightly wavy, and terminating at each end in a point.

The first two varieties are obtained from the blood-vessels. The last form is met with in the intestinal canal, uterus, &c. These cells may be readily isolated by macerating small pieces of the muscular coat of the alimentary canal, &c., in dilute nitric acid, containing about twenty per cent. of strong acid. By a little teasing, with the aid of fine needles, separate cells may be readily obtained. Fig. 166 represents some of the contractile fibre cells from the ileum. These cells may also be demonstrated in most of the lower

Fig. 166.



Muscular fibre cells, from the small intestine, × 215.

animals; but it is worthy of remark that a portion only of the alimentary canal of some fish is surrounded by involuntary muscle, while it has been shown that the whole of the muscular fibre of the intestine of the common tench is of the striped variety (Weber).

204. Examination of the Muscular Structure of the Heart and Tongue.—The muscular fibres of the heart will be found to exhibit the transverse striæ characteristic of voluntary muscle; but they are arranged in long bands, and upon carefully examining a well-prepared specimen, taken either from the heart of man or of most animals, frequent and distinct anastomoses and branchings of the fibres may be observed. The sarcolemma is of such extreme tenuity that it is exceedingly difficult to demonstrate; indeed its existence is questioned by many observers.

In order to exhibit these fibres, the heart of man, or that of any small animal may be taken, and after boiling it for a short time in water, small pieces may be cut off, and carefully torn up with needles. The length of time which the boiling should be continued, varies in different cases. Half a minute is sufficient for the hearts of very small animals; sheep's hearts may be boiled for a quarter of an hour.* Fatty degeneration of the muscular fibres of the heart has already been alluded to. A familiarity with the appearance of the muscular fibre of the heart in health is of great importance with reference to the subject of fatty degeneration of the organ. An examination of a great number of hearts in both healthy and diseased conditions, will alone enable the observer to form an opinion with which he will himself feel satisfied. Sections of the muscular substance of the tongue are readily made by drying the organ when perfectly fresh, and removing a very thin section with a sharp knife. This may be moistened in water, treated with different reagents, and preserved in glycerine, glycerine jelly, or other preservative fluid. See also § 251.

* The course of the bands of fibres of the heart is well described in Mr. Searle's article in the "Cyclopædia of Anatomy and Physiology," Vol. ii., page 619.

Mr. Gant has lately examined the tissues and organs of animals which obtained the first prizes at the cattle show, and has found that the muscular fibres of the heart have undergone fatty degeneration. In some the organ was soft and flabby, and had nearly lost its contractile power. This change resulted in part, no doubt, from the accumulation of adipose tissue on the organ itself, but was principally due to the deterioration of the muscular fibres of the organ. As would be supposed also, the voluntary muscles of the body had undergone a corresponding change. The value of this highly fatted meat as an article of food is also considered in the essay referred to.*

205. Examination of Nerves. — The general anatomy of the trunk of a nerve is demonstrated without difficulty. It is better to take as thin a fibre as possible, tear it up with very fine needles upon a glass slide, and after the addition of a drop of serum, it may be covered with thin glass. The delicate nerve fibres of any small animal, or the ciliary nerves may be taken. The nerves of the frog are very large, but exhibit all the essential structures of nerve fibres. Glycerine will be found a good medium for examining nerve fibres in, but the observations should never be limited to the results obtained by one method of investigation alone, for in this case, many erroneous inferences would be drawn.

If a nerve be placed in a little water, a curious change takes place. The constituents of which the medullary sheath is composed, become altered so as to exhibit two distinct lines (white substance of Schwann), a change which probably depends upon the fatty matter being partly separated from the albuminous material with which it is incorporated. Although this appearance is undoubtedly produced by soaking in water, the existence of a special highly refracting material within the tubular *membrane* and around the *axis cylinder*, cannot be questioned.

The investigation of the manner in which nerves termi-

* "Evil Results of Overfeeding Cattle," by F. J. Gant. Churchill, 1858.

nate, is one of the most difficult inquiries that the observer can undertake. In many structures a nervous network may be demonstrated, but this can hardly be regarded as the termination of the nerves. The terminal fibrils may often be traced for some distance, but then they are lost. In many cases they certainly lose their white substance of Schwann, and the axis cylinder may be traced a slight distance beyond this point, but is then lost among other tissues. Recent researches, however, have proved that the essential part of the nerve, the axis cylinder, is in much closer relation to the external coverings of sensitive surfaces than was formerly supposed. In many organs a prolongation of the nerve has been traced quite to the surface, and seems to lose itself near the point of attachment of the epithelial cells. In investigating the mode of termination of nerve fibres, the papillæ of the tongue of many of the lower animals, especially of the frog,* the olfactory mucous membrane, the retina, and the Pacinian corpuscles, are the tissues which seem to give the best prospects of success. I should recommend any one desirous of prosecuting such an inquiry to select one of the above textures, and investigate it in every way which seems to afford the slightest prospect of success.

The general distribution of the nerves beneath the skin, may be well seen in the ear of the mouse, from which the thin skin covering it has been carefully dissected off. In the dura mater also, even in man, I have seen many individual nerve fibres arranged so as to form with others a coarse network, and a single fibre may often be traced for a very long distance. The fibres themselves do not divide, but for the most part are arranged two or three together. The fibres in these localities frequently leave their companions and pass a short distance with others, so that a network is in this manner formed upon the surface of the dura mater and other membranes, and immediately beneath the skin. The mesentery of the mouse is also a very favourable structure

* Dr. Waller's paper "On the Mode of Termination of the Nerves in the Papillæ of the Frog's Tongue."—(Phil. Trans., 1849).

for demonstrating the mode of branching of nerve trunks. The course of sensitive nerve fibres may be well followed out in thin sections of the snout of the pig, mole, and other animals, in which the disposition of the fibres is very beautiful. In the investigation of the disposition of nerve fibres, Mr. Lockhart Clarke's fluids and a mixture of acetic acid and glycerine will be found of great service. Phosphoric acid and solutions of iodine have been used by some investigators in researches upon the structure of nerves. Doubtless there are many other chemical reagents which experience will show to be useful in investigations upon the nervous system.

The structure of nerves becomes much altered in disease. If the trunk be subjected to much stretching or pressure, all trace of the existence of individual fibres is gradually lost, and the whole cord assumes a fibrous appearance, or fat granules and globules manifest themselves in and about the fibres, which undergo a process of absorption. Of fatty degeneration of nerve fibre I met with a most beautiful example not long ago, in a case of Dr. Todd's, in which one of the pneumogastric nerves had become incorporated with, and stretched over, the walls of a large aortic aneurism. The fibres of the nerve trunks contained numerous granules and minute oil globules.

206. Examination of Mucous Membrane.— Mucous membrane consists of one or more layers of epithelium, which have been described as resting upon the basement membrane, the characters of which have been adverted to, page 161. Beneath the basement membrane is a layer of areolar tissue (*sub-mucous areolar tissue, sub-basement tissue* or corium). To this structure, muscular fibres, or their tendons, when these exist, are inserted. In this tissue ramify the vessels and nerves. The thickness of the mucous membrane and other characters of the several structures of which it is composed vary much in different localities. The mucous membrane of the mouth, especially at the back part of the tongue, may be readily subjected to examination, and the different structures enumerated may be made out. It is desirable

The vessels which run between synovial membrane and cartilage are very tortuous, and exhibit considerable dilatations and varicosities. The characters of serous and synovial membranes are fully described in Dr. Brinton's article "Serous and Synovial Membranes," in the "Cyclopædia of Anatomy and Physiology," to which the reader is referred.*

* Besides the works mentioned in the text, the following may be consulted upon the subjects treated of in the present chapter. Articles in the "Cyclopædia of Anatomy and Physiology." "Physiological Anatomy and Physiology of Man," by Todd and Bowman. Kölliker's works. Gerlach's "Gewebelehre," Leydig's "Lehrbuch der Histologie." Rokitansky's "Lehrbuch der Pathologischen Anatomie," Wien. 1855. Wedl's "Pathological Histology," translated by the Sydenham Society. Jones and Sieveking's "Pathological Anatomy."

CHAPTER VI.

EXAMINATION OF THE ALIMENTARY CANAL. — *Epithelium Villi.—Hypertrophy of Sub-mucous Tissue of the Stomach. —Ulcers of the Intestines.—Salivary Glands and Pancreas.* —EXAMINATION OF THE RESPIRATORY ORGANS.—*Of the Lung.* — ORGANS OF CIRCULATION. — EXAMINATION OF ORGANS OF SECRETION.— *Liver.— Portal and Hepatic Vein and Artery. — Vessels of the Gall Bladder. — Of Injecting the Ducts of the Liver.—Liver Cells.—Of Injecting the Lymphatics of the Liver.—Of the Morbid Changes in the Liver. — Liver of the Lower Animals. — Of the Kidney.—Epithelium.—Basement Membrane.—Matrix.— Of the Kidney in Disease.—Bright's Kidney.—Examination of the Kidney in the Lower Animals. — Kidney of the Frog and Newt.—Examination of the Spleen.— Thymus and Thyroid. — Lymphatic Glands. — Of the Suprarenal Capsules.* — EXAMINATION OF THE ORGANS OF THE NERVOUS SYSTEM. — *Examination of the Brain and Cord.—Of taking the Specific Gravity of the Brain.* —EXAMINATION OF THE ORGANS OF GENERATION.

EXAMINATION OF THE ALIMENTARY CANAL.

208. Epithelium.—The epithelium of mucous membranes s very readily subjected to examination, and its character s found to vary much according to the locality from which t is taken. The chief varieties of epithelium, and the nethod of examining them have already been referred to (§ 172). In order to obtain a specimen of epithelium rom a mucous membrane, all that is required is to scrape he surface gently with a knife, and place what has been

removed upon a glass slide. After moistening it with a little water, syrup, or a mixture of glycerine and water, which does not cause the cells to become so turgid from endosmosis, the specimen may be placed in the microscope. The thin glass cover should not be allowed to press too hard upon it.

The epithelium of mucous membranes is liable to undergo various changes in character in the course of disease. When exposed to the air, the soft, thin, and moist epithelial covering becomes converted into a firm, hard, almost cuticular investment. Such a change is often seen in the epithelium covering the glans penis when this is not protected by the prepuce. In cases of *procidentia uteri*, when the os is completely exposed, its soft mucous covering becomes harder and almost cuticular. Tubercles are not unfrequently found connected with the mucous membrane and skin of the genital organs as a consequence of syphilis, and in structure may be compared to *warts* which are developed upon cuticular surfaces in other parts of the body. There are, however, morbid alterations affecting the growth of the epithelial cells both of mucous membrane and skin, far more serious than these. Sometimes from the mere irritation of a foreign body, a redundant and exceedingly irregular growth of coarse, ill-formed epithelial cells takes place. The mass gradually increases in size, and if it be allowed to pursue its own course, may ultimately become so enormous, and require so large an amount of nutrient matter, as to exhaust the powers of the patient and cause his death. Some of these growths have received the name of *epithelial cancer*, and always commence upon the surface. The structures beneath the cuticle are more or less affected in this condition.

A thin layer of pale muscular fibres has been described by Brücke as situated immediately beneath the basement membrane of the small intestine. The contractile fibre cells of which it is composed are arranged in two layers, one of which takes a circular and the other a longitudinal direction. This is termed the muscular layer of the mucous coat,

to distinguish it from the muscular coat of the intestine which lies external to the sub-mucous tissue.

209. Villi.—Muscular Fibres.—Lacteals.—The villi are best shown by making a perpendicular section of the mucous membrane of the small intestines with a very sharp knife, taking care, if possible, to make them take one direction by allowing a stream of water to flow over them, as referred to in describing the method of examining the papillæ of the skin (§ 244).

The *muscular fibres* of the villi, demonstrated first by Brücke, are to be shown by washing off the epithelium, and treating them with a solution of acetic and nitric acid, composed of about four parts of water to one of acid. For a description of the arrangement of these fibres, I must refer to Kölliker's work.

The elementary structure of the muscular coat may be demonstrated by soaking small shreds in nitric acid diluted with four or five parts of water.

The *Lacteals* may sometimes be demonstrated in consequence of being filled with chyle at the time of death, but their arrangement may be very satisfactorily observed in the villi of a rat or mouse which has been fed upon a considerable quantity of fatty food for some time before death. The animal should be killed by dashing it suddenly on the floor, for unless death be immediate, the lacteals become emptied before they can be submitted to examination.

210. Hypertrophy of Sub-mucous Tissue.—Cancer of the Stomach.—In certain morbid conditions, the sub-mucous tissue in this region is found as a hard, dense, somewhat transparent-looking layer, varying in different cases from the eighth or tenth of an inch to an inch or even more in thickness, and almost of a cartilaginous consistence. Thin sections may be very readily examined, and will, in many instances, be found to be composed of the original elements of the tissue, but coarser and more abundant than in health, with a certain proportion of granular matter, and a few badly-defined cells, the nature of which it is not easy to explain.

In the majority of cases of the so-called "cancer of the pylorus," nothing more than the thickening of the sub-mucous areolar tissue above referred to can be observed, and upon microscopical examination none of the cells characteristic of malignant growths can be detected. A similar condition is not unfrequently found affecting the sub-mucous tissue of the colon, and cæcum, and in other situations. It is important to distinguish this affection from true *cancer*, as in its general appearance to the unaided eye it is found so closely to resemble scirrhus, although it is essentially different from this disease in a pathological point of view. Microscopical examination generally enables us to decide the question.

In some cases I have observed that the thickening is almost or entirely confined to the muscular coat. In one of these sent to me by Dr. Hall, of Brighton, the walls of the pylorus were nearly an inch in thickness, and upon making a thin section of the firm, hard, fibrous-looking tissue and examining it under a quarter, it was found to be composed of coarse bands of organic muscle.* The same remarks will in great measure apply to the so-called *cancer of the rectum*. Many of these cases really consist of thickening of the coats of the bowels, and are not of a cancerous nature at all.

There are, however, instances from time to time observed in which the meshes or areolæ of the tissue are much enlarged, and filled with cells having the general aspect of cancer cells, while the fibres composing the walls of these spaces are found to be more numerous and of increased thickness. To such, the term *cancer* may be correctly applied. After a time these morbid changes involve the mucous membrane itself, and an irregular ulcerating surface is formed. In examining an ulcer of this description, a little of the secretion from the surface, the surface itself, and the hardened tissue beneath, should be separately subjected to observation.

In the examination of these structures, thin sections

* "Archives of Medicine," No. III.

entirely through the thickened mass should be obtained with the aid of a Valentin's knife. The section, after being slightly washed, may be subjected to examination with the usual precautions.

The morbid changes occurring in the mucous membrane of the stomach in various cases of disease, have recently been investigated with great care by Dr. Handfield Jones, to whose works the reader is referred for information on this head.*

211. Ulcers of the Intestines.—The surface of ulcers of the intestine may be examined by scraping, or by cutting off small pieces with curved scissars. Sometimes the villi situated immediately around the ulcer will be found to be very much increased in length. This change had taken place to a great extent around some ulcers of the small intestine of a patient, who died of fever some time ago in King's College Hospital. The villi round the margin of the ulcers were many of them three or four times as long as those in other parts of the intestine. Whenever ulcers of the intestinal canal are examined, we must always endeavour to ascertain if the ulcer has eaten into the muscular coat of the intestine, a point which can easily be decided by the presence or absence of unstriped fibre in the tissue which forms the base of the ulcer.

A weak solution of glycerine is the most advantageous medium for immersing structures of this kind in for microscopical examination.

There is yet much to be learnt with reference to the nature of various morbid changes affecting the mucous membrane of the intestinal canal, and especially the villi. The investigation will be best conducted after the vessels have been injected with Prussian blue fluid. A portion of intestine is readily injected if the pipe be inserted into a small trunk of an artery after all the divided vessels have been tied. Many of these may be gathered together and a ligature passed round them at once.

* "Medico-Chirurgical Transactions," Vol. xxxvii., page 88. "Pathological and Clinical Observations respecting Morbid Conditions of the Stomach," 1855. —Churchill.

212. Salivary Glands and Pancreas.—The investigation of the salivary glands and pancreas scarcely requires any special remarks. The best idea of their structure is obtained by subjecting one of the smallest labial or buccal glands and Brunner's glands to examination. The ultimate follicles and epithelium are very easily demonstrated in specimens which have been soaked for some time in glycerine. It is often troublesome to trace the continuity of the duct with the follicles, in consequence of some of the latter covering its terminal portion. The ducts of the salivary gland and pancreas may sometimes be injected, and it is advantageous to subject the organs to firm pressure for some time previously, so as to absorb as much as possible of the fluid they contain, and favour the entrance of the injection. Good sections may often be obtained from specimens which have been hardened in alcohol and soda. The arrangement of the capillaries is easily made out in specimens injected with vermilion, chromate of lead, or transparent injection. If the vessels are injected with gelatine only, very instructive sections may be made. In such investigations, however, it is necessary to make a vast number of sections and examine them carefully, or the observer will not be able to form a correct idea of the structure of the gland.

In disease the structure of these organs becomes variously modified. Sometimes obstruction of the duct causes accumulation of the secretion and consequent dilatation. Small concretions sometimes cause this obstruction. Salivary calculi vary considerably in size, and are composed of phosphate and carbonate of lime with animal matter, which is deposited with the earthy salts. Small aggregations of epithelium, held together by mucus, probably form the nucleus of these calculi.

Examination of the Respiratory Apparatus.

213. Lung.—There is not much difficulty in demonstrating the different tissues of which the lung is composed. Small pieces may be cut off, and spread out upon the glass slide in the usual way; the preparation being moistened with water

r serum. The addition of a little acetic acid causes the ellow elastic tissue to become very distinct. The boundaries id arrangement of the air-cells may also be readily shown.

No opinion with reference to the nature of the walls of e air-cells can be arrived at, unless injected as well as injected specimens are examined. The twisted and runken capillaries of the recent lung containing a few ood corpuscles, produce an appearance which is very likely give rise to erroneous inferences with regard to the disition and coverings of these vessels. Either the Prussian ue or carmine injecting fluid may be employed. A most structive preparation of the lung, however, is made by jecting the vessels with tolerably thick transparent gelatine, hich transudes through their walls, and fills the air-cells. fter the lung has been thoroughly injected, it is set aside to t cool. Thin slices may be examined, and the vessels will seen *in situ* apparently bare, and uncovered by epithelium.*

Much difference of opinion has been expressed with ference to the existence of epithelium in the air-cells of the ng. I have lately carefully examined healthy human lungs hich have been prepared in various ways, and have comletely failed to demonstrate the presence of such a structure the healthy adult, or in the lungs of several mammalian nimals. I have never seen such appearances as are repreented in many drawings, showing this epithelium so disnctly, that one would be led to conclude that it was to be en without the slightest difficulty. In the fœtus and young hild, however, cells are found in the air-cells, but it seems o me very doubtful if these take any part in the function f respiration. The whole subject requires very careful nvestigation.

214. Trachea and Bronchial Tubes.—The *mucous membrane* f the trachea and bronchial tubes must be examined in the ecent state by cutting thin sections with a very sharp knife.

Beneath this mucous membrane is an abundant plexus of lymphatic vessels. In many cases these contain lymph cor-

* "Physiological Anatomy," Todd and Bowman, page 393. Mr. Rainey in the "Medico-Chirurgical Transactions," Vol. xxxii., 1849, page 47.

puscles and fatty matter in a granular state, so that their arrangement may be easily made out. The lymphatics upon the surface of the lung, immediately beneath the pleura, may also sometimes be very clearly demonstrated. I have one specimen taken from a child, in which these lymphatics are completely distended with large oil globules and granular matter, so that the position of their valves is rendered very distinct, and the smallest branches can be followed into the intervals between the lobules of the lung. In this specimen the tubes certainly form a network, but in many situations appearances are observed which lead to the conclusion that these tubes also commence in cæcal extremities.

In examining the ciliated epithelium of the air-passages, it is only necessary to scrape the surface gently, and, if necessary, the preparation may be moistened with a little serum, as water would very soon stop the motion.

215. Respiratory Apparatus in Lower Animals. — The breathing apparatus in various animals may be examined with great advantage.

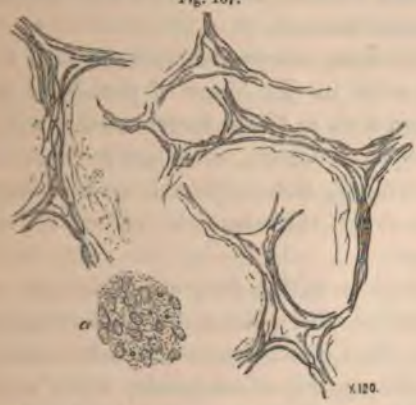
Tracheæ, characteristic of the class of insects, may be readily obtained by removing the viscera of a common fly or other small insect, and tearing carefully with needles. They may be examined after the addition of a drop of water, or they may be dried and moistened with a drop of turpentine, or mounted in Canada balsam. The branchiæ of many mollusca (oyster, mussel) exhibit ciliary motion very beautifully. The gills of fish, the lungs of frogs, newts, and serpents, will also furnish many very instructive specimens.

216. Examination of the Lung in a Morbid State.—The same general method of procedure is employed here. The lungs of emphysematous patients are particularly worthy of study. According to the observations of Mr. Rainey, the pulmonary membrane is found perforated with many minute holes, and here and there numerous oil globules may be detected; the fibres of yellow elastic tissue are stretched, and have lost their elasticity; the vessels are much elongated, and the interspaces between them much enlarged.*

* "Medico-Chirurgical Transactions," Vol. xxxi., 1848, page 297.

Of *tuberculous lung*, different parts should be submitted to examination. If we find a cavity, its contents, the surface of the walls, and a section of the immediately subjacent tissue should be examined. If the tubercles have not broken down, small portions may be removed upon the point of a knife, moistened with a drop of water, and examined in the

Fig. 167.



Fragments of pulmonary tissue expectorated in the sputum. From a case of phthisis.
a. Cells or tubercle corpuscles, from the same specimen.

microscope. A tubercular lung which has been injected, affords very instructive specimens. The beautiful preparations of Professor Quekett, show that the capillaries into which the injection has passed are those of the original air-cells of the lung, and not new vessels belonging to the tubercle.

Fig. 167 represents the general appearance of fragments of elastic tissue of the lung, which are met with in the sputum in many cases of phthisis. The small cells are tubercle corpuscles, which will be more fully described under "Sputum." These little bodies are usually associated with a considerable quantity of granular matter, and many minute oil globules are often present.

The characters of different specimens of sputum are considered in chapter viii.

Crystals of cholesterine are occasionally met with amongst the cheesy matter which makes up the greater part of some

tuberculous masses found in the lung after death, especially when these are circumscribed and thus prevented from escaping into the bronchial tubes. If, however, no crystals can be detected, a portion of the mass, placed in a watch-glass, may be treated with a few drops of alcohol. As the alcohol gradually evaporates, beautiful crystals of cholesterine form, and may be subjected to microscopical examination in the usual manner.

The small, white, calcareous masses, which are not unfrequently met with in the lungs of phthisical patients, and which are from time to time expectorated in sputum, may be examined as opaque objects, with low powers; or fragments may be broken off, and subjected to examination. After having been dried, they may be placed in turpentine or Canada balsam.

If we test them with a drop of acetic acid, we shall find that they dissolve with effervescence, showing the presence of carbonate. One part of the acetic acid solution may then be treated with excess of ammonia, when a precipitate of phosphate of lime will be immediately thrown down. The presence of lime may be detected in the other portion of the acid solution, by adding to it a little solution of oxalate of ammonia.

The relation of the tuberculous matter to the walls of the air-cells, can only be demonstrated in an injected specimen of tuberculous lung. By many it is held that tubercle is nothing more than the altered epithelium of the air-cells. See "Sputum," § 273. The transparent injecting fluids before recommended, afford the most satisfactory results in inquiries of this nature. The examination of the solidified pneumonic lung, of cancerous lung, and other diseased conditions of the pulmonary tissue, is conducted according to the methods of investigation already described.

Organs of Circulation.

The method of investigating the structure of the arteries, has been described in page 174, and of the heart in page 186, so that it is unnecessary to discuss the subject further under

his head. The mode of demonstrating the arrangement of the capillaries has been described.

Organs of Secretion.

217. Liver—General Examination.—The liver may be subjected to examination in various ways, and to demonstrate its structure very different processes are required. If the cells alone are to be examined, a freshly-cut surface may be scraped with a sharp knife, and the matter thus removed placed in a drop of water or serum, and covered with the thin glass. The appearance of a cell wall is pretty distinct in water, but I believe this is due partly to the difference in refractive power of the water and the material of which the so-called cell is composed, and partly to the action of the water itself upon this. If the cells be placed in serum or glycerine, they appear perfectly solid, and no envelope whatever can be discovered. I have never been able to discover even the slightest interval between the supposed cell wall and cell contents, which would certainly exist, under certain circumstances, if the former structure were present.

In order to demonstrate the relation which the different elements bear to each other, the best way is to cut a very thin section by means of Valentin's knife, from the fresh liver; or thin sections may be taken from portions of liver which have been hardened in alcohol, chromic acid, &c. The vessels of the liver may sometimes be demonstrated by washing the cells away from a thin section with a stream of water, and then treating it with a little dilute caustic soda. In specimens prepared in this way, however, the capillaries are often quite invisible. From the extreme tenuity of their walls in many cases, not a trace of them can be discovered, indeed the existence of the capillary wall can only be proved by filling the vessels with transparent injection in the first instance.

A consideration of the various elementary tissues of which the different organs of the body are composed, would of itself almost lead to the inference that several different methods must be employed when we desire to demonstrate

their individual characters. The medium in which these different tissues are most satisfactorily examined, depends upon certain physical characters, chemical composition, transparency and refractive power. It is, therefore, next to impossible to demonstrate all the anatomical elements of which an organ is composed in one single specimen. The student should bear in mind that the idea of the organ as it exists during life, is formed from building up, as it were, in his own mind the various structures, the arrangement of which has been demonstrated by several distinct methods of investigation.

218. On Demonstrating the Structure of the Liver.—The investigation of the structure of the liver is somewhat difficult, owing to the numerous distinct tissues which compose the organ and their intimate connection with each other. I shall discuss, in the first place, the mode of investigating the anatomy of the healthy liver; and, secondly, refer to methods applicable for ascertaining the nature of some of the morbid changes to which the organ is liable.

Lobules of the Liver.—The arrangement of the lobules in most livers is very different to that of the pig. In the latter there are distinct lobules, each being inclosed in a capsule of fibrous tissue. In the human liver, and in that of most animals, although there is a mapping out of the entire organ into small elementary organs, or lobules, these are not separated from each other as in the pig, but the capillaries of one lobule communicate at various points with those of adjacent lobules. They are not separated by fibrous or other tissue, and no structure answering to the description given of Glisson's capsule, can be demonstrated in this situation. Great confusion with regard to the nature of the "lobule," has arisen from observers considering the pig's liver as the type to which others should be referred, whereas its arrangement is exceptional and totally different from the human and most mammalian livers.

Of the Healthy Liver.—To demonstrate the general arrangement of the vessels and duct.

Portal Vein.—The general arrangement of the portal

vein may be easily demonstrated by injecting one of the large trunks of this vessel. Any of the ordinary injecting materials may be used, but I prefer the Prussian blue injection to which sufficient gelatine has been added to cause it to set firmly. It is desirable not to attempt to make a very complete injection, but to leave the capillaries, in the centre of the lobules, in an uninjected state.

Hepatic Vein.—The same process is applicable for demonstrating the arrangement of the branches of the hepatic vein. The injecting pipe may be placed in one of the branches exposed on the cut surface of the liver. The injection runs very readily, and upon examination it will be found that the capillaries in the centre of the lobules only are filled. When the injection has set, thin sections may be cut with Valentin's knife or with the double-edged scalpel; and it is desirable to take several thin sections from the surface of the organ. The sections may be preserved in fluid or dried and mounted in Canada balsam; I much prefer glycerine as the preservative medium. The portal vein may be injected in one part of a liver, and the hepatic vein in another part. Sections of the latter, of course form the exact complement of those of the former. In the one, the central portion of the lobule has been injected, while in the other, the injection is confined to the vessels and capillaries at the circumference of the lobule. By injecting the portal and hepatic veins of a liver with different colours, these points may be shown in one preparation. Beautiful specimens of this kind may be prepared by injecting one vessel with carmine and the other with Prussian blue (page 68).

Artery.—The arrangement of the artery is also shown by injection; the surface of the organ is supplied by an extensive arterial network, and the portal canals also contain a similar network. The coats of the ducts are largely supplied with arterial blood, and the finer ducts are in close relation with numerous small branches of the artery. The precise mode in which the blood is poured into the veins has been a subject of great dispute, but I have many preparations

which show that the blood is poured into the portal capillaries near the circumference of the lobule as Kiernan long ago inferred, and not into those near the centre.*

219. Of Injecting the Ducts of the Liver.—In order to inject the ducts of the liver, it is necessary in the first instance to remove the bile, for the greatest amount of force which can be employed is insufficient to cause this fluid to permeate the ducts, and it is quite impossible to make the injection pass it. In fact after death, the smallest ducts almost invariably contain a certain quantity of bile. By injecting water into the portal vein for some time, a certain quantity permeates the capillaries and passes into the ducts. Thus the bile becomes diluted, and is forced out from the duct. Gradually in this manner the ducts are, as it were, washed out, and every particle of bile removed and made to flow out in the same direction as that in which it passes during life.

Since the publication of my paper in the Phil. Trans. for 1855, and memoir upon the anatomy of the liver, in which this mode of investigation was described,† some observers of high authority have expressed a doubt as to the possibility of forcing water through the vessels, to the extent advocated in my paper, without their rupture, and the destruction of the other structures. The plans which I followed have been repeated several times, and have in every instance confirmed the results which I previously arrived at. It is desirable to describe the process somewhat at length, so that other observers may find no difficulty in following out the plan.

Injection of the Liver with Water.—A large pig's liver within half an hour after its removal from the animal, was arranged as follows:—A piece of glass tube, the sharp edges of which had been removed, and one end a little enlarged in the blowpipe flame, was inserted into the *portal vein*. The

* "Phil. Trans.," 1833.

† "On the Anatomy of the Liver," illustrated with sixty-six photographs of the drawings, 1856.

vessel was tied round the tube with strong thread, all chance of slipping being prevented by the dilated extremity of the tube. A piece about four inches in length was inserted into the *hepatic vein* in the same manner. The liver was placed in a dish, over the edge of which the tube inserted into the hepatic vein was allowed to project, in such a way that fluid flowing from it would be conveniently received in vessels placed near the stool upon which the dish was supported. A quantity of water at about the temperature of 100° Fahrenheit was placed in a vessel about four feet above the liver. The water from this reservoir was conducted to the portal vein by means of a glass syphon and India-rubber tube provided with a stopcock. Before connecting the flexible tube with the portal vein, some of the water was allowed to flow freely through it, and permitted to gravitate into the vein in such a manner as to allow all the air contained in that vessel to rise to the orifice of the tube before the connection was rendered complete. It is very necessary to prevent air from being driven into the capillaries; for if this should happen, rupture of the vessels and extravasation of the fluid will inevitably occur. The liver having been kept warm by the application of cloths dipped in hot water, the stopcock was turned so as to allow the water at 100° gradually to pass along the branches of the portal vein, and traverse the capillaries of the lobules. If such an arrangement be made we shall invariably notice that the entire organ soon swells to twice its size, while blood slowly trickles from the tube inserted into the hepatic vein. The blood soon becomes paler in consequence of its dilution with the water, the liver becomes tense, and the whole surface moist in consequence of the transudation of a little water; the small arteries are distended, the lymphatics are gorged, and the areolar tissue surrounding the vessels in the transverse fissure becomes puffy from the accumulation of water; bile passes along the duct, and the gall bladder becomes filled. Its contents may be forced out through the common duct by pressure, and it soon becomes re-filled, and this process may

be repeated many times, the fluid which is removed containing less bile each succeeding time.

The water was allowed thus to wash out the vessels of the liver, and to permeate the ducts, for about four hours, and the fluid collected from the hepatic vein amounted to 34½ ounces. The last portions which passed through were perfectly colourless, and contained no traces of sugar, which substance had been previously detected in considerable quantity. The liver was then removed, and injecting-pipes inserted into a branch of each of the following vessels distributed to different lobes:—*portal vein, hepatic vein, hepatic artery,* and *duct.* A pipe should also be inserted into the branch of *portal vein,* distributed to the lobe in which the duct is to be injected. While the vessels are thus distended with water, branches are readily found, and the pipes can be inserted with ease. The liver was then wrapped up in soft cloths, small pieces of sponge being placed here and there, and subjected to considerable pressure during the next twenty-four hours, by being placed beneath a board loaded with about fifteen pounds.

It is desirable only to attempt the injection of the liver during cold weather, otherwise decomposition may have commenced before the fluid has been sufficiently absorbed to permit the introduction of the injection into the vessels.

After the water has been absorbed, the liver is very much reduced in size, and almost of a clayey consistence. The vessels are now quite empty, and ready to receive any injection which the observer may desire to introduce. As before stated, I have tried various kinds of the ordinary opaque injections, but although these may be forced in very satisfactorily, it is absolutely impossible that the arrangements of the duct can be made out, while the smallest branches can hardly be distinguished under these circumstances, as a higher power is required for their demonstration than can be conveniently applied to the examination of an opaque injection. For these, and several other reasons, I have used transparent injections, and give the preference to the Prus-

blue solution, the composition of which is given in
67.

Some of this injection was carefully forced into the
ral vessels, until the masses of liver were properly in-
d. It is desirable not to push the injection too far, as
is often to be learned from a partial injection than
one in which all the capillaries are completely filled.

We have, then, one lobe in which the *portal vein* is
ted, another lobe injected from the *hepatic vein*, a third
the *artery*, and a fourth in which the injection has been
d into *the duct*. Of the three former, thin sections
be made after the lapse of a quarter of an hour, with a
double-edged scalpel, or with Valentin's knife. These
be gently washed on both surfaces, and immersed in
erine. After having been allowed to soak in this fluid
alf an hour, or longer, they may be placed in a cell and
ected to examination.

Before however the arrangement of the duct can be
e out, a further operation is necessary. The injection
d into the duct will pass to the smallest branches,
ugh which it will be conducted to the cell-containing
ork of the lobule. It will run amongst the cells and
nd the tubes of this network to such an extent, that
cent tubes will come into close contact—the capillary,
h intervenes between them, being empty, or nearly so.
section were made and examined, we should be able to
e out nothing very definite; the duct could be traced
the lobule and shown to be continuous with the injected
ion, but the individual tubes could not be made out, or
east, only one or two here and there could be demon-
ed. It is obvious, that if the capillaries were injected
the duct, this difficulty would cease, and the individual
s of the cell-containing network would be separated by
jected capillary vessel. The lobe in which the duct has
injected is therefore to be placed in water slightly
n, and the portal vein injected with perfectly clear parch-
t-size. A pipe has already been inserted into this vessel.

When the capillaries are quite filled, the pipe is closed with a cork, and the lobe placed in cold water until the size has completely set.* Thin sections may now be made in any direction, and as the lobe is very transparent, a small branch of the duct may often be followed for a very considerable distance. The sections should be preserved in glycerine. By comparing specimens from the different lobes which have been injected, the peculiar characters of each vessel will be readily made out. A rabbit's liver is very easily injected; but it is better to take one liver for each vessel, as the branches distributed to the different lobes are too small to receive the pipes.

After the pig's liver had been injected in the manner above described, thin sections were examined in the microscope, and with the aid of the neutral-tint glass reflector, their outline was traced upon transfer paper in the manner described in page 35, and drawings were made.†

220. On the Arrangement of the Vessels of the Gall-bladder, Transverse Fissure, and Portal Canals of the Human Liver. —The very peculiar arrangement of the vessels of the gall-bladder is referred to in my "Monograph on the Liver," page 29. The only author who had previously noticed this beautiful disposition of the vessels, is Professor E. H. Weber,‡ but he makes no mention of a similar arrangement of the vessels in the transverse fissure, and in the portal canals; and it is surprising that, at least as far as I can ascertain, no observer has yet figured the very remarkable disposition of these vessels.§ As the arrangement of these vessels is very beautiful, and the preparation from which the drawings were copied tolerably perfect, I introduce them here for the sake

* For this purpose it is better to employ a mixture of size and glycerine.—"How to Work with the Microscope," page 38.

† "Archives of Medicine," No. I., Plates I., II., III., and IV.

‡ "Annotationes Anatomicæ et Physiologicæ. Programmata Collecta Fasciculus II," page 225. "Berichte über die Verhandlungen der Königlich Sachsischen Gesellschaft zu Leipzig," No. III., 1850, s. 185.

§ The arrangement of the vessels and vasa aberrantia in the transverse fissure of the human liver is represented in fig. 25 of "The Anatomy of the Liver," and in fig. 1 of my paper in the "Phil. Trans." for 1855.

of illustration. The gall-bladder, the transverse fissure, and the portal canals are, as is well known, abundantly supplied with arterial blood, especially in the neighbourhood of the ducts. In these localities there exists an arrangement which permits the free circulation of the blood through the arteries, and facilitates its return into branches of the portal vein. Each branch of artery is accompanied by two branches of

Fig. 168.



Vessels of the human gall-bladder as seen from the outer surface. The artery was injected with vermilion, and this central vessel is left white in the cut. The vein was injected with white lead, and is dark in the drawing. One branch of vein is seen on each side of every branch of the artery. One-half larger than natural.

Fig. 169.



Vessels in a portal canal of the human liver injected. The *central dark* vessel is the artery. The veins have been left light. Two accompany each branch of artery as in the gall-bladder. Natural size.

the vein, and this arrangement exists even in the case of very small divisions. The small branches of the arteries anastomose very freely, in some cases forming five or six-sided spaces, so that an arterial network is formed. This is met with on the external surface of the gall-bladder, fig. 168, in the transverse fissure, and in the portal canals. The vessels composing this network are accompanied on either side by a branch of vein. These also form networks, and the two venous branches communicate freely with each other, by

transverse branches which pass over or under the artery. The trunks of the veins and arteries are of course distinct, and the blood, as in other cases, passes through capillaries before it reaches the veins. The vessels described are from the eighth to the twentieth of an inch in diameter. Such an arrangement of double veins facilitates the rapid return of the blood after it has passed through the arteries, and, as each branch of the vein is as large as the artery, would permit the return of a larger quantity of blood by the veins than was transmitted by the arteries in a given time, in case the volume of blood should have been increased by the absorption of fluid.*

221. Liver Cells.—The hepatic cells even in a state of health, generally contain a few oil globules, which vary a good deal in size, but which are for the most part very minute, fig. 170. In disease the cells may become wasted and shrunk; they may be filled with granular matter, or gorged with fat, as shown in the cell situated in the centre of the figure; or the fatty matter may have increased so enormously in quantity as to cause the obliteration of the cell form altogether, in which case a thin section of the liver will be found to present, under the microscope, an appearance not to be distinguished from ordinary fatty tissue. Not unfrequently the cells of the liver, especially those in the central part of the lobule, will be found to contain granules of yellow colouring matter. The cells of a fatty liver contrast remarkably with the starved state of the cells of a scrofulous liver, or with the pale granular cells which are often met with in the liver of patients who have died of diabetes. Chemically, the amount of fat is found to vary much, and the balance shows the enormous increase in a more striking point of view than the microscope. From a fatty liver which I analyzed some time ago for

Fig. 170.



Liver cells, containing a few oil globules. The nucleus and nucleolus are distinct in the cell on the right hand, × 215.

* "Archives of Medicine," No. II.

Dr. Budd, I obtained as much as 65·19 per cent. of fatty matter; and upon comparing this with the quantity obtained from a scrofulous liver, a remarkable difference was noticed, for in the latter only ·57 grs. per cent. of fatty matter were obtained. The nature of the so-called liver cell has been already referred to in page 151.

222. Of Injecting the Lymphatics of the Liver.— Many unsuccessful attempts had been made to inject the lymphatics of the liver, before the plan which ultimately succeeded was adopted. I had been able to force injection for some distance along the larger trunks in the opposite direction to that in which the valves opened, but could not obtain satisfactory injections of the smallest vessels. The largest lymphatic vessels in the portal canals are often injected by rupture of the coats of the duct, and by extravasation of the injection, as Mr. Kiernan remarked in his paper. The same has many times occurred to myself, but under these circumstances the injection always runs towards the transverse fissure, in the direction which the arrangement of the valves permits the fluid to pass readily, and the smaller branches of lymphatics are never injected. The plan which I adopted was the following. An ox liver was thoroughly injected with warm water from the portal vein, as if the ducts were to be injected; gradually the organ became distended, and much fluid returned by the lymphatic vessels. Many large trunks running over the surface were fully distended with water. Into one of these swollen trunks a small pipe was inserted without much difficulty, and the vessel was tied round it. The whole organ was wrapped up in cloths and subjected to considerable pressure for upwards of twenty-four hours. When the water had been absorbed, the lymphatic vessels were quite invisible, and it would have been impossible at this time to have found a trunk into which a pipe could have been inserted. A little of the Prussian blue injecting fluid was now forced into the pipe from a small syringe. It passed for some distance along the trunk of the vessel, and by pressing the large trunks a little from time to time, was

made to pass the valves, and so forced into the smaller branches. By using slight but gradually increased pressure, the trunks were so distended as to render the closing of the valves impossible. In the course of half an hour or longer, an abundant network of lymphatics upon the surface had been fully injected, without any extravasation. It was now considered desirable to wait awhile, before introducing more fluid. After a few hours the injection was resumed until as much fluid had been forced in as could be introduced without running the risk of rupturing the vessels. I have tried the same plan with the human liver, but hitherto with very imperfect success, the trunks are much smaller, and their walls more delicate than those of the liver of the ox.

After the lymphatics had been injected as above described, thin pieces were removed for microscopical examination. Upon cutting thin sections from the surface, it was discovered that the injection had passed into many of the lymphatics of the portal canals, not only into the canals just beneath the capsule, but into some lying at the depth of an inch or an inch and a-half in the substance of the liver.

I know of no drawing or description of the smallest lymphatic vessels, either of the surface of the liver or the portal canals, and the appearances delineated in the accompanying woodcuts, figs. 171, 172, could only be obtained where a transparent injecting fluid had been employed, so that the specimen could be examined by transmitted light.

The network which lies partly in the substance of the fibrous capsule of the liver, and partly immediately beneath this structure, is represented in Plate XIV., "Archives of Medicine," No. II. The smallest vessels have been injected, though in many situations not quite perfectly. There can, I think, be little doubt that the smallest branches form an intricate network. I have not been able to demonstrate the existence of blind extremities, although I am not in a position to assert that lymphatic vessels never commence in this manner. In the plate referred to, some very narrow branches

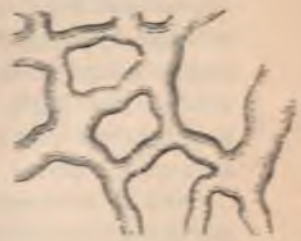
represented, many not being more than 1-2000th of an in diameter. In the preparation from which that drawwas taken, a network is seen in many places, and the ches which do not absolutely communicate are in many nces exactly opposite each other, a circumstance which ers it more probable that the tube in the interval is

Fig. 171.



rom a portal canal of the liver of the ox. Several small s are seen passing along the smaller canals, × 15.

Fig. 172.



A portion of the network represented in fig. 171, more highly magnified, × 215.

jected, than that there are cœcal tubes lying immediately site. The point at which the injection ceases is ragged, of the same diameter as the rest of the tube, while if e were commencing blind extremities, they would be ded, and probably a little wider than the rest of the tube. many places the injection had accumulated in front of the es, and had distended the tube very much.

In fig. 171, from a portal canal, the injection is perfect, ough doubtless the tubes are distended beyond their ral extent. Here, evidently, there is a network entirely ounding the vessels and duct lying in the portal canals, on either side of the large canal, smaller ones are observed ass off. These also have their lymphatic vessels. No d extremities can be found, and if they existed, I think ast a few would be distinguished in a part of the prepaon where the injection is evidently very perfect.

I have not been able to determine positively if branches enter the substance of the lobules from the portal canals, although many appearances have been observed which render this probable. In some places injection seems to have passed from the branches in the portal canal, to some distance within the lobule, and, as far as I can make out, it is situated between the capillaries and the cell containing network. There is no evidence of extravasation, and the appearance precisely accords with what one would expect to find if the above view were true. Nevertheless, I am unwilling to advance hypotheses or indulge in speculations as to the precise nature of an arrangement which is doubtless demonstrable, and think it better to wait the result of further investigation before publishing the drawing of the appearance above referred to.

223. Of Investigating the Nature of Morbid Changes occurring in the Liver.—It would occupy too much space to describe the methods of investigation required to demonstrate various alterations in structure which take place in the liver in disease, but a few general observations upon this head may perhaps be useful.

In investigating the morbid changes occurring in an organ having so complex and delicate a structure as the liver, it is of the first importance to ascertain positively the precise locality of the changes. Although it would appear at first sight a simple matter to settle whether any given alteration was situated in the centre or at the circumference of the lobule, this is often a matter of great difficulty, for although the position of the artery and duct would enable us to ascertain at once the circumference of the lobules, these tubes are often not to be distinguished unless they have been injected previously. The observer will find that it is better in the first instance to inject a branch of the portal vein in one part of the liver, and one of the hepatic vein in another. This will enable him at once to distinguish the different parts of the lobule. Practically this plan is simple enough if the Prussian blue fluid be used, and even very small pieces

of liver sent for examination, may be injected in this manner. A very imperfect injection is all that is required to settle this point. It is of very great importance to determine in some instances the precise situation of a particular morbid change. For instance, in some cases fatty matter accumulates in the centre, and in others at the circumference of the lobules, and although the arrangement of the oil globules in the two cases is somewhat different, and by a practised eye could be distinguished, the observer will be able to decide the point at once, and quite positively, if he takes the trouble to inject a branch of the portal or hepatic vein. I need hardly remark that trunks of moderate size are readily distinguished from each other, and the portal vein is always accompanied by a branch of artery and duct which however cannot always be seen. In many cases it is important to observe the character of the cells in different parts of the lobule, and to distinguish between those situated in its central and external parts.

In some cases of disease, a wasting occurs in the centre of the lobules, and when this has affected several adjacent ones, an appearance like interlobular fissures is produced, and without the knowledge of this fact, the central part of the lobules might easily be mistaken for their boundaries. Again, the capillaries are prone to degenerate in some diseases, and their canals to be obliterated. This commences sometimes in those connected with the portal and sometimes in those opening into the hepatic vein.

It has been held by many that *cirrhosis* consists essentially in the effusion of lymph in the interlobular fissures, which by its contraction and subsequent conversion into fibrous tissue, impedes or entirely prevents the circulation in the lobule. It is easily shown that this material is abundantly supplied with vessels, and I have demonstrated branches of the duct in considerable number. ("Archives," No. II.)

In certain conditions the walls of the capillaries appear to be much thickened, or an albuminous material effused between them and the tubes of the cell containing network, or the thickening may, and probably does, affect both structures.

In consequence, the distance between the cells and the blood becomes much increased; their selective agency and attractive force operate through a greater distance than in health, and the changes in the blood effected by the cells, are imperfectly carried on. Such a point as this cannot be demonstrated without great difficulty, and it is necessary to make very careful injections.

Much yet remains to be made out in the morbid anatomy of the liver, and there are few inquiries more likely to lead to important results than these, not only as regards pathology, but also with reference to the treatment of disease. The extent of the subject is such, that a number of observers may find employment, and it is one which well deserves to receive earnest and attentive study.*

224. Kidney. — In the examination of the kidney, the epithelium and fragments of the tubes may be readily obtained by scraping the freshly cut surface. In this manner also Malpighian tufts may often be separated, but it is impossible to ascertain the relation of the different structures to each other, as by the process of scraping they are inevitably very much torn. A thin section in which these points may be demonstrated, is obtained either with a sharp thin-bladed knife, or more advantageously with a Valentin's knife, by which means a section including both the cortical and medullary portion of the organ may be made. After washing the section very slightly, it may be placed with a drop of water between two pieces of glass, and examined in the microscope, first using a low power (an inch glass), by which the general arrangement of the tubes will be seen, and afterwards a quarter of an inch object-glass, by the aid of which the different characters of the epithelium in the straight and convoluted portions of the tubes may be demonstrated.

Fig. 173.



Epithelium from the uriniferous tube. *a*. Treated with acetic acid, × 215.

225. Basement Membrane and Epithelium. — Just at the

* A few papers on the Morbid Anatomy of the Liver will be found in the numbers of the "Archives of Medicine."

lge of the specimen, a portion of a tube stripped of epithe-
ım, and exhibiting the basement membrane very distinctly,
ay often be observed (fig. 174*b*). The thick polyhedral
lls of glandular epithelium of the convoluted portion of the
bes (fig. 173) should compared with the t squamous cells which cupy the straight part. will be found that in e latter the central annel is wider than the former position, though the total dia-
eter of the tube is ss. This arises from ie greater thickness of he secreting epithelium the convoluted portion. he epithelium of the onvoluted part of the riniferous tubes has been escribed by Dr. Isaacs, f New York, as tessel-
ated.* In looking at knuckles of tubes, an appearance is ften produced as of a circumscribed cyst, arising, as Dr. John-
on has shown, from the bending of a tube as it enters and merges from the different meshes of the capillaries, fig. 174.

Fig. 174.



Section of kidney. *a*. Convoluted portion of uriniferous tube. *b*. A tube stripped of its epithelium. *c*. Outline of tubes and crumpled capillaries having a fibrous appearance—the so-called *matrix*. *d*. Malpighian body. Loops of vessels shrunk, showing cells in their walls, × 215.

* Some confusion seems to have arisen in reference to the use of the term *tessellated*, which has been made by some authors synonymous with *polyhedral*. t seems better to restrict the term to those varieties of cells which are exceedngly thin and tile-like (if I may be permitted to use such an expression), and itted to each other by their margins, after the manner of a tessellated pavement. If the cell was nearly as thick in one direction as in the other, the term ould be inapplicable. The internal layer of choroidal epithelium is a good xample of the tessellated variety, but the term clearly ought not to be applied o the epithelium of the liver and kidney. Dr. Isaacs, I think wrongly describes he liver cells when he says that they "resemble tessellated epithelium," and e also considers the renal epithelium to be of the same character.—"Researches nto the Structure and Physiology of the Kidney," by C. E. Isaacs, M.D., "Transactions of the New York Academy of Medicine," 1857.

The cut ends of the tubes often appear curled over, as it were, giving the appearance of a thick ring.

226. Matrix.—The appearance which has been described as resulting from the presence of a matrix may be seen very clearly in a section of the kidney of a mouse, or in that of many other rodents. Of late, much discussion has arisen with reference to the presence or absence of a fibrous matrix in the healthy human kidney, and observers are not agreed as to which is really the case. It was first described by Goodsir; and both Kölliker and Dr. Johnson have given drawings representing it very distinctly. It must, however, not be forgotten how very difficult it is to say how much of the appearance is due to the presence of the walls of the tubes and capillary vessels, and how much to the existence of a structure (the so-called matrix) independent of these. Where the capillaries are injected with transparent injection, no fibrous appearance is to be detected; and I believe, at least in healthy kidneys, that the material resembling fibrous tissue, really consists of the walls of the tubes and the shrunken and compressed capillary parietes. I have been brought to this conclusion from examining a great number of specimens prepared in various ways. The only structure which exists besides these, is a small quantity of a clear transparent material, which connects the walls of the capillaries with those of the tubes; in healthy kidneys it is not easy to convince one's self even of the existence of this. The nuclei visible in such great number, are probably situated in this interval, but of the nature of these little is yet known. The appearances above alluded to may be observed if a thin section of the kidney be made with Valentin's knife and slightly washed in water. Such a point requires to be investigated in various ways before any conclusion can be arrived at, and it is essentially necessary that the vessels should be slightly distended with transparent injection, otherwise their shrunken condition may easily be mistaken for a form of fibrous tissue.* In disease the fibrous appearance is

* See also page 161 and a paper in the "Archives of Medicine," No. III.

more distinct, but I think it may be explained equally well by considering it as due to the formation of a new tissue altogether, or thickening of the walls of the vessels or tubes, as by attributing it to a thickening of the matrix. In some cases, in consequence of shrinking of the tubes, the meshes of the matrix appear more distinct than in health.*

227. Vessels of the Malpighian Tuft. — Here and there, apparently upon the vessels of the Malpighian tuft, fig. 174*d*, a few cell-like bodies are often seen. These have been described by some as epithelial cells upon the external surface of the vessel, but the researches of Mr. Bowman proved that the vessels are quite bare. The appearance of epithelium upon the surface of the vessels, is caused by the loops of capillaries being shrunken and collapsed. When distended with transparent injection, no such appearance is observable, but here and there a few very small granular cells are observed. These cells, or nuclei, are probably connected with the wall of the vessel. This subject has been already referred to, page 164, fig. 154.

Dr. Isaacs has since published a number of drawings to prove that epithelium exists on the vessels. In one of his drawings (Plate XXV.), the diameter of these cells is even greater than that of the uriniferous tube—which is hardly probable could be the case, even though they were much swollen by endosmosis.† Although I have examined kidneys of various animals in different ways, and have tried the plan recommended by Dr. Isaacs, I have never been able to confirm the conclusions he has arrived at with reference to this point.‡

* "On Diseases of the Kidney," page 323.

† "Structure and Physiology of the Kidney."—(Transactions of the New York Academy of Medicine, Vol. i., 1857.)

‡ Dr. Isaacs injects watery and ethereal solutions into the ureter and bursts the capsule, the Malpighian tuft having been slightly injected from the artery in the first instance. By soaking fine scrapings of the kidney in water for a few days, the epithelial cells within the capsule were washed out, so that the space thus left between the tuft and capsule became filled with water which had soaked through the capsule. These processes seem simple enough, though I should think it a very difficult matter to inject fluid into the tubes so as to

228. Bright's Kidney.—This term has been employed to include all those morbid conditions of the kidney which are associated with albuminous urine. Of late, however, certain important characters have been made out, which have enabled us to distinguish several essentially distinct morbid conditions of kidney, which result from special changes having taken place in that gland. Some physicians, nevertheless, still insist that the pathological states of kidney which have been described as distinct diseases, are really different stages of the same disease. It is difficult, however, from a careful consideration of the facts at present known, to come to the conclusion that the small contracted kidney so commonly met with in old drunkards, with its rough tuberculated surface, and diminished cortical portion, is a different stage of the fatty kidney, or that it results from the occurrence of morbid changes, at all resembling those which end in the production of the large, smooth, and pale kidney of fatty degeneration. Microscopically, as well as chemically, these forms of disease are distinguished by well-marked characters, while the history of the patient, the cause of the morbid alteration, and its results, are totally different. Dr. Johnson distinguishes "acute" and "chronic nephritis" from "fatty degeneration," and he gives cases of three other forms of disease which have not been accurately described by any previous writer; these are "waxy degeneration" (corresponding to, and often found in conjunction with the so-called waxy degeneration of the liver), "non-desquamative disease," and "suppurative nephritis." All practitioners who are in the habit of treating diseases of the kidney, should be acquainted with Dr. Johnson's researches upon the subject.*

229. Microscopical Examination of the Kidney in Disease.—Portions of diseased kidney are subjected to examination

burst the capsule. I hope some day to have an opportunity of seeing Dr. Isaac's preparations, as I am compelled to confess that all the attempts I have made have quite failed in demonstrating any approach to the appearances he has described and figured so distinctly, neither have other methods of observation proved more successful in my hands.

* "Diseases of the Kidney," 1852.

in the same manner as specimens of the healthy organ. Sometimes a thinner section will be required, in consequence of the opacity resulting from deposition of fatty matter, or a morbid quantity of epithelium, &c., within the tubes; or from thickening of the walls of the vessels, or the formation of a new material external to them. In the chronic nephritic kidney, the condition of the minute vessels should be especially taken notice of, as their walls are often much thickened, fig. 162, page 176. The addition of a little acetic acid, or weak solution of caustic soda, often renders the vessels very distinct; and if the preparation be well washed in water previous to examination, in order to wash away the epithelium and granular matter from the tubes, the walls of the latter and the vessels will be more distinctly shown. Injected specimens of diseased kidneys should also be submitted to examination. The kidneys of cats are usually found to have the convoluted portion of the tubes loaded with oil, and, in many instances, much oil is found in the Malpighian tuft. The fatty matter is frequently so abundant as to give the tubes the appearance of being injected with some white material when examined by reflected light. Sections of kidney may be preserved by immersion in some preservative solution, such as weak spirit and water, or in the creosote solution. They should be placed in large thin glass cells made after the method described in "How to Work with the Microscope," page 43.

It is scarcely necessary to repeat here what I have already stated with reference to the importance of injecting the vessels with some transparent fluid. Even though a kidney be cut in several places, the vessels in a small piece may be injected without much difficulty.

230. Advantages derived from the Examination of the Organs of the Lower Animals.—The student will often experience a great difficulty in making out clearly the structure of the kidney, liver, and other organs, in a healthy state in man. Owing to various circumstances, particularly to post-mortem alterations, or to the commencement of morbid

changes, the microscopical characters are often but ill-defined. Great difficulty again is found in obtaining perfectly healthy specimens of these organs in the human subject, and it is only in the occasional cases of accidental death, occurring to young healthy persons, that we have an opportunity of examining the glands in a normal state. For these reasons, great advantage will be gained by subjecting the corresponding organs in the lower animals to examination. In them, the structures will often be found more distinct, and may be more readily demonstrated. The importance of being thoroughly familiar with the structure and microscopical characters of any particular organ in a healthy condition, cannot be sufficiently dwelt upon, and it is to a want of this knowledge, that many erroneous descriptions of morbid appearances must be attributed. All who wish to use the microscope successfully, for the purpose of examining organs in disease, will do well to become acquainted with minute anatomy generally, not only of the human subject, but of the lower animals, for without such knowledge it will be found impossible to prosecute pathological inquiries with any degree of success.

231. Liver of the Pig and other Animals; Kidney of the Frog, Newt, Horse, &c.—The liver may be examined in different animals. The anatomy of this organ in the Crustacea (crabs, lobsters), Mollusca (snails), and the cœcal tubes which appear to represent the hepatic organ of insects, are especially worthy of study. The liver of the frog, when injected, shows well the arrangement of the minute vessels, but there is no appearance of a division into separate lobules. Instructive preparations may be obtained from the liver of fishes; although in these classes the lobules are not separated from each other by a distinct interval, the arrangement of the vessels and their mode of distribution are the same in all vertebrate animals. Small branches of the portal vein, hepatic artery and hepatic duct run together and give off small branches, which are separated from each other by about the same distance in all parts of the organ, and these alter-

with branches of the hepatic vein, so that every part he secreting structure is only separated by a short val from the small trunks of these vessels. If injected the portal vein with one colour, and from the hepatic y or vein with another, the injections may often be to meet, and in this manner good illustrative specimens ined. The best colours to use for this purpose are the ine and Prussian blue solutions, §§ 97, 98, and the beautiful appearance is produced when the portal vein jected with the former, and the hepatic vein with the r.

Kidney of Frog and Newt.—The general arrangement structure of the kidney may be beautifully seen by ining a portion from a recently killed frog or newt. tube, in the case of the frog, will be found ciliated for ort distance from the Malpighian ; but in the newt the uriniferous in its whole length is lined with ted epithelium, which continues in e motion for some time after the val of the organ from the body of animal. In order to display this tiful object, we must proceed as ws:—After destroying the newt by ing off the head, the abdominal cavity id open, and by turning the viscera ne or other side, the kidneys may be sed. Towards the pelvis the kidney ents much the same appearance as in frog: but, upon tracing it upwards, ill be found to become gradually ner, and to extend quite into the acic portion of the animal. It is this r thin part of the kidney which shows the ciliary ion to the greatest advantage, fig. 175*a*. A probe is esented in the cut underneath that portion of the kidney ch should be examined. Here the secreting tubes lie

Fig. 175.



upon one plane, so that an individual tube may often be seen at one time with active ciliary motion throughout its whole length. A more beautiful object under a half inch object-glass, can scarcely be conceived. The portion of the kidney, above described, is to be very carefully removed from the body by delicate manipulation 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, and 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. In examining the frog's kidney, a thin section must be made with a very sharp knife, taking care to disturb the structure as little as possible. The section may be moistened with a little of the serum, and examined in a glass cell. After examination by the low powers, both these preparations may be examined by a power of 200 diameters or upwards.

Kidney of the Horse and other Animals.—The kidney of the horse is well adapted for displaying the Malpighian tufts, as in this animal they are unusually large, and, when injected, show the arrangement of the vessels very distinctly. A section of the straight portion of the tubes cut at right angles from a fresh kidney, will show well the general anatomy of this part of the organ. In an injected kidney, such a section shows the outline of the tubes and their relation to the capillary vessels between. Sections should be taken from the cortical portion of the kidney, from the bases of the pyramids, and in two or three positions nearer their apices. Such specimens are very instructive, and afford an excellent idea of the general structure of the organ and the relation of its different anatomical constituents to each other.

The kidneys of mice and other rodents, as above mentioned, will be found to display the matrix well. All that is required for this object is to cut a thin section and wash it well previous to examination. The kidneys of rodent animals

are very readily injected,—and with the Prussian blue fluid in the course of a few minutes. The Malpighian tufts can be completely filled, and in many specimens, not only is the small artery leading to the tuft well injected, but the efferent vessel and the capillaries into which the latter breaks up, are also beautifully shown. Such preparations are readily preserved in glycerine. The kidneys of small fish and snakes are well worth careful examination. The tubes of the kidney of the common field snake (*coluber natrix*) will be found to be ciliated.

Glands without Ducts.

232. Examination of the Spleen.—The investigation of the anatomy of the spleen is one of the most difficult researches the anatomist can undertake, and no one has yet succeeded in demonstrating satisfactorily the exact relation which the different anatomical elements bear to each other. The most favourable specimens are obtained from spleens which are tolerably hard when removed from the body; but at the same time it must be borne in mind that many of these firm hard spleens are not perfectly healthy. The spleen of many of the lower animals, as of the rat, rabbit, cat, and many others, are very firm and well adapted for investigation. The spleen, like other organs, may be hardened artificially, but owing to the large amount of blood and dark pulpy material which it contains, and which is usually rendered very hard and opaque, little is to be made out in this manner. Different modes of investigation must be employed according to the structures to be examined. The various cells in the spleen pulp are readily demonstrated by placing a small portion of the pulp on a slide and covering it with thin glass. It is important to look for large compound cells, consisting of aggregations of blood corpuscles, and it is desirable to notice if any blood crystals are to be discovered. The pulp should not be diluted with water, in consequence of the physical changes in the cells which would result. The characters of the different cells under the influence of acetic acid and

other chemical reagents must be noted. Blood crystals are very frequently met with in the blood of the spleen as was first noticed by Funke.*

If it be desired to investigate the arrangement of the tissue of the spleen, it is desirable to choose an organ which contains very little blood. I have obtained some instructive specimens by washing the blood vessels out, in the first instance, with tepid water. When the blood is removed, the organ is placed in cloths and subjected to pressure in order to remove the water; next, the vessels may be injected with plain size. I have some preparations in which exceedingly fine branches of the artery have been injected with the Prussian blue fluid, but I have not been able to ascertain their mode of termination. If the vein be injected on the other hand, thin sections appear almost like masses of extravasation. I have tried to inject the arteries with the Prussian blue solution and the veins with plain size, and although this plan, or some modification of it, will in all probability be found to succeed ultimately, I have never yet been able to obtain specimens which demonstrate the manner in which the arteries terminate, or their mode of connection with the veins.

The *trabecular tissue* of the spleen is very readily examined, and its arrangement is well shown in specimens which have been injected with plain size, so that very thin sections can be obtained. Some portions should be treated with acetic acid and the effects of other reagents ascertained. The muscular fibre cells are shown in portions of the tissue which have been immersed in diluted nitric acid. Dr. Billroth in his investigations, found great advantage in the use of sesquichloride of iron for the purpose of hardening the sections.† For a description of the anatomy of the spleen, the reader is referred to Mr. Henry Gray's "Astley Cooper Prize Essay," and chapter xxxv. of Todd and Bowman's "Physiology."

* *Vide* note on page 129.

† Beiträge zur vergleichenden Histologie der Milz, "Müller's Archiv," 1857, page 88.

The connection between the appearance of a vast number of white corpuscles of the blood (Leucocythemia) and enlargement of the spleen, has been shown by Professor Bennett, of Edinburgh. The characters of the blood will be referred to in a subsequent chapter, but for full information upon the whole subject, the reader is referred to Dr. Bennett's valuable work.*

233. Examination of the Thymus and Thyroid, &c.—These glands should be examined in the perfectly fresh state. Thin sections, obtained by a Valentin's knife, will afford the best specimens; the section will generally require washing slightly, in consequence of being covered with the softer and pulpy portion of the gland, which renders the arrangement of the tissue obscure. The glands may be hardened in a solution of chromic acid, in spirit, or in boiling water — but by these processes the cellular portion of the gland becomes somewhat modified. For making out the relation of the lobules and other structures to each other, hardened specimens are, perhaps, to be preferred. In many of the smaller animals the thyroid gland is almost membranous, and this renders it very favourable for microscopical examination, especially in the case of injected specimens.

234. Examination of Lymphatic and Lacteal Glands. — In the examination of these glands, a little of the thick fluid which is poured out from a freshly-cut surface, should be placed between glasses, without the addition of water or any other preparation, and examined in the microscope. The student should make himself very familiar with the character of the cells obtained from lymphatic glands, and should carefully observe their behaviour upon the addition of acetic acid, dilute solution of caustic soda and other reagents, and he should compare the changes which take place, with those which occur when the white corpuscles of the spleen, and white blood corpuscles are treated in a similar manner. The resemblance of these bodies to pus globules should also be borne in mind, and the reaction of

* "Clinical Lectures on the Principles and Practice of Medicine," by J. H. Bennett, M.D., F.R.S.E., 1858.

the latter should be very carefully studied. The minute structure of lymphatic glands is an exceedingly difficult subject to investigate.

My friend, Professor Donders, of Utrecht, gave me a beautiful specimen of a mesenteric gland of the dog injected with vermilion. In this the substance of the gland appears to be composed of a dense network of lymphatic vessels.

The student should endeavour to make preparations in which the lymphatics or lacteals have been injected with one colour and the blood vessels which supply the gland with another.

The method of demonstrating the arrangement of lymphatics has already been alluded to and many of the same remarks are applicable to the investigation of these glands, pages 179, 213.

235. Suprarenal Capsules.—Until of late years the suprarenal capsules were very seldom examined even cursorily, and in the reports of many post-mortems, otherwise elaborately complete, the condition of these organs was not even mentioned. In the year 1855, Dr. Addison, of Guy's Hospital, published his memoir on "The Constitutional and Local Effects of Disease of the Suprarenal Capsules." The eleven cases there given, seemed to establish a relation between the deposition of brown colouring matter in the skin, and disease of the suprarenal capsules. Since this time, great attention has been paid to the state of these organs in all cases in which the colour of the skin has been observed to be at all darker than natural, and a great amount of very conflicting evidence has been obtained in this country and on the continent. Some observers have expressed themselves far more positively than Dr. Addison, in favour of the connection between the bronzing of the skin and disease of the suprarenal capsules; while others have brought forward a mass of evidence which to them appears positively conclusive against the existence of any such connection. The latter consider that the cases in which the condition of the skin is associated with disease of the suprarenal capsules, are to be regarded merely as accidental, and they have taken great

pains to collect examples of bronzed skin where the suprarenal capsules were healthy, and instances of disease of these organs where the colour of the skin was natural.

Now to a casual observer it would appear that a question of this kind could very soon be settled, and that it had already resolved itself into a mere quibble in which one set of men collected evidence on one side, while an opposite party was unworthily spending enormous labour and time in elaborate researches for the sole purpose of upsetting their conclusions and pushing an opposite doctrine. But every one at all accustomed to scientific investigation, and really working with the sole object of ascertaining the truth, must feel how very difficult it is, practically to decide a question of evidence of this apparently simple character. On the one hand there is the danger of being led into error from drawing conclusions from insufficient data. On the other, the chance of losing perhaps for ever a valuable and important conclusion because the facts upon which it depends, appear at the time to shine very dimly through an overwhelmning mass of doubtful and conflicting evidence. When such a question comes to be taken up by others, it is impossible to help observing that while one class of minds have a natural tendency to confirm the opinions of the first observer and involuntarily almost, but eagerly, clutch at any isolated circumstance which supports the original doctrine; another class, perhaps over cautious, if this be possible, of receiving anything except upon the most incontrovertible evidence, involuntarily rush into the opposite error, consider as an accidental coincidence what may really be a consequence, and thus they acquire a habit of scepticism. The original difficulty is for a time increased as the evidence on opposite sides accumulates, while a new element of discord is introduced in the production of a number of badly reported cases. It is only after the lapse of some time that the evidence amassed can be thoroughly sifted and the truth at length discovered. On the present question it seems to me that we have not yet reached the period when a positive conclusion can be drawn. Many observers have taken up this investigation

seriously. The researches of Mr. Hutchinson and Dr. Harley in this country, and those of Professor Brown Sèquard and Professor Virchow, in France and Germany, are particularly worthy of notice.

It is important that all who are endeavouring to draw conclusions in this investigation, should consider the following points:—

1. That until recently little attention has been paid to the state of the suprarenal capsules, but that during the last few years these organs have been very carefully examined.

2. That there are many cases on record of disease of the suprarenal capsules without bronzed skin, and cases of bronzed skin have occurred without any disease of the capsules.

3. There is reason to believe that the term "bronzed skin" has been applied to very different appearances.

4. All observers who have reported cases, have not been sufficiently careful to describe minutely the state of the suprarenal capsules. While some have spoken of these organs being in a morbid state upon the evidence of microscopical examination alone, others have only recorded cases in which the changes were extensive and sufficiently evident to the most cursory investigation. It should be noted that great differences are observed in the microscopical characters of these organs in health, or at least in the case of capsules which have been removed from the bodies of persons apparently in good health at the time of their death.

I trust these observations will not be considered altogether out of place here. The only apology I have to offer for their introduction is the knowledge of the numerous errors which have been from time to time introduced into investigations of this nature, in consequence of those who take up the inquiry not being careful enough to record the exact nature of the facts upon which the evidence they try to bring forward in support of or against any particular doctrine, is grounded, and the firm conviction that it is the duty of a teacher, especially of subjects bearing directly upon medicine, to take every opportunity of directing serious attention to

the circumstances under which erroneous inferences may be deduced.

The general form, shape, size, colour, and consistence of the healthy suprarenal capsules, are well known, but it is not so easy to define the microscopical characters of these organs in a state of health.* I think, generally, it is better not to attach much importance to the existence of a greater or less proportion of fatty matter than usual, in the cortical portion. Certainly no alterations of this nature will justify the observer in stating the capsules were *diseased*. The microscopical characters should be accurately described and drawings given. In the cases brought forward by Dr. Addison, the alterations were so great that it was not necessary to resort to microscopical examination to discover them; but lately slight modifications in structure, only discoverable by minute observation, have been considered by some as sufficient to justify them in placing the case under the head of "diseased suprarenal capsules," although as yet we are quite ignorant of the nature or import of such alterations in structure, and indeed are unable to assert if they be morbid at all.

Although the accompanying drawings give a good idea of the general characters of the cortical portion of the suprarenal capsules in health, it is only right to remark that great difference is observed in the proportion of fatty matter in capsules, which I believe to be healthy. The reader must therefore not put down as *diseased* every specimen which he finds differing in these particulars from the woodcut.

The structure of the cortical and medullary portions of the suprarenal capsules is distinct. The former consists of nearly parallel rows of cells containing many oil globules, lying in a meshwork of capillary vessels, and passing from the internal, towards the external surface of the organ. The latter is composed almost entirely of areolar or fibrous tissue,

* "They measure from an inch and a quarter to an inch and three quarters in height, and about an inch and a quarter in width; their thickness is from two to three lines. The weight of each suprarenal capsule in the adult is from one to two drachms."—Quain's "Anatomy," Vol. iii., page Huschke estimates the weight at from 80 to 180 grains.

and nerve fibres with cells resembling ganglion cells in some respects, which are very abundant. Leydig considers that the yellow ganglion cells in the central part may be gradually traced into the cells of the cortex. Different opinions have

Fig. 176. Fig. 177.



Suprarenal bodies under different powers. All the structures represented were obtained from organs which had the usual appearance of healthy bodies.

Fig. 176.—*a*. From the cortical portion, about midway between the medullary portion and the surface, showing the manner in which the lines of cells at certain places pass into collections of oil globules, × 49. *b*. Small coloured cells from the inner part of the cortical portion. Some of these contain oil globules, and in the upper part to the left is one large one, consisting entirely of large fat globules. *c*. Oval cells, also from the cortical portion, containing varying proportions of fat and granular colouring matter, × 215. *d*. Large vesicles filled with oil globules forming a line. These appear to be inclosed in a membranous tube,—the lines in the lower part of the figure indicating the existence of such a structure; but the appearance is not conclusive, as the adjacent capillaries, being empty and stretched, would give rise to the appearance represented, × 130. *e*. Inner portion of lines of cells, and outer part of medulla, × 130. *f*. Oval vesicle, from the part opposite to which it is placed, magnified 215 diameters. *g*. Cells from the innermost part of the cortex, containing very much yellow pigment, magnified 215 diameters.

Fig. 177.—Vessels of a healthy suprarenal body injected with Prussian blue fluid. At *k* the lines of cells appearing as if they were inclosed in tubes is represented—and above, the relation of the capillary vessels to these is shown. At *i*, capillaries, and below *k* are seen collections of cells of various forms. The lines of tubes in this specimen were very much wider than those represented at *e*, fig. 176. The increased size of the drawing is, however, principally due to the circumstance of the vessels being injected, × 130. The section from which *e* was taken had been a good deal stretched and compressed between the thin glass.

been entertained with reference to the arrangement of the cells of the cortex;—Simon think they lie in tubes; Kölliker, on the other hand, considers that there is no membrane, but that the cells merely lie in spaces; Ecker and Frey think that they are grouped together in oblong vesicles, but that these do not communicate with each other. It has not yet

been satisfactorily determined if the cells are inclosed in a complete tube of basement membrane, or merely lie in elongated spaces imperfectly separated by bands of fibrous tissue. I incline to the latter view, but am not able to express myself at all decidedly. The reader will find the views of different observers on this point given by Dr. Harley in his original papers on the "Histology of the Suprarenal Capsules." Again, as to the existence of a proper cell wall there is much difference of opinion. Some entertaining the idea that the cell-like bodies found in the cortex are mere aggregations of oil globules and granular matter, while others think they are covered with a proper cell wall. The existence of a nucleus has been distinctly proved by the recent researches of my friend Dr. Harley, and the same observer thinks there is a cell membrane.* I have not been able to satisfy myself of the existence of this cell membrane, nor have I been able to prove that these cell-like bodies lie in distinct tubes. They may be in parallel spaces with imperfect septa, formed partly by the capillary vessels and partly by a small quantity of fibrous tissue. It seems to me that further observation is required to solve the question, but I think it probable that there are membranous tubes in which the cells lie. Usually the healthy organs are sufficiently firm to be cut with a knife, and very thin sections may be obtained with Valentin's knife. After being gently washed, they may be placed in glycerine. Dr. Harley recommends previous hardening in chromic acid, but this is not necessary in all cases, as exceedingly thin sections can readily be obtained without any previous hardening. The process of colouring by imbibition, as recommended by Dr. Harley, is a very valuable one, and may be employed with great advantage. The mode of effecting this is described in page 159. The arrangement of the capillaries is very easily made out in injected specimens. They are exceedingly numerous, and arranged after the manner of those of the liver. The investigation of the minute anatomy of the suprarenal capsules is a subject of great interest and considerable im-

* "The Histology of the Suprarenal Capsules," by George Harley, M.D., "Lancet," June 5th and 12th, 1858.

portance, and one which is worthy of very attentive study. As yet, little is known of the functions of these bodies, and many points in their anatomy are involved in much obscurity.

236. Examination of the Brain.—The brain should be subjected to examination as soon as possible after death. In examining the fresh brain, small portions may be removed on the end of a knife, placed upon the glass slide, and moistened with a little serum, or weak solution of sugar, but it must be admitted little can be learnt by such a mode of examination, as the relation of the structures to each other is completely destroyed. For examining the arrangement and distribution of the nerve fibres, portions of brain should be hardened in the chromic acid solution, when very thin sections can be obtained with a sharp razor. Dilute solution of caustic soda is also exceedingly useful for rendering the nerve tubes more distinct. The minute anatomy of the brain may be studied in man and in the higher animals.

The examination of the dura mater and arachnoid is conducted according to the general plan already laid down. Very small pieces are removed, carefully torn up with needles, moistened with water, and covered with thin glass. The gritty substances (brain sand) in the pineal body, and those which are not unfrequently met with in other parts of the brain, and the *corpora amylacea*, may be separated from the brain substance by washing in a glass of water, in which they will sink to the bottom; the supernatant fluid may then be poured off, and replaced by fresh water. After this process has been repeated a few times, the bodies in question will become quite clean. They may then be examined in water, tested with appropriate reagents, and preserved in aqueous fluid, or dried and mounted in Canada balsam.

The vessels of the brain may be readily examined if the white or grey cerebral matter be first removed by washing a thin section with water. The addition of a little very dilute caustic soda renders the outline more distinct.

The investigation of the anatomy of the central organs of the nervous system is by far the most difficult which the

student can undertake, and it is not easy to lay down principles for his guidance. Very much yet remains to be discovered with reference to the chemical solutions adapted to render the anatomical elements of these tissues distinct. There can be no doubt that modes of investigation will at length be found out which will enable us to demonstrate satisfactorily the relation of the delicate structures which make up the nervous system, to each other. The observations made in §§ 74, 90, should be referred to, and the student should try for himself a number of fluids of different composition. I cannot too strongly recommend the plan invented by Mr. Lockhart Clarke, which is given below, for carrying out inquiries of this nature.

If a portion of white cerebral matter be treated with water, the nerve fibres soon become changed in character, apparently in consequence of the partial separation of the oily from the albuminous constituents which are contained within the tubular sheath. The oily matter forms distinct and separate globules, often of considerable size, or it tends to collect in quantity in different parts of the fibre, which produces a beaded appearance. A similar change takes place in nerve fibres generally, if they are not examined very recently, or if they have been soaked for a short time in water. Fig. 178 represents some of these changes.*

Fig. 178.



Small piece of cerebral matter immersed in water, × 215.

237. Examination of the Spinal Cord.—Different parts of the cord may be examined in the fresh state, but in order to demonstrate the beautiful structure described and figured in modern works, we must have recourse to certain methods of preparation. A solution of chromic acid is invaluable for investigating the structure of the cord. Segments of different parts are placed in the solution and allowed to harden, when very thin sections may be readily obtained and examined.

* See also Todd and Bowman's "Physiology," Vol. i., fig. 252.

The method of preparation adopted by Mr. J. Lockhart Clarke, in his beautiful and highly important investigations on the structure of the spinal cord, was the following:—

"A perfectly fresh cord was hardened in spirits of wine, so that extremely thin sections, in various directions, could be made by means of a very sharp knife. A section so made was placed on a glass slide, and treated with a mixture composed of one part of acetic acid and three of spirits of wine, which not only makes the nerves and fibrous portion more distinct and conspicuous, but renders also the grey substance much more transparent. The section was then covered with thin glass, and viewed first by reflected light with low magnifying powers, and then by transmitted light with higher ones.

"According to the second method, the section is first macerated for an hour or two in the mixture of acetic acid and spirit. It is then removed into pure spirit, and allowed to remain there for about the same space of time. From the spirit it is transferred to oil of turpentine, which expels the spirit in the form of opaque globules, and shortly (sometimes immediately) renders the section perfectly transparent. The preparation is then put up in Canada balsam, and covered with thin glass. By this means the nerve fibrils and vesicles become so beautifully distinct, that they may be clearly seen with the highest powers of the microscope. If the section be removed from the turpentine when it is only semi-transparent, we sometimes obtain a good view of the arrangement of the blood-vessels. This mode of preparation succeeds best in cold weather, for in summer, the cord, however fresh when immersed in the spirit, remains more or less spongy, instead of becoming firm and dense in the course of five or six days. The spirit should be diluted with an equal quantity of water during the first day, after which it should be used pure. Certain modifications of this mode of preparation may be sometimes employed with advantage by a practised hand."* These processes are more or less applicable to the

* "Philosophical Transactions," 1851, Part II.

investigation of the brain and nervous ganglia generally. At the present time, Mr. Clarke is engaged on investigations into the structure of the medulla oblongata, mesocephale, &c., which will shortly appear.

All Mr. Clarke's observations were, however, verified on perfectly fresh sections of the cord unchanged by the addition of any chemical reagent.

238. On Ascertaining the Specific Gravity of the Brain. — As much attention has of late been paid to the density of the brain in various cases, and as these investigations are likely to lead to very important conclusions, I think it desirable to describe here the method of pursuing such inquiries.

The researches of Dr. Bucknill, Dr. Sankey,* and others, have shown that the density of the brain varies considerably in different conditions. The specific gravity of the entire organ is in many cases affected, but it is obviously of the first importance to ascertain the density of the different portions separately. In this manner various parts may be proved to have suffered in nutrition, although no structural changes can be detected, even with the microscope. The specific gravity of the entire brain in health is about 1039; in cases of paralysis it is much higher, but varies from 1036 to 1050.

From very numerous observations Dr. Sankey has ascertained that the average specific gravity of the grey matter is 1034 in both sexes, while the mean specific gravity of the white matter is 1041.

Dr. Aitken† has ascertained the specific gravity of the central parts of the brain to be as follows: the central ganglia 1040 to 1047; the cerebrum from 1030 to 1048; the cerebellum from 1038 to 1049. In a case of chronic hemiplegia the specific gravity of the corpus striatum and optic thalamus on the right, or sound side, was 1025, while the same parts on the left or paralysed side were 1031. It

* Dr. Bucknill, "Lancet," December 25, 1852. Dr. Sankey, "British and Foreign Medico-Chirurgical Review," January, 1853.

† Dr. Aitken, "Glasgow Medical Journal," No. I., 1853.

is desirable that the specific gravity of the different parts of the brain in health should be ascertained by an extended series of observations, as it is probable that very important results would be arrived at by comparing the numbers with those obtained in cases of disease.

Method of ascertaining the Specific Gravity of the Brain.—The specific gravity is ascertained by placing little pieces of the brain, about the size of a small nut, in solutions, the density of which has been previously taken. A number of saline solutions are prepared, varying in specific gravity from 1025 to 1055.

Solutions of chloride of sodium were first employed, but Dr. Aitken recommends sulphate of magnesia. Glycerine would also answer the purpose well, but the expense of the solution would be too great. The same portion of fluid should not be used for more than one or two experiments.

The salt is dissolved in a considerable quantity of water, and the density of the solution ascertained with an accurately graduated hydrometer, or with the specific gravity bottle. To a portion of this solution more water or salt is added, as the case may be, and the specific gravity is again ascertained as before. Portions of this are diluted until we have prepared a number of solutions, which may be preserved in separate bottles, each having the specific gravity of the solution it contains marked upon it. When an experiment is made, a little of each solution is poured into small glasses placed in regular order; the piece of brain is to be placed in one, and if it rises to the surface it must be tried in the next lighter one above it; but if it sinks to the bottom it must be removed with forceps and placed in a more dense solution. After a few trials, a solution will be found in which the morsel neither sinks to the bottom, nor swims on the surface. The weight of equal bulks of the brain and of the fluid is the same, and the specific gravity of the fluid used, which is known, indicates that of the brain, which is required.

Important results are also to be obtained by ascertaining

the proportion of solid matter in different parts of the brain in various cases, and extended observations upon the proportion of fatty and saline matters would in all probability yield valuable results.

The percentage of solid matter in different parts of a brain which may be concluded to be healthy, is shown in the following note.*

* The brain was obtained from the body of a man who was in good health at the time, and was killed by falling from the top of a house. He died about eight hours after the fall.

White matter of cerebellum—	
Water	67·27
Solid matter	32·73
White matter of hemispheres—	
Water	69·45
Solid matter	30·55
Medulla oblongata—	
Water	73·75
Solid matter	26·25
Optic thalamus—	
Water	74·60
Solid matter	25·40
Gray matter cerebellum—	
Water	79·94
Solid matter	20·06
Corpus striatum—	
Water	79·96
Solid matter	20·04
Gray matter of convolutions—	
Water	80·58
Solid matter	19·42

The following cases show how the proportion of water and solid matter may vary in disease.

1. Brain of a child aged six weeks. Cause of death unknown. Body generally well nourished; viscera all healthy; brain very soft, though examined within eight hours after death—of a waxy appearance.

Water	89·60
Solid matter	10·40

2. Brain of a girl æt. nineteen, who died of diabetes. The brain was very firm, and no morbid appearances were observed. The white and grey matter contained

Water	74·85
Solid matter	25·15

3. Brain of a woman aged forty, who died of apoplexy. White matter of cerebrum apparently healthy.

Water	71·4
Solid matter	28·6

4. Softened cerebral matter surrounding the clot.

Water	81·49
Solid matter	18·51

5. Brain of a girl aged about twelve, who died from induration of a portion of white matter of the anterior lobe of the left hemisphere, about the size of a walnut.

Indurated portion—	
Water	75·24
Solid matter	24·76

ORGANS OF GENERATION. DEVELOPMENT.

The microscopical examination of the generative or presents no great difficulties, but there are a few p connected with the demonstration of the anatomical racters of some of these which it may be desirable to a to briefly.

239. Female Organs of Generation.—The *ovary* fro firm, fibrous texture, is cut with some difficulty, and very thin sections are required, it is better to inject vessels in the first instance with plain size, or size colo with transparent injection, in order to give it a consist more favourable for cutting with a knife. The Gra vesicles are very readily seen, and their different tissues be demonstrated by removing small portions with a of scissars. The ovary of the bitch or rabbit is more fa able for demonstrating the different anatomical points the human ovary. In order to examine the distrib of the vessels, it is only necessary to inject the arteries the carmine or Prussian blue fluid. These organs are hi vascular, and the distribution of the capillaries to the of the Graafian follicles is very beautiful.

The *Fallopian* tube may be examined in the same spec as the ovaries, where the vessels have been injected. epithelium lining the Fallopian tubes is columnar and ated. Its characters are easily made out by examining of the mucus scraped from the lining membrane of a which has been slit up. The arrangement of the ve

6. White cerebral matter from the opposite side, and from the same that in which the indurated portion was situated.

Water	80·29
Solid matter	19·71

7. Brain in which there was an indurated portion in the anterior p one hemisphere.

Indurated portion, sp. gr. 1042—

Water	81·59
Solid matter	18·41

8. Anterior portion of opposite hemisphere, which was healthy. S gravity, 1044.

Water	70·29
Solid matter	29·71. — "Archiv

Medicine," No. II., page 155.

of the tube is very beautiful, and thin sections, through the different coats should be obtained with Valentin's knife, and portions of mucous membrane should be carefully dissected off from the muscular coat, in order that the arrangement of the vessels upon the surface may be examined.

Uterus.—The examination of the uterus should be conducted in the same way. The mucous membrane of an impregnated uterus, which constitutes in fact *the membrana decidua*, is very highly vascular, and the numerous glands which it contains are better displayed in injected than in uninjected preparations. I have made beautiful preparations of these glands without difficulty in the unimpregnated uterus of many of the lower animals as the pig, bitch, cat, and some others. For all these injections I recommend strongly the Prussian blue fluid, and glycerine as the medium for preserving them in.

The mode of demonstrating the character of the muscular fibre-cells of the uterus has been already adverted to. The character of these is very different in the unimpregnated organ and at various periods of pregnancy.

The method of investigating some of the morbid conditions of the generative organs, will be discussed under their proper heads (ovarian dropsy, fibrous tumors of the uterus, warts, cancerous tumors).

240. Male Organs of Generation.—The anatomy of the *testis* is very readily investigated. A portion of one of the seminal tubules is easily drawn out with the aid of forceps and examined in fluid. The pressure of the thin glass must be very carefully avoided. A little solution of caustic soda renders the cells in the interior more distinct. In man, spermatozoa are never found in the seminal tubules, as their development is not complete until the cells in which they are formed have arrived at the epididymis. The structure of the testicle is more easily made out in the lower animals. Some specimens in which the vessels have been injected should also be submitted to examination. The testicles of rodent animals afford very demonstrative specimens.

The *Vas deferens* is so hard that thin transverse and longitudinal sections are easily cut with a sharp knife. The fibres of organic muscle in the coats of the tube are demonstrated by the application of a little caustic soda. The characters of spermatozoa are described in the chapter on "Urine."

The arrangement of the vessels of *the penis* should be studied in specimens in which the arteries have been filled with transparent injection and the veins with plain size, in the manner already adverted to in page 209. The mode of examining the mucous membrane of the urethra is the same as recommended in the examination of other mucous membranes.

241. Investigation of the Structures connected with the Embryo and the Development of Organs.—The highly vascular *placenta* should be studied in organs in which the vessels have been injected with size and glycerine, very faintly coloured with Prussian blue solution. The cells of the tufts are easily made out in pieces removed from a healthy placenta. The addition of a little acetic acid or solution of soda, renders the specimen more transparent.*

The subject of development is a difficult one for the student, and should only be undertaken by those who have much time at their disposal. Advantage will be derived from the use of fluids for hardening tissues previously alluded to, and glycerine will be found to render some structures very distinct, while on the other hand, some tissues are not to be distinguished at all when immersed in this medium. The reader is referred to the remarks on rendering soft tissues hard and transparent, § 90.

Besides those mentioned in the text, the following works may be referred to upon the subjects treated of in the present chapter:—"Physiological Anatomy and Physiology of Man," Todd and Bowman; "Kölliker's Handbuch der Gewebelehre des Menschen," translated for the Sydenham Society, by Busk and Huxley; Strausdurkheim, op. cit.; Dujardin, "Observateur au Microscope," Paris, 1843; Quain's "Anatomy," by Dr. Sharpey and Mr. Ellis; "Descriptive and Surgical Anatomy," by Mr. Henry Gray, and the text books of minute anatomy and physiology.

* For a description of the anatomy of the placenta, see Dr. Arthur Farre's article in the "Cyclopædia of Anatomy and Physiology."

CHAPTER VII.

Organs of Special Sense.—Skin and its Appendages.—Cuticle.—Pigment Cells.—Papillæ.—Of making a Vertical Section of Skin.—Sebaceous Glands.—Sweat Glands.—Hairs.—Molluscum.—Warts, Corns, &c.—Examination of the Tongue.—Examination of the Nose.—Examination of the Eye.—Of making Sections of the Cornea and Sclerotic.—Choroid and Ciliary Processes.—Examination of the Crystalline Lens.

Examination of Skin and its Appendages.

242. Cuticle.—The cuticle may be subjected to examination either by scraping the surface, in which case only the most superficial cells, which are often not well defined, will be obtained; or by making a thin section of dried cuticle with a sharp knife. If a portion of skin be allowed to remain for some days in a moist atmosphere, it will be found that large flakes of cuticle can be readily detached, small fragments of which may be moistened with water in the usual way, and subjected to examination.

The epithelium will be found to vary in character according as it is taken from the deep or the most superficial layers of cuticle. In the former situation the epidermic cells are more or less rounded in form, while on the surface they are flattened and adhere to each other, forming small scales, in which the original form of the cell is with difficulty made out. The deepest layer of the cuticle appears to consist chiefly of minute granules, with a few small cells. It is here that the colouring matter is deposited in the dark races, and it was to this portion of the cuticle that the term *rete*

mucosum was applied. As the cells approach the surface, the colouring matter appears to diminish in quantity, owing probably to changes taking place in the chemical nature of the material. The cells composing the deeper layers of the cuticle are soluble in acetic acid, while those on the surface are unaffected by this reagent.

Upon examining the under surface of the cuticle, which has been removed as above directed, it will be found to present several depressions, in which the tactile papillæ of the cutis are lodged; and upon removing the cuticle by maceration, from some situations, such as the palm of the hand, or heel, or from the anterior surface of the leg, the epithelial lining of the sweat ducts as they pass through the cutis, will often be found adhering firmly to it. Preparations of this kind may be preserved in glycerine, to which a very little acetic acid has been added.

243. Pigment Cells.—The cells containing pigment are very readily demonstrated in the skin of the negro, in that of several of the lower animals, or in the freckles which may often be obtained from different parts of the body of some subjects.

A preparation of the cuticle of the negro may be preserved in Canada balsam. The cuticle may be separated as above described, dried flat between folds of clean paper, or between two plates of glass, and mounted in the usual way. The method of preparing a vertical section of the cuticle is described in § 245.

The walls of the vessels of the peritoneum, lungs, &c., and the skin, of the frog, contain beautiful varieties of very dark pigment cells, which consist of several branches of irregular form radiating from the central part of the cell.

244. Papillæ.—The papillæ may be shown in two ways, either by making a vertical section of the skin previous to the removal of the cuticle; or the latter may be taken off in the manner described in § 242, and a section of the true skin only made.

The best situations from which to take the skin for the

purpose of examining the papillæ, are the palmar surface of the hand and fingers, and the sole of the foot. After the cuticle has been removed, a transverse section of the skin with the papillæ may be made as follows: a gentle stream of water is to be allowed to flow over the papillæ, in order to make them all fall in one direction, which is readily effected by inclining the piece of skin downwards while the water is running. After being drained, a cut is made with a very sharp knife across the piece of skin in its upper part, in a direction at right angles to that which the papillæ have been caused to assume. Upon now turning the preparation so that the freshly-cut surface is in the most dependent position, and allowing the jet of water to flow, the direction of the papillæ will be reversed, and it is obvious that a very thin section off the freshly-cut surface will contain one or more rows of *entire* papillæ. The section may then be examined, and may be preserved in liquid; or it may be placed upon a glass slide, gently dried, and mounted in Canada balsam. The papillæ of the skin of the foot of the dog are large and well-marked.

In order to examine the structure of the papillæ, a tolerably fresh specimen of skin should be chosen, and as thin a section as possible should be made. The specimen may now be treated with weak caustic soda, or with a little acetic acid, and subjected to examination. It is in this way that the nerves may occasionally be demonstrated in the papillæ, and frequently the vascular loop may be thus rendered distinct; but the arrangement of the vessels is always better shown in a specimen injected with an opaque injection.

The "axis-corpuscles," or touch-bodies may be shown in the papillæ situated at the tips of the fingers, or in the palm of the hand, by treating the specimen with acetic acid. A papilla may be met with in this situation terminating in two or three points. One of these will perhaps contain a touch-corpuscle, while in the others only a vascular loop can be seen, and no nerve fibre whatever can be distinguished. I have obtained beautiful specimens from sections of the skin

of the finger of a monkey which had been soaking for some time in glycerine. For detailed information on the subject of the axis-corpuscles, I must refer to Kölliker's "Gewebelehre," translated for the Sydenham Society, and to Sharpey and Ellis's "Anatomy."

245. Method of making a Vertical Section of Skin.—In a section of this kind all the structures entering into the formation of skin can be seen, and the arrangement of the hair-bulbs and sebaceous follicles may also be demonstrated if the skin be taken from a part in which these structures abound. The disposition of the sweat ducts and the arrangement of the glands may be well shown in such a preparation. It is exceedingly difficult to cut a section of skin in the recent state sufficiently thin for observation; hence, a modification of the method usually employed must be resorted to.

The skin should be perfectly fresh, and a piece about two inches square, or rather less, is to be stretched, with the outer surface downwards, upon a thick deal board, by means of numerous pins. If the sudoriferous glands are to be included in the preparation, care must be taken to leave sufficient of the subcutaneous areolar tissue. The piece of skin is allowed to dry by exposure to the air. Several small pieces, taken from various parts of the body, may be pinned out on the same board, care being taken to attach a label to each. Specimens may be taken from the scalp, eyelids, chin, mamma, axilla, arm or leg, palm of the hand, tips of the fingers, scrotum, and sole of the foot. With these, the varying thickness of the epidermis and true skin, and other peculiarities in the different regions may be demonstrated. The portion of skin, being quite dry, is to be removed from the board, and, after cutting off the edge, several thin sections may be made, by the aid of a very sharp knife, through its whole thickness. In order to obtain a good specimen of the spiral portion of the sweat ducts, the skin of the heel should be selected, and the section should be made parallel with the furrows, and in a slightly slanting direction, instead of at a right angle with the surface.

The sections may next be placed in a watch-glass with a few drops of clean water; and in the course of a short time it will be found that they have again attained their original thickness, in consequence of the absorption of water. They may now be submitted to examination, and after selecting a satisfactory specimen, it may be mounted in weak spirit and water, glycerine, or other preservative fluid; or the specimen may be washed in water, placed upon a slide, and allowed to dry slowly by spontaneous evaporation (when it will be found to have adhered tightly to the glass), and mounted in Canada balsam with the usual precautions.

If the section appear opaque when examined in aqueous fluids, it may be treated with a little weak potash or caustic soda, and carefully washed again before being mounted. If the skin contains very much fat, this may be removed by soaking the section for a short time in ether previous to moistening it with water. In this way a most beautiful section, showing all the structures, including the sweat ducts, may be sometimes procured. Good sections may often be preserved very well in a solution of chloride of calcium. Carbonate of potash has been employed for rendering the section transparent. The skin may be macerated in dilute nitric acid (one of acid to two of water) for twenty-four hours, when the sweat glands are easily distinguished upon making a section (Giraldès, quoted by Kölliker).

246. Sebaceous Glands.—The sebaceous glands are very easily demonstrated. Their arrangement is made out very distinctly in vertical sections of the skin of the scalp of the fœtus. I obtained some very beautiful specimens from skin which had been hardened for some time in acetic acid. The hairs and hair bulbs are also often well shown in the same specimen.

247. Sweat Glands.—The sweat glands are also demonstrated most readily in the skin of the fœtus. The gland itself may be easily dissected out from the subcutaneous areolar tissue of the axilla, in which locality the glands are of large size. They may be preserved in glycerine. The

course of the ducts through the cuticle should be noticed, especially in the cuticle of the heel, where they pursue a spiral course. If the skin be removed from the heel and allowed to dry, sections can often be obtained in which the connection between the spiral portion of the duct in the cuticle and that part which passes through the true skin, may be demonstrated. These sections require moistening with water, and they may be mounted in a solution of chloride of calcium, or naphtha and creosote fluid. Glycerine renders them too transparent.

248. Hairs.—The structure and mode of growth of hair may be well observed in sections of the skin of the fœtus. The mode of obtaining transverse and longitudinal sections of hair has been described in "How to Work with the Microscope." The moist structures surrounding the bulb of the hair (root sheaths) when drawn from its follicles, are well seen in specimens which have been soaked in glycerine, and the cells in the medulla of hair are also best displayed in the same manner. The fibrous structure of the hair is sometimes well seen at the ends where the fibres are separated from each other, and not unfrequently, in hairs which have been twisted for some time into knots, the hard elongated fibres of which they are composed have become unravelled as it were, and the manner in which these are combined so as to form the shaft of the hair is well displayed. A drawing of a diseased hair which is much split up, is represented in chapter xi.

249. Molluscum.—Some time since, through the kindness of Mr. Bowman, I had an excellent opportunity of examining the tumours from a case of molluscum in every stage of growth, and I was led to the conclusion that these tumours are really composed of altered structures connected with the hair bulb, and were not dependent upon a morbid state of the sebaceous glands as was previously supposed. The conclusions I arrived at were as follows:

1. That neither the sebaceous glands nor the sweat glands, nor their ducts, were concerned in the formation of the tumours.

2. That the tumour consisted essentially of a morbid alteration of the structures concerned in the formation of the hair, especially of the cells at the deepest part of the follicle, and of the follicle itself.

3. That the subcutaneous areolar tissue was considerably hypertrophied; both its white and yellow elements being coarser and more abundant than in health.*

Many tumours connected with the skin depend upon an altered growth of the hair. I have seen hairs coiled up in the centre of small fibrous tumours beneath the skin. The follicle seems to have been closed at its summit, and the egress of the hair being prevented, it gradually becomes twisted up in consequence of its growth still continuing from the root. The areolar tissue and other structures in the neighbourhood become gradually involved in the alteration, and the tumour as it increases in size becomes of more complicated structure, so that its real nature is not very easily made out.

250. Warts, Corns, and other growths, which consist of thickened epidermis, may be subjected to examination, and sections obtained in the same way as directed for making sections of skin.

In disease the subcutaneous areolar tissue is sometimes found thickened over a considerable extent, or over small circumscribed spaces; in which latter case the sensation of small subcutaneous tumours is produced if the affected portions of skin be pinched up between the finger and thumb. The condition termed *Elephantiasis* appears to consist of a thickening and hypertrophy of the subcutaneous areolar tissue, and the pouring out of lymph into the areolæ or interspaces, which subsequently becomes organised and a part of the tissue. Sections of skin in this state may be made after being hardened in alcohol or in a solution of chromic acid.

* The results of examination of the tumours, with drawings of the microscopical appearances, will be found in the sixth volume of the "Transactions of the Pathological Society of London," page 313, 1855.

Examination of the Tongue.

251. Tongue.—The principal points of interest to be demonstrated in the tongue, are the papillæ and the arrangement of the muscular fibres. Different methods of preparation are employed according to the character of the tongue to be examined. The papillæ of the tongue of the frog and other animals in which the mucous membrane is soft and moist, may be snipped off with a pair of scissars, and examined in glycerine or other solution. The epithelium of the tongue is readily demonstrated. The vessels of the papillæ of the frog's tongue are seen more distinctly if the specimen be treated with a little dilute acetic acid, but it is better to examine their arrangement in an animal whose vessels have been injected with the Prussian blue solution. The distribution of the capillaries to the palate, tongue, and all the parts about the mouth of the frog and other batrachia is very beautiful. It is not difficult to trace nerve fibres into the papillæ of this class of animals, and their distinctness is much increased by treating the specimen with caustic soda, but no one has ever yet succeeded in demonstrating conclusively how these nerves terminate. Their finest branches may certainly be followed to a point very near the summit. It is probable that the patient investigation of this subject, and the employment of different solutions for the purpose of rendering the textures hard and transparent, which should be injected into the vessels (page 72), would lead to important results. The tongue of the mouse and other small mammalian animals, will afford clearer and more beautiful specimens than those of man and the larger animals.

In order to demonstrate the general arrangement of the papillæ and the structures beneath, in the tongue of man and mammalian animals, it is better to boil the organ in order to harden it. Exceedingly thin sections may then be obtained very easily with a sharp razor. These sections should be made in different directions, and if the instrument be made to cut parallel to the filiform papillæ, even thin

sections of these structures may sometimes be obtained. They must afterwards be rendered transparent by the addition of a drop of dilute caustic soda or acetic acid. In such a section the muscular fibres can often be traced quite to the sub-mucous tissue, where their tendons become continuous with the white fibrous element. The form of these muscles, and their mode of interlacement have been well described in Dr. Salter's article "Tongue," in the "Cyclopædia of Anatomy and Physiology." The reader is referred to this article, to a paper by Mr. Zaglas on the muscular structure of the tongue of man and certain of the mammalia, in Goodsir's "Annals of Anatomy and Physiology," and to Todd and Bowman's "Physiology," for a description of the anatomy of the tongue.

252. Nose.—Much yet remains to be discovered of the minute anatomy of the mucous membrane of the nose. It rapidly undergoes post mortem change, and it is, therefore, necessary to examine it as soon after death as possible. The upper brown portion, near the ethmoid bone, should be especially examined. The student should obtain specimens from the sheep, as they can always be obtained perfectly fresh. The head may be sawn through longitudinally, a little on one side of the centre, and the delicate mucous membrane carefully removed from the laminæ of bone which it covers. With the aid of a very sharp knife, or scissars, thin pieces may be obtained fit for examination. Care must be taken to prevent the pressure of the thin glass. The epithelium of the sinuses and lower part of the nose is columnar and ciliated; that near the orifice is scaly, and approaches in character to that of skin; while in the *olfactory region* it is not ciliated, but consists of a thick layer of small granular cells.* The nerves are destitute of the white substance of Schwann, and take the form of delicate flattened bands, with oval nuclei scattered at tolerably equal intervals along the trunks. The termination of the nerves has not

* Todd and Bowman's "Physiology," Vol. ii., page 5.

been ascertained, although there can be no doubt that delicate filaments reach up to the epithelial cells. Between the latter, delicate nerve filaments may be discovered, and, according to the recent observations of Eckhard and Ecker, may be traced quite to the free surface of the epithelium. In some instances, the nerve filaments seem to terminate in the epithelial cells. The mucous membrane is highly vascular, and the capillaries form many dilated loops which were first noticed by Professor Quekett. The structure of the cells in the olfactory region of the nose is worthy of very careful investigation.

253. Ear.—The investigation of the minute anatomy of the ear is exceedingly difficult. The nervous structure is so delicate, that it undergoes very rapid changes after death. In investigations upon any special point, in the anatomy, it is better to examine the ears of animals, and afterwards compare the results with those obtained from researches on the human ear. Mr. Toynbee gives the following directions for removing the internal ear from the human subject. These will be found useful to the student of this branch of morbid anatomy.

"The simplest method of removing ears for the sake of dissection is, in the first place, to saw off the calvarium in the usual way, and then to take out both the petrous bones together, by means of two transverse vertical sections, one in front of each petrous bone, and the other posterior to it. The anterior of these sections should pass in a line a little anterior to the anterior clinoid processes, and the posterior in a line through the posterior third of each mastoid process. By means of these two sections, the trumpet-shaped extremity of each Eustachian tube, a portion of the mucous membrane of the fauces, and the whole of each petrous bone, together with the mastoid process, can be taken out. The disadvantage of this procedure is the disfigurement which is apt to ensue from the falling in of the face. To avoid this disadvantage, another mode of removing the ears may be resorted to: this consists in taking out each petrous bone separately in the

following manner:—The calvarium having been sawn off, an anterior section is to be made on each side on the same line as in the above plan, but extending only as far as the outer part of the body of the spheroid bone; a posterior section on each side is then to be made, as in the first plan, but not extending further inwards than the basilar process of the occipital bone. These two sections are to be made with a saw, or with a chisel and hammer; the apex of each petrous bone is then to be separated from the sphenoid and occipital bones, and each petrous bone, the outer ear and integument being detached and reflected downwards, is to be drawn outwards, taking care, by inserting the scalpel deeply, to remove as much of the soft parts as possible. With this second plan there is a difficulty in removing the whole of the guttural portion of the Eustachian tube: with care, however, this portion may be removed, especially if the final sections separating the petrous bone from the occipital and sphenoid, be made to pass obliquely from above, downwards and inwards. The organ of hearing having been removed, the dissection may be conducted in the following manner:—The auditory nerve in the meatus should be first carefully examined, premising that a previous inspection has been made of the portiou of the brain to which the *portio mollis* and *portio dura* nerves are attached. The size of the external meatus having been ascertained by allowing a strong light to fall into it, its anterior wall is to be removed by the cutting forceps, made by Messrs. Ash, of Broad Street, Golden Square; the state of the epidermis, the ceruminous glands and secretion, the dermis, the periosteum, and bone, are to be noticed. The outer surface of the membrana tympani is then to be examined; also the state of its epidermoid and dermoid laminæ, its degree of tension, and the amount of motion possessed by the malleus when pressed upon by a fine point. The next step is to ascertain the condition of the guttural portion of the Eustachian tube, to lay open the cartilaginous tube with the scissars, and then expose the cavity of the osseous portion by means of the cutting forceps.

In doing this, the *tensor tympani* muscle is exposed; its structure should be examined, and, if it has not a healthy appearance, portions of it should be submitted to microscopic inspection. The upper wall of the tympanum is next to be cut away by means of the cutting forceps; in doing this, great care must be taken not to disturb or disconnect the malleus and incus, which lie immediately beneath it. After the tympanic cavity has been exposed, the first step is to draw the tensor tympani muscle, and to ascertain how far it causes a movement of the membrana tympani and ossicles. The incus and stapes are now to be touched with a fine point, so as to ascertain their degree of mobility; the tendon of the stapedius muscle is also to be pressed upon. The condition of the mucous membrane of the tympanum, and of the mastoid cells, is then to be ascertained, and any peculiarity of the cavity, the existence of bands of adhesion, &c., to be noted. The most delicate part of the dissection, viz., that of the internal ear, must now be undertaken. The cavities of the vestibule and cochlea, are to be exposed by removing a small portion of the upper wall of each. Before reaching the vestibule, the superior semicircular canal will be cut through and removed; the membranous canal should be drawn out and inspected. As the cavities of the vestibule and cochlea are laid bare, it is desirable to see that the quantity of perilymph is natural, as well as its colour and consistence. The outer surface of the membranous labyrinth having been observed, it should be opened so as to expose the endolymph and otoconia, portions of all which parts should be removed for microscopic inspection. This having been effected, the remaining membranous semicircular canals are to be exposed, and the connection of the base of the stapes to the fenestra ovalis carefully examined. The last stage of the dissection consists in removing parts of the lamina spiralis, in examining them microscopically, and in exposing from within, by following the course of the scala tympani, the membrane of the fenestra rotunda. The only organ which now remains unexamined, is the stapedius

muscle; in order to expose it, the course of the aquæductus Fallopii, beginning at the stylo-mastoid foramen, should be followed until the base of the pyramidal eminence, containing the muscle, is reached."*

234. Eye.—The microscopical examination of many of the tissues of the eye is a matter of great difficulty; and although it is impossible to describe at length the various plans adopted for demonstrating the anatomy of these different textures, it is nevertheless desirable to indicate a few of the operations which are employed in the investigation. The student should practise observations on the anatomy of the eye as much as possible; for if he is in the habit of investigating these structures he will be able to undertake any branch of microscopical inquiry with a fair prospect of success. The eye should be injected through a branch of the ophthalmic artery with the Prussian blue solution and in the course of a few minutes very perfect injection of the different tunics may be obtained. The eyes of oxen, from their large size, are most convenient for this purpose, and a pipe may be inserted easily into one of the smallest vessels divided in the removal of the eye. The human eye is not easily injected after its removal from the head in consequence of the small size of the vessels. After an injected eye has been allowed to stand for some time, the different tunics may be examined. In this way beautiful injections of the retina will sometimes be obtained. When eyes are to be preserved for the purpose of subsequent observation, glycerine will be found the most efficient preservative solution, but it should be used diluted with an equal quantity of water in the first instance, otherwise shrinking to such an extent occurs that the structures are afterwards submitted to examination with great difficulty, whereas if the strength of the glycerine be gradually increased, this inconvenience is avoided.

In order to examine the *choroid*, the sclerotic must be

* "A Descriptive Catalogue of Preparations Illustrative of Diseases of the Ear," in the museum of Joseph Joynbee, F.R.S.—Churchill, 1857.

removed, and in doing this it will be found more convenient to cut a narrow strip quite out of the sclerotic in its entire circumference, than to make a simple incision.

256. Of making Sections of the Sclerotic, Cornea, and Retina.—Thin sections of the cornea and retina are made upon the same principle as those of the skin. The sclerotic is first cleaned by cutting away all the muscles adherent to it with sharp scissars, and the eye is then cut into two parts with a sharp knife, without removing the vitreous humour. It may be divided either transversely or in a longitudinal direction. When the cornea is to be examined, the anterior part may be well washed with water, and the ciliary processes, &c., removed; after making little notches around it with scissars, in order that it may dry as flat as possible, it is to be pinned out upon a small piece of board with numerous pins. It is allowed to dry spontaneously, and then thin sections may be made with a sharp scalpel and moistened with water, when they swell out to their former size. The section may be treated with a drop of acetic acid, when the structures of which it is composed will become clearly visible.

In order to obtain a section of the retina, the posterior part of the eye with the vitreous humour adhering is carefully notched, and pinned out as in the former case. With care the greater part of the vitreous may be cut away with scissars, but a thin layer should be allowed to dry upon the surface of the retina. Thin sections may be made and treated as in the case of the cornea. Dilute acetic acid or dilute caustic soda may be applied to the section after it has been examined in pure water. The eyes should be perfectly fresh at the time they are pinned out. Specimens prepared in this manner should be compared with others obtained from recent organs.

257. Choroid and Ciliary Processes.—Injections of the Choroid are made as above described. The greater part of the black pigment may be washed away with a stream of water, or by agitation in water. The ciliary processes, when injected with transparent injection form very beautiful micro-

scopical preparations, and the arrangement of the capillary vessels in the thin layer of the choroid known as the *tapetum lucidum* is most beautiful from its regularity. These specimens may be preserved in glycerine.

238. Examination of the Crystalline Lens.—The crystalline lens may be examined in the recent state by moistening a portion with a drop of water. It may be boiled, and some of the fibres carefully torn off, and afterwards moistened. Or it may be soaked for some time in a solution of chromic acid, and then subjected to examination; or lastly, it may be dried, soaked in oil for a considerable time, and a thick perfectly transparent section made, which may be ground to any required degree of tenuity; the surfaces may be afterwards polished. Sections prepared in this manner may be mounted in Canada balsam.

In examining the character of the fibres of the lens, it is better to boil it previously, and tear off a few fibres with forceps: these may be afterwards carefully separated from each other with needles. The arrangement of the fibres should be examined in different animals, especially in the human subject, the ox, the horse, and in fishes.*

If the disposition of the fibres of the surface is to be shown, the lens requires hardening in a solution of chromic acid. The lens may then be examined in a deep glass cell, in some of the chromic acid solution with a low power.

In examining cataracts we should carefully observe the microscopical characters of the soft external pulpy part, as well as of the hard internal nucleus. In many of these cases numerous oil globules will be observed, which, from my own observations, appear to consist chiefly of cholesterine held in solution in an oily fat; and other larger globules, consisting of some very transparent substance presenting nearly the same refracting powers as this portion of the lens, but evidently of very different composition, as they are not miscible with it, may be observed. Occasionally, also, small

* Todd and Bowman's "Physiology," chapter xvii.

plates of cholesterine have been noticed. There is always much granular matter.

Upon the subjects treated of in the last chapter, amongst many others, the following works should be consulted:—

Various articles in the "Cyclopædia of Anatomy and Physiology." "Kölliker's Handbook," translated by Busk and Huxley for the Sydenham Society. Todd and Bowman's "Physiology." "Chemistry of Vegetable and Animal Physiology," Mulder. "Lectures on Clinical Medicine," Dr. Bennett, 1858. "Chemie und Mikroskop am Krankenbette," Dr. Hœfle,—Erlangen, 1850. "Rudiments of Pathological Histology," by Carl Wedl, M.D., translated by the Sydenham Society.

CHAPTER VIII.

LYMPH, CHYLE, BLOOD, SALIVA, MILK, BILE.—*Examination of Blood.—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.—Diptherite.—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.* PUS.—TUBERCLE.—*Examination of Pus; Microscopical Characters.—Examination of Tubercle.*

LYMPH, CHYLE, BLOOD, SALIVA, MILK, BILE.

259. 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 of an animal which has been fed upon food containing much fatty matter for some time before death. The character of the corpuscles should be observed and their reaction with acetic acid studied. The mode of examining lymphatic glands and lymphatic vessels has been described in §§ 222, 234.

260. 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. If in this manner the individual globules cannot be seen

distinctly, a little syrup or serum 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 (fig. 179), 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.

Fig. 179.



Blood corpuscles, from healthy human blood, × 215.

If a little strong syrup be added to a drop of blood, the corpuscles will become much flatter from exosmosis of a part of their contents; while, on the other hand, if placed in water, they become spherical from endosmosis, and ultimately burst. It is not difficult to make a solution of similar density to that in the interior of the corpuscle; and in this manner, as Dr. Rees expresses it, we may "take the specific gravity of a blood corpuscle," if we ascertain the specific gravity of the solution which has been added to the blood.

Acetic acid causes the membrane of the corpuscle to become more transparent and clear, and to swell up from endosmosis. After the application of this reagent, the blood corpuscle may be scarcely visible, but the membrane is not dissolved by it. Strong hydrochloric and nitric acids do not dissolve the globules; with the latter reagent the outline is often rendered darker and thicker, while the entire globule becomes smaller. The 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 so been mixed with the urine in very small quantities at a time.

Blood crystals, and the method of obtaining them, have been described in § 163.

261. 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 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 are likely to employ it, to the original paper, than to give a short summary of the plan which would be useless in a practical point of view.*

262. Blood in Disease.—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

* 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.

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 contains much granular matter. 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 their nature is closely allied to these. In a case which I had an opportunity of examining, some years

Fig. 180.



From the blood of a patient suffering from cholera, × 215.

Fig. 181.



Blood corpuscles adhering very intimately to each other. When they were pressed beneath the thin glass, they could be separated, but soon became attached again, and by attempting slight separation, they could be drawn out in a string-like form, × 215.

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. The outline of the cell was distinct and well defined, fig. 180.

Sometimes the blood corpuscles adhere together with unusual tenacity. Of this I met with a very unusual

* Bennett on "Leucocythemia," 1852. "Clinical Lectures on the Principles and Practice of Medicine," 1858, page. 817.

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 naked eye, floating in a clear serum, if a drop of the blood was placed on a slide and covered with thin glass. By pressure they were made to separate, but soon adhered again. In this case, there certainly appeared to exist an attraction between the corpuscles. It seems impossible to explain the circumstance by supposing any unusual alteration in the density of the serum and corpuscles. I never saw such an appearance as that represented in fig. 181 before, and I have never met with such a case since.

263. Blood of Lower Animals.—The blood of the lower animals, particularly of the rat or mouse, bird, frog, newt, and fish, should be examined when opportunities occur. 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 interior 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 it. Splenic blood has also been found to contain free crystals. The subject of blood crystallization has been considered in § 163.

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. The former is to be placed in a moist bag and carefully tied down to the frog plate. Among mammalia, in the wing of the bat.

264. 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 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. These cells are figured in "Illustrations," "Sputum," I., fig. 3. 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.

265. 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. The general characters of the oil globules, and the fact of their not running together, and forming larger globules when pressed, should be noticed, fig. 182. This is prevented by the albuminous 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 con-

Fig. 182.



Milk globules, × 215.

reniently applied by using the little bulbs (§ 138). In the igure some globules thus treated are seen running together.

The colostrum, or milk secreted first after delivery, will e found to contain many large cells, consisting of an invest- ng membrane, filled with oil globules resembling those which re floating free in the surrounding fluid.

By microscopical examination, the most common adul- eration of milk can be readily detected,—such, for instance, s chalk and flour (starch globules). It has been said that nilk has been adulterated by the addition of sheep's or other brains. Such cases are, no doubt, very rare, as they 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 of the least importance is water, and this, I believe, is the only one ever carried out to any great extent.

266. Examination of Bile.—The only insoluble substances met with in bile are epithelial cells of a columnar form, occa- sionally 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 appear- ance, and may be 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 § 164.

Serum.

267. 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 fig. 183.

Albumen in a serous fluid can always be detected by the application of heat, or upon the addition of nitric acid.

268. 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 peritonæum. 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

Fig. 183.



×215

Deposit, from about two ounces of fluid, removed from the chest of a girl aged twenty-three. *a*. Granular cells, probably from the walls of the cavity in which the fluid had collected. *b*. Claws of echinococci. The circular, oil-like masses were rendered granular by acetic acid. These characters at once show the nature of the case.

consequence of being filled with minute oil globules. The
culi present a delicately fibrous appearance, with numerous
ls entangled in the meshes formed by the interlacement
the fibres. Plates of cholesterine are sometimes found in
tic fluid. The fluid which accumulates in hydrocele is
lly perfectly clear, containing a few delicate cells, and,
aps, a few free oil globules. Spermatozoa are sometimes
with, and occasionally many plates of cholesterine are
nt.

69. Fluids from Cysts. — Upon contrasting the serous just alluded to with those which are found within the s of cysts, a marked difference is always observed, both ir chemical as well as in their microscopical characters. example of a cystic fluid, ovarian serum may be ced; but the fluid found in cysts in different parts body, as in the antrum, in the eyeball, thyroid gland, mamma and other organs, &c., will be found to present milar characters.

e deposit of ovarian fluid consists usually of cells, free ar matter, oil globules, and perhaps blood corpuscles. nfrequently, many crystalline plates of cholesterine served in it. The cells are composed of at least two t forms:—1. Small, delicate, transparent, and faintly ar cells, without the slightest appearance of a nucleus, eing somewhat larger, and smaller, than a pus cor- 2. Large cells, often as as the thousand of an inch meter, but varying in size, ark colour by transmitted, white by reflected light. which have been termed ular corpuscles," "com- granular cells," "inflam- globules," &c. (page 156), are aggregations of minute bules in a cell form. They are almost constantly pre- n the fluids which are now under consideration, and

Fig. 184.



Collections of minute oil globules, the so-called inflammation corpuscles, compound granular corpuscles, &c., from softened brain, × 215.

have a structure apparently identical with that of bodies presenting similar characters, and found fi in softening of the brain (fig. 184),—sometimes in of vessels undergoing fatty degeneration, in the —especially in pneumonia in an stage, in cystic tumours of the malignant growths, in the urine i cases, and in other fluids and sol tures in a state of degeneration instances, the fatty matter ab cholesterine, which crystallizes an alcoholic solution. I have s in which the cholesterine crysta after cells of this kind had for s been preserved as permanent obj presence can always be demonst treating the cells with a litt alcohol and allowing the sol evaporate spontaneously. The of the student is particularly directed to the occu cells of this description in various morbid products.

Fig. 185.



b

Deposit from ovarian fluid. *c*. Blood corpuscles rendered spherical by endosmosis. *b*. Pale granular cells. One of the large cells, containing a few oil globules, is also represented. The large dark cells are not shown in this figure, but the general characters of these may be seen by referring to the last figure.

Fig. 185 represents the appearance of the depos specimen of serum obtained case of ovarian dropsy. In s cases ciliated epithelium is m the fluid of ovarian cysts. Th panying figure (fig. 186) was t a specimen I met with seven The cyst from which it was was originally developed from and was not connected with the Fallopian tube.

Fig. 186.



Ciliated epithelium. Granular cells and collections of oil globules, from the serum of an ovarian cyst, × 215.

Sputum, Vomit, Fæces, &c.

It is proposed to give a short description of th scopical appearances of the different varieties of which come most frequently under the observatio

ractitioner,—the nature of which may affect the diagnosis
f the case. It is now generally admitted that in some cases
uch is to be learned by a careful examination of the sputum
the microscope, and there are even a few instances in
ich the nature of morbid changes going on during life
s been ascertained, and a decided prognosis justified
a very early period of the disease, when there were
lly no other symptoms to attract special attention, and
hing was discoverable from a most careful investigation
the physical signs. It is, however, quite true that the
ure of many cases is to be satisfactorily ascertained with-
the necessity of resorting to a microscopical examination
he sputum, and there are some in which the microscope
not afford the slightest help. At the same time, every
titioner should now be familiar with the microscopical
acters of the principal varieties of sputum; for in the
se of practice he will certainly now and then meet with
bscure case, in the diagnosis of which the microscope
afford him the most important help.

70. Examination of Sputum. — Some observers have
mmended that the sputum should be thrown into water,
at certain pieces may be selected for examination; but
ak, as a general rule, it is better to avoid the admixture
ter, as it necessarily causes a physical alteration in many
e cells, and produces complete disintegration of some.
l pieces of sputum should be removed from the vessel
the aid of forceps and scissars, and placed upon a glass
. It is better to remove at once two or three specimens
different parts of the sputum, and place them on the
glass slip for examination. As great difficulty is often
rienced in removing portions, in consequence of the
cious character of the sputum, my friend Mr. Sansom
designed a pair of forceps which completely overcomes
difficulty. These are represented in fig. 34. The blades
slightly cup-shaped and the edges sharp, so that pieces
he viscid sputum can easily be cut off. Pieces of sputum
often require teasing out with needles upon the slide,
l if, from the opacity of the specimen it is necessary to

add a fluid, it is better to use a little glycerine and wate white of egg. The specimen is to be covered with thin g in the usual manner.

271. Of preserving Specimens of Sputum as Permane Objects.—Specimens of sputum may be preserved in glyceri and water, and keep very well, but are rendered very tran parent; the naphtha and creosote solution, dilute spirit, an water impregnated with arsenious acid are also employed fo preserving sputum. The preservation of the recent cha racters 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. I have, therefore, appealed to Dr. Andrew Clarke, who has had very great experience, and he makes the following remarks upon the relative nature of different preservative solutions which he has tried upon specimens of sputum.

"Of twenty specimens (or thereabout) of tubercular sputum mounted in 1846, one remains; of many mounted in 1847 about six remain, and so on in increasing numbers to the present time. Specimens mounted up to 1850 (this is from memory) were preserved in the spirit and water solution, No. 1 in the note. Of any given number of specimens mounted by me at any time, and under apparently the same circumstances, rarely more than a half keep good for two years.

"Success in the preservation of specimens of tubercular sputum, in my experience, hinges much more on the care taken in mounting and in the frequent coating with cement, than on the nature of the preservative fluid.

"Contrary to general experience, I find it undesirable to steep specimens of sputum for any time before being mounted.

"Three years ago I mounted several specimens of on kind of expectoration in different fluids. Looking at thes specimens now, I should recommend the subjoined formul

as the most worthy of adoption. The saline fluids preserve the specimens least changed—but not for the longest time."*

272. 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, 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, I 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,

* 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 two parts of saturated camphor water. This forms the common A^1 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.

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.

white and yellow fibrous tissue, fragments of cartilage, bone, &c. Many of these are figured in "Illustrations of the Use of the Microscope in Clinical Medicine. Urinary Deposits," Plates I., II., III., Sputum, Plate I., Vomit, Plate I.

Of the Different Kinds of Sputum.

The anatomical elements met with in sputum vary much. Its character is also much influenced by the time which elapses prior to its expectoration.

273. Mucus, which is formed in 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 "Illustrations," Sputum, Plate I., figs. 1, 2, 5. Not unfrequently cells of columnar ciliated epithelium from the trachæa or bronchial tubes are present. Fig. 187 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.

Fig. 187.



Colourless bronchial sputum, × 215.

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 to be contained within a cell wall. Two or three of these are represented in the figure. They are often 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, and the true pus corpuscle, in which this reagent developes two or three characteristic highly refracting bodies, which distinguishes it from different forms of epithelial cells.

274. 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.

275. 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 every form of cell is 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 formed partly of blacks, introduced in respiration; but sometimes the dark colouring matter is formed, or at any rate collected, 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, death

takes place 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 vary 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.

276. 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. No physician would attempt to diagnose a case from the examination of the sputum only, and I much doubt if the characters of the sputum alone are so invariable as to enable one 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 the existence of the disease of a different kind. 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, as being derived from the smaller bronchial tubes. In many cases, but not in all, the microscope certainly affords very important information.



Tubercle corpuscles, × 215.

The general character of tubercle corpuscles is represented in the figure. They are seldom found in sputum unless mixed with a considerable quantity of granular

* "On the Pathology, Diagnosis, &c., of Thoracic Consumption," third edition.—Longman, 1856.

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 in all cases be distinguished as a special deposit. The characters of tubercle are described in page 290, and those of tubercular lung in page 201.

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 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

Fig. 188.



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 many other microscopists. 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 fig. 188, was found in the sputum of a case of phthisis of about a year's duration. Fragments of this kind are not unfrequently found, but several specimens should be subjected to examination, and the effect of acetic acid should be tried. 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 appearances 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. This crystalline fat usually exists in considerable quantity dissolved in other fatty matters.

277. Diptherite.—There is nothing very distinctive in the exudation effused upon the surface of the mucous mem-

brane of the fauces in these cases. 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

Fig. 189.



Fig. 190.



False membrane, from cases of diptherite.

Fig. 189.—From a case 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. 190.—From another case 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. No envelope is to be detected as would have been seen in the case of the pus corpuscle, but here it has been dissolved by the acid.

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 a well formed corpuscle. 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 formation of such cells was to continue for a certain period of time, well defined pus corpuscles would make their appearance.

In this condition then it would appear that the greater part of the epithelial layer is stripped off from the subjacent structure 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 were made occurred in the practice of Mr. Woody, of Tamworth, whose assistant, Mr. Spratly, I have to thank for the specimens and careful notes of the cases.

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. In the fragments of false membrane which I have examined, I have failed to find any structures (capillaries, areolar tissue) entering into the formation of mucous membrane, except epithelium.

278. Entozoa and Vegetable Organisms in Sputum. — *Hydatids* are 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.* 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 claws of the echinococci will sink to the bottom and may be removed with a pipette. The appearance of these is characteristic. See fig. 12 in the Introduction and chapter xi, on Entozoa.

Fig. 191.



Fungi in various stages of growth, with epithelium of the mouth, expectorated by a patient in the last stage of phthisis, × 215.

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. 191 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.

279. Other Structures met with in Sputum.—*Blood Corpuscles* are occasionally met with in small numbers in all

* "Medical Times and Gazette," 1852. See also Livois, "Récherches sur les Echinocoques chez l'homme," &c.—Thèse, Paris, 1843.

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 are aggregated into small masses, and Dr. Radclyffe Hall has described such collections as inclosed in a filmy cell.

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, whence they 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. 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.

280. Examination of Vomit.—As vomit usually contains a vast number of substances often separated 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 the pipette, if the vomit be very fluid; and with the aid of scissars and forceps, if it be very viscid, as in the case of sputum.

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 membranous 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

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 serie, 2 nde Jaarg, No. I. en II.)

Hœfle, "Chemie und Mikroscop am Kraukenbett Erlangen," 1848.

Jacubowitsch, de Saliva, diss. Dorpat, 1848.

Virchow, "Verhandlungen der Physikal. Medicin. Gesellschaft in Würzburg," 2 Bd., Sitzung. vom. 4 Jar., 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," Feb. 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 Pyhsiology.)

Dr. Anton Biermer, "Die Lehre vom Auswurf," Würzburg, 1855.

connected with the cause of this affection, but its 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 sarcina (fig. 4) will be described in the last chapter. The vomit which contains the vegetable organism usually ferments for some time after 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-bladder?), 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, 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.

281. 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.

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 fig. 192, were obtained from the liquid stools of a girl aged eighteen, who was suffering from cough and fever. The oval masses are probably fragments of a clot of blood. The specimen was sent to me by Mr. R. E. Thompson, of Cambridge.*

Fig. 192.



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.

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,—perhaps forced off by the violent contraction of the villus. 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

* "Archives of Medicine," No. II., page 141.

times. In the majority of cases, however, they are not
sent. Undigested muscular fibre, exhibiting the transv
striæ very beautifully, large crystals of triple phosphate
fragments of substances taken as food, are also gener
met with.

Masses of vegetable confervoid growths have occasion
been passed by the bowels, but such cases are not comm
one is mentioned by Dr. Farre, and another by Profe
Bennett.

Professor Quekett and Mr. Brooke have met with s
elastic fibres in the fæces, exhibiting the tranverse st
which are normal in the fibres of the ligamentum nuch
the giraffe. The transverse division depended probably
incipient decomposition. The division is sometime
distinct and complete as to have led to these fibres b
mistaken for confervoid growths.*

282. Discharge from the Uterus and Vagina.—The char
of these discharges varies very much. In subjecting t
to microscopical examination, it is better to avoid the a
tion of water or other fluid if possible.

In uterine and vaginal discharges, the following
stances are not unfrequently met with. Epithelium of
vagina, pus globules, blood corpuscles, small transparent
or circular granular cells, usually occurring in abundan
the mucus about the os and cervix uteri, and small oil
bules.† The *trichomonas vaginæ* is referred to in page 3

Dr. Arthur Farre has shown that many of the m
branous masses discharged in cases of dysmennorrhœa
sist of a lamina of epithelium from the vagina. Someti
the whole of the epithelial coat is shed entire, producin
cast of that canal. Formerly these were supposed to
had a uterine origin.‡

* "Principles of Human Physiology," Dr. Carpenter, fourth ed
page 438, note.

† Upon the microscopical characters of Leucorrhœal discharges
Memoir of Dr. Tyler Smith, in Vol. xxxv. of the "Medico-Chirurgical Tra
tions," should be consulted.

‡ "Archives of Medicine," No. II., page 71.

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.

Pus. Tubercle.

283. Examination of Pus.—The microscopical examination of pus is easily performed. When found in the secretions, the practitioner must not draw too hasty a 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 upon 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. In order to ascertain if blood contains pus, M. Donnè adds a drop of ammonia to it, and examines it in the microscope.

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 (fig. 193 *a*). These have a dark outline, are of rather an irregular form, highly refracting, but do not appear to be soluble in ether.

Fig. 193.



Occasionally I have found pus cells in which the central contents were very dark, and slightly separated from the cell wall (fig. 194). 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.

Fig. 194.



284. 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 "mucous 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.

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.

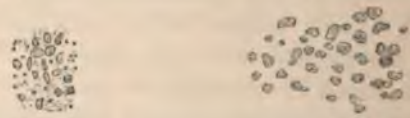
At the same time it must not be supposed that the diagnosis of pus is a matter of secondary importance; and all that is intended in introducing these observations is to impress upon the student the importance of not stating that pus has been found in any particular locality, or in any particular fluid, merely because a few cells having all the characters of a pus globule have been observed. To say 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 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 will 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.

285. 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, that its characters are not often 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

Fig. 195. Fig. 196.



Tubercle corpuscles, from the interior of the eyeball of a child aged eight. Removed by Mr. Hulme, × 215.

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

ssential characteristic elements of this exudation, for they re not always to be made out in structures which are idently tubercular. It is probable that they consist merely small masses of the exudation itself, and doubtful if they ssess powers of growth or multiplication. Many appear-ces lead to the inference that they result merely from breaking up of the tubercular deposit. Very different nions as to the nature of the tubercle corpuscle are held various authorities. Schroeder van der Kolk considers t tubercle results from a change taking place in the linary epithelium of the pulmonary air cells, and this nion is entertained in a more or less modified form by a at number of observers.* Of the existence, however, this epithelium in health there is much difference of nion (page 199). In some cases, where the disintegration the lung tissue has not proceeded to a very great extent, bercle corpuscles may be detected in the sputum.

For the opportunity of examining many interesting speci-ns of sputum in phthisis, I have to thank many friends, pecially Dr. Scott Alison, of the Consumptive Hospital.

* On this subject consult the papers of Dr. Radclyffe Hall, Dr. Thompson, r. Andrew Clarke, and others, referred to in the note on page 283.

CHAPTER IX.

ON URINE, URINARY DEPOSITS, AND CALCULI.—*Collecting Urine for Microscopical Examination.—On Examining Urinary Deposits in the Microscope.—Chemical Examination of Urinary Deposits.*—EXTRANEOUS SUBSTANCES MET WITH IN URINE.—OF URINARY DEPOSITS.—*Mucus.—Vibriones. — Torulæ. — Penicillium 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 objects 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 constituents of urine, urinary deposits, and calculi, have been fully described in other works,* to which the reader is referred for more complete information. In the

* "Illustrations of Urine, Urinary Deposits, and Calculi," containing upwards of 170 separate figures and woodcuts, 1858. "Tables for the Examination of Urine."

present chapter, therefore, 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 refer to its value, in assisting us to form a diagnosis in many cases of disease. Within the last fifteen or twenty years, the investigation of urinary deposits has been so much simplified by the conjoint use of the microscope and chemical analysis, that the nature of the greater number of deposits has been correctly ascertained. The investigations of Dr. Prout, followed by those of Drs. Golding Bird, Bence Jones, Christison, Owen Rees, Johnson, and many others, have shown the importance of the examination of the urine in disease, and the advantages derived from such an examination with reference to diagnosis and treatment.

By frequent examination of different specimens of urine, the student will soon become familiar with most of the deposits he is likely to find. 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 is perhaps surprised to discover no deposit whatever, whilst in examining others, the whole field of the microscope is 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 substances, the presence of which leads to this difficulty, have obtained entrance into the urine accidentally. Portions of hair have been mistaken for casts of the renal tubes, starch granules for 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. For the more minute chemical

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 should expect to find the secretion highly alkaline, having a strongly ammoniacal odour, and containing crystals of triple phosphate, with granules of earthy phosphate; and upon carefully focussing, numerous vibriones may generally be observed. 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* are present, we shall find that the deposit increases in quantity after the urine has stood 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 some beautiful investigations 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 (§ 104).

288. Magnifying Powers required in the Examination of the Urine.—Urinary deposits often require to be examined with different magnifying powers, 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 are often readily distinguished by the former, but crystals of this substance are sometimes so minute that it is absolutely necessary to use high 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 about 400 diameters (× 400), will be of advantage. The casts of the tubes, epithelium, and the great majority of urinary deposits can, however, be very satisfactorily demonstrated with a quarter of an inch object-glass.

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).

289. 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 ascertained.

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 (§ 140) may be applied.*

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.

290. Examination of the Deposit in the Microscope.—The drop of urine with the deposit, removed by the pipette, being

* "Tables for the Examination of Urine."

now inclosed in one or other form of cell (§§ 108, 109), various parts of the specimen 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 a similar manner. 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 under the field of the microscope, the student should endeavour to recognize every object as it passes under view. This, however, will for some time be found 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 subjected to examination; especially in urine obtained from the wards of a hospital, upon which the first microscopical observations of the student are usually made.

291. 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 figs. 197, 198, 199.

Extraneous Substances.

Fragments of human hair.
Cat's hair.
Hair from blankets, of various colours.
Portions of feathers.
Fibres of worsted, of various colours.

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 substances 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 many others which will occur to the mind of every one. With the microscopical characters of these bodies, the student should be perfectly familiar as soon as possible; and, as they can be obtained without the slightest difficulty, this is easily effected. Without this precaution, he will find himself in constant difficulty, and his ignorance will cause him to make the most ludicrous mistakes.

The origin of most of these substances is obvious. Some of them become slightly altered by being allowed to stand 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, 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, fig. 197. The fibres become soft and swollen by soaking, and may easily be mistaken for casts. The round pores which they contain much 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

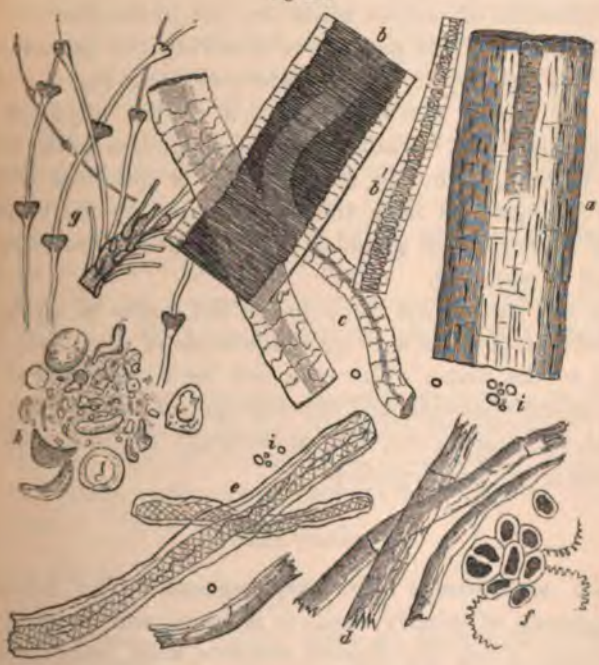
Fig. 197.



Fig. 198.



Fig. 199.



Extraneous substances not unfrequently met with among urinary deposits.

Fig. 197.—Fibres of coniferous wood, showing the peculiar pores. These are small fragments dead wood swept from the floor. They may very easily be mistaken for casts, and the pores not unlike epithelial cells.

Fig. 198.—Globules of potato starch.

Fig. 199.—*a*. Fragments of human hair. *b*. Cat's hair. *c*. Hair from blanket. *d*. Fibres flax. *e*. Fibres of cotton. These as well as worsted fibres are often coloured. *f*. Fragments tea leaves, showing cells and spiral vessels. *g*. Portions of feathers. *h*. Bread crumbs, owing wheat starch partly altered by baking and maceration. *i*. Free oil globules, consisting small particles of butter. All × 215.

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, and 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 the "Microscopical Journal," No. II.

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. This point has been already noticed in page 140.

In one case which came under the notice of my friend Dr. Stewart, jeweller's rouge (sesquioxide of iron) had been added to the urine. The man had been to several of the metropolitan hospitals and imposed upon the physicians, but at last Dr. Stewart was able to ascertain the nature of the peculiar red brown deposit.†

Of Urinary Deposits.

292. 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 assume,

* "On the Characters of Extraneous Matters," see also Plates I., II., III. in "Illustrations of Urine, Urinary Deposits, and Calculi."

† "Microscopical Journal," No. II., page 93.

with their microscopical characters. The proposed arrangement has no reference to their chemical nature, microscopical characters, origin, or 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, and 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.

293. 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

* "Tables for the Examination of Urine," Dem. iv., page 12.

perfectly transparent substance, in which only a few minute granular points can be detected. 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. 200 represents the general appearance of mucus found in urine. In the upper part of the figure is represented a cell of bladder epithelium.

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, after it has left the bladder. In some cases this change even commences in the bladder itself, and its expulsion is often a matter of the greatest difficulty. 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.

Fig. 200.



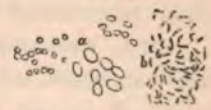
Mucus and small granular cells from healthy urine. In the upper part is a small cell of bladder epithelium, × 215.

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 encrusted with these minute crystals.

294. 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, and 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. 201 *b*, 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. Its characters are described in § 299.

Fig. 201.



Vegetable organisms met with in urine. *a*. Different forms of fungi. *b*. Vibriones, × 215.

295. Torulæ.—Certain forms of vegetable fungi or torulæ are developed in urine after it has been standing some time.

Fig. 202.



Penicillium glaucum in different stages of development. From acid urine, × 403.

Fig. 203.



Sugar fungus in various stages of growth. *a*. Thallus. After Dr. Hassall.

The period which elapses before the appearance of the fungi,

and the particular species which is developed, vary 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.*

Fig. 201*a*, represents sporules of fungi of three different characters. Fig. 202 shows 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.

296. Penicillium 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 arrives 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. 203. 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.

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 *Penicillium glaucum*, the same fungus which is developed in the lactic acid fermentation. This species is represented in different stages of growth in figs. 201*a*, 202, 204, 205.

The microscopical characters of the fungi in different specimens of urine vary considerably; but, according to the observations of Dr. Hassall, these differences depend not

* "Tables for the Examination of Urine."

upon the existence of several distinct species of plants, but rather upon the stage of development which the fungus has reached. Thus, in some specimens of urine, the growth of the fungus is arrested at the sporule stage (fig. 202), in another not until a thallus (figs. 204, 205) is formed, and in a

Fig. 204.



Penicillium glaucum, from acid urine, × 215.

Fig. 205.



Penicillium glaucum, × 215.

third it goes on until ariel 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 penicillium glaucum, as well as the sugar fungus, may be met with in saccharine urine, because all the necessary conditions for its development may be present, namely, exposure to air, an acid liquid, 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 xi.

299. Epithelium of the Genito-urinary Passages. — The forms of epithelium which may occur in urine are very

* On the characters of fungi met with in urine, see "Illustrations," Plate XIX.

numerous, as the characters of the cells differ very much in different parts of the genito-urinary mucous membrane.

The specimens represented in figs. 206 and 207 were carefully removed from the mucous membrane of the urinary

Fig. 206.



A. Epithelium from the convoluted portion of the uriniferous tubes. *a*. Treated with acetic acid. B. Epithelium from the pelvis of the kidney. C. Epithelium from the ureter. D. Epithelium from the bladder. *a*. Large cells from the trigone. *b*. Columnar cells lining mucous follicles. *c*. Cells from the fundus, × 215.

passages of a male subject, with the exception of the cells marked *b, c* in D, which were found in urine.

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 219.

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. 206B.

Ureter.—The epithelium is very abundant, and of the columnar or cylindrical form. The nucleus is usually large and distinct, fig. 206C.

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 D;— 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* D, appears to line the mucous follicles, while the scaly lies on the surface of the mucous membrane between them.

Urethra.—The epithelial cells of the urethra, fig. 207, are, for the most part, of the columnar form, but mixed with

Fig. 207.



Cells from the urethra, × 215.

Fig. 208.



Healthy vaginal epithelium, × 215.

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. 208. They vary, however, much in size and form, and are sometimes very irregular in shape, with uneven ragged edges.

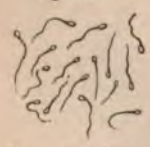
298. Spermatozoa.—The urine should be examined for spermatozoa as soon as possible after it has been passed, as they very rapidly become destroyed. They may be readily detected with a power of about 200 diameters (fig. 209), if the eye is familiar with their appearance; but to demonstrate them to persons who have not seen them before, it is better to employ a power of from 300 to 400 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," No. I., page 48, No. II., page 139.

The occasional presence of spermatozoa in the u not inconsistent with perfect health. It is only whe appearance is constant and accompanied with othe important symptoms that the practitioner is justi interfering. We must always exercise the greatest in these cases, for the mere allusion condition has done more harm to the p mind, than can be counterbalanced by th produced by medical treatment. The occ presence of spermatozoa in urine mu be looked upon, in itself, as evidence existence of that condition, to which th of *spermatorrhœa* has been applied,—a term which sorry to put into print at all; for I doubt if any sing has been productive of more unutterable misery tha indeed, it would be well if we could abolish it alto Instead of making use of it, we should be more corre said that "the patient was suffering from such an symptoms associated with the presence of spermatozoa urine." In the majority of cases in which this ill- word is used, it excites the most terrible alarm in the p mind, from which, perhaps, he does not recover for while in the sense in which it is used by many practi it only means that spermatozoa have been found in hi as indeed they occasionally are in the urine of almos young healthy man.

Fig. 209.



Spermatozoa from urine, × 215.

The only bodies at all liable to be mistaken for s tozoa that I have ever seen, are a form of vegetable which I have only once met with, in a specimen kindly sent to me by my friend Mr. Masters, of P Rye. Mr. C. Roberts, of St. George's Hospital, ha very careful notes of the case. Some of the bodies i tion very closely resembled spermatozoa, but their true was ascertained by noticing the characters of man specimens of the vegetable growth. These are fig No. III. of the "Archives," where also will be fo account of the case.

299. Trichomonas Vaginæ.—Donné observed some rounded cells with vibratile filaments projecting from them in the urine of females suffering from leucorrhœa, and considered them as 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 found the trichomonas in the vaginal mucus, both of impregnated and unimpregnated women.* I have never seen cells in any cases at all resembling M. Donné's figure.

Casts of the Uriniferous Tubes.

This forms 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. Johnson, to whom we are indebted for much that we know upon this subject.

The microscopical characters of the forms of casts most commonly met with in urine will alone be referred to here; and for a full description of the characters of the urine in which they occur, and their pathological interpretation, I must refer to Dr. Johnson's work.†

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 contain-

* Scanzoni "Beiträge zur Geburtskunde," Band II.

† "On Diseases of the Kidney," by G. Johnson. Papers in the "Medico-Chirurgical Transactions," Vols. xxix., xxx. Reference may also be made to Frerich's work "Die Brightsche Nierenkrankheit und deren Behandlung, Braunschweig."

ing 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, such an inference would undoubtedly be correct. We must not, therefore, expect to find in one case epithelial casts alone, in another granular casts alone, in a third fatty casts alone, 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 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 observations on 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 formed of some transparent albuminous material which is poured out into the canal, and there becomes 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 readily passes from the tube and escapes into the urine. If the epithelial layer, on the basement membrane of 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 tubes 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.

Drawings of the various forms of casts will be found in "Illustrations of Urine, Urinary Deposits, and Calculi," Plates XIV., XV., XVI., XVII., and XVIII., but a few of the most important have been repeated here to make the text clearer. The manner in which casts are formed is described in the explanation of the anatomy of the kidney, illustrated in the same work.

300.—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, fig. 210. Some casts contain only granular matter, figs. 210*b*, 214, and epithelial débris. More rarely casts will be found to 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. 211.

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.*

* "Illustrations of Urine, Urinary Deposits, and Calculi," Plate XII., fig. 1.

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. The cases are generally of an acute character, and terminate fatally in a short time (three or four weeks), but this is not invariably the case, as I have seen two or three cases occurring in children in which these casts and cells were most abundant, which have recovered completely. The deposit, from a fatal case, is figured in Plate XVI. "Illustrations of Urinary Deposits."

301. — II. Casts of Considerable Diameter, *about the* 1-500*th of an inch.* Dr. Johnson speaks of "large waxy casts," which 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 represented in fig. 212; at *a* is represented a large cast, perfectly transparent. Two of the casts in the figure, and the one depicted at *a*, fig. 213, are seen 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 at least it is probable that these casts of large diameter are formed in the lower part of the straight portions of the uriniferous tubes where these are very wide. Often it is evident that the material is deposited in successive layers. In fig. 213 at *a* such a cast is represented. 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 between the cortical and 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 in the lower straight portion of the uriniferous tubes.

CASTS OF THE URINIFEROUS TUBES.

Fig. 210.

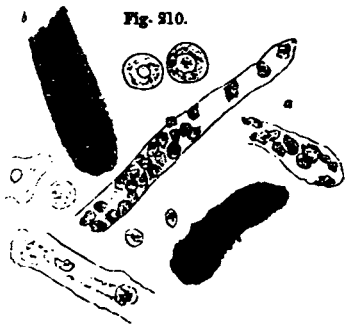


Fig 211.



Fig. 212.

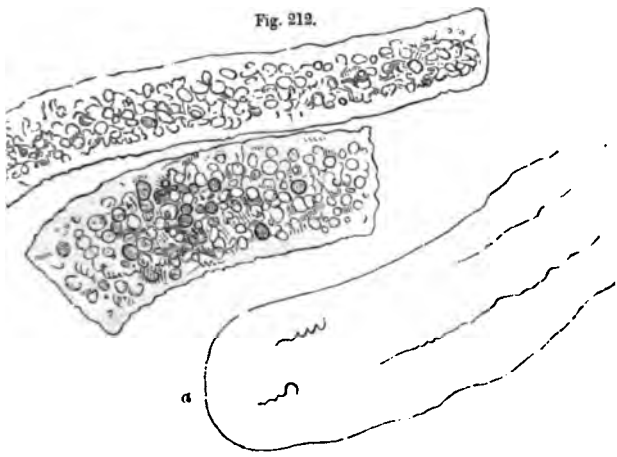


Fig. 213.

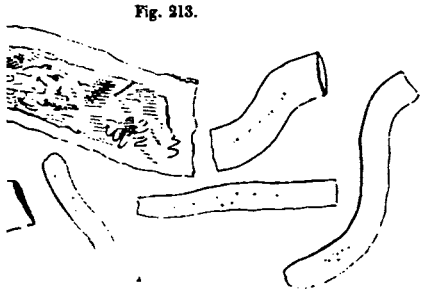


Fig. 214.



210.—Epithelial casts. *a*. Casts containing cells of epithelium. *b*. Casts containing matter. From urine of *acute dropsy*.
211.—Casts containing fat cells and oil globules, from a case of *fatty degeneration* ney.
212.—Large casts, some containing many cells, others consisting of a perfectly trans- ux-like material, characteristic of *desquamative nephritis*.
213.—*Waxy casts*. *a*. Of large size. *b*. Small waxy casts.
214.—Small granular casts from the urine of a patient suffering from *chronic nephritis*. figures × 215.

302.—III. Casts of Small Diameter, *about the* 1-1000*th of an inch.* These are the "small waxy casts" which, according to Dr. Johnson, 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. 214; 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, fig. 213*b*.

303. 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 cells consist usually of epithelial cells of the kidney, enlarged and gorged with oil, figs. 211, 215*a*. 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. Occasionally, cells containing oil globules may be derived from some other part of the mucous surface of the urinary passages. Fig. 216 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. 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.

304. Conditions in which Fatty Matter may be met with in Urine.—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., fig. 215*b*. When fatty matter occurs in this state only in urine, its presence is usually accidental. It may have dropped into the urine accidentally, or introduced in consequence of the secretion having 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 § 303.*

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 an exceedingly minute state of division. In a specimen of chylous urine, for which I have to thank my friend Mr. Cubitt, of Stroud, there existed nearly thirteen

Fig. 215.



a. Oil globules inclosed in cells. *b*. Free oil globules as they appear when oily matter has been accidentally mixed with urine, × 215.

Fig. 216.



Epithelial cells and oil globules from the membranous portion of the urethra, × 215.

Fig. 217.



Fatty matter in a molecular state as it occurs in chylous urine. Small granular cells are also present, × 215.

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 an extremely minute state of division, to which the term "molecular" has been applied, and in which state the fatty matter is found in chyle. Upon micro-

* The composition of the fat in these cases is very interesting. I have found it to contain 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 much cholesterine; and also from some organs in a state of fatty degeneration. See "Archives of Medicine," No. I., page 8; "Illustrations of Urinary Deposits," Plate XVI.

scopical examination, the field was seen to be covered with very minute molecules, like small dots, revolving with a slight wavering 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 fig. 217.*

In urine, therefore, in which we find distinct *oil globules* floating about, these may be derived from the presence of a little *oil* or *butter* which has accidentally fallen into the urine, or from 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 in some other situation;—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 included in this class often resemble each other very closely when examined only by the unaided eye; but they differ widely in their microscopical characters, in their behaviour with chemical reagents, and also in their pathological importance.†

305. Pus.—The microscopical characters of pus have been described in §§ 283, 284. 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. 218 shows the appearance of pus globules: at *a* some are shown, acted upon by acetic acid. If decomposition of the urea, accompanied with the development of carbonate of ammonia, occurs, the globules become converted into a glairy viscid mass, see "Mucus," § 293.

Fig. 218.



Pus corpuscles. *a*. Treated with acetic acid.

* The case is fully reported, with analyses of the urine, in No. I. of the "Archives of Medicine."

† The method of distinguishing these deposits from each other is described in "Tables for the Examination of Urine."

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 derived from the kidney, the crystals were altogether absent.*

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 supernatant urine contains a trace of albumen, which may be detected by the application of heat or upon the addition of nitric acid.

306. 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, fig. 219.

Some of the crystals are of a more quadrilateral form, while others appear almost like an octohedron, in consequence of the central part of the crystal not being developed. A crystal of this form is represented. 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.

Fig. 219.



Crystals of triple phosphate. Small globules of phosphate of lime, with vibriones, × 215.

* "Clinical Lecture," by Dr. Todd. "Medical Times and Gazette," No. 185.

302.—III. Casts of Small Diameter, *about the* 1-1000*th of an inch.* These are the "small waxy casts" which, according to Dr. Johnson, 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. 214; 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, fig. 213*b*.

303. 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 cells consist usually of epithelial cells of the kidney, enlarged and gorged with oil, figs. 211, 215*a*. 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. Occasionally, cells containing oil globules may be derived from some other part of the mucous surface of the urinary passages. Fig. 216 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. 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.

304. Conditions in which Fatty Matter may be met with in Urine.—1. Fatty matter may occur in the urine as distinct

CRYSTALS OF URIC ACID.

Fig. 223.



Fig. 224.



Fig. 225.



Fig. 226.



Fig. 223.—Common forms of uric acid crystals.

Fig. 224.—Small crystals of uric acid of a rhomboidal form; many of them resemble sect of small cylinders.

Fig. 225.—Less common forms of uric acid crystals. *a*. Crystal-like Cayenne pepper gra × 130. *b*. Six-sided crystals of uric acid. *c*. Mass, with small uric acid crystals projec from it. *d*. Small pyramidal crystals of uric acid, very uncommon. *e*. Peculiar forms of u acid.

Fig. 226.—Large halbert-shaped crystals of uric acid. *a*. Cayenne pepper grain, × 215.

Occasionally, the very dark granular appearance of certain casts is due to a deposition of urates upon their surface after the casts have been passed. In these cases the granular appearance is removed upon applying a gentle heat to the slide upon which the deposit is placed.

Third Class of Urinary Deposits.

308. 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 the subject of some beautiful investigations by Scherer.* In some instances, however, the uric acid is undoubtedly deposited 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 figs. 225 *a*, 226 *a*, the appearance of two of these crystalline masses is depicted. The crystals also vary 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.

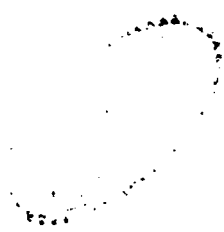
Fig. 227.



Uric acid crystals, formed by adding nitric acid to urine, × 215.

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 this form that this substance is deposited when any of its salts are decomposed by

* "Untersuchungen," 1843. Lehmann's "Chemistry;" translated by Day, Vol. ii., page 408.



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 octohedra, 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. 229, several of these appearances are represented; the crystal being the same in each case, but viewed in a different position. In the four lower figures the crystal is shown with one of its lateral angles towards the observer, and rotated upon its long axis. I have been able to observe all these different forms by causing the crystals to rotate 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.

Octohedra 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 ofter occur amongst deposits of pale lithates, which may obscure them from view. Upon the addition of a drop of potash, however, the lithate is dissolved, while the crystals of oxalate of lime are not affected, and can be distinguished readily upon microscopical examination.

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.

310. Dumb-bell Crystals.—*Dumb-bell Crystals of Oxalate*

of Lime. These crystals were also first described 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 may be composed of oxalurate of lime, for substances which crystallize in the octohedral form do not possess this property. The composition of these crystals is discussed in page 330.

A very perfect form of these dumb-bell crystals is represented in fig. 231; 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. 230); and not unfrequently crystals of an irregular form occur, one side being even and regular, while the opposite presents different characters. Dumb-bells will generally only be met with in urine for a few consecutive days, and they are almost always accompanied with octohedral crystals (fig. 230). 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 manner in which these crystals are formed is not known. Carbonate of lime found in the urine of the horse and other herbivorous animals is deposited in allied forms, and the earthy matter of shell, according to the observations of Mr. Rainey, takes a very similar form.*

By the prolonged action of acetic acid, I have found that the crystalline matter was dissolved, leaving a small quantity of organic matter, taking the precise form of the original crystal, and appearing like a cell wall (fig. 232).† A similar

* Mr. Rainey's paper contains many new and interesting observations bearing upon the deposition of crystalline material in the form of spherules or dumb-bells. "Medico-Chirurgical Review," Vol. xx., page 451.

† "Medical Times," 1851, page 374.

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. 233, some crystals of urate of potash (prepared artificially) are represented in this form, but 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 fig. 234 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. Dr. Bacon has added some interesting observations upon the composition of these

Fig. 235.



Crystals of triple phosphate, showing their form.

Fig. 236.



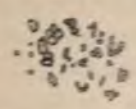
Rare form of triple phosphate, × 215.

crystals, which will be found in Dr. Golding Bird's work on "Urinary Deposits," to which the reader is referred for further information upon this subject. See also the observations upon oxalate of lime calculi, page 330.

Chemical Characters.—Dumb-bell crystals possess the same chemical characters as the octohedra of oxalate of lime. They are, however, dissolved by the prolonged action of acetic acid.

311. Triple Phosphate. — Besides the ordinary form of crystals of triple phosphate (figs. 219, 235), there are others which occur more rarely in small quantities. Fig. 236 represents some crystals of triple phosphate, of a beautiful form, not very frequently met with. This form is represented in Plate XXII. of "Illustrations of Urinary Deposits," figs. 1 to 6. The specimen from which the drawing was taken contained also many octohedral crystals of oxalate of lime. If a little ammonia be added to healthy urine, the ammoniaco-magnesian phosphate is precipitated in the form of beautiful stellate feathery crystals, "Illustrations," Plates IX., XXIII.

Fig. 237.



Unusual form of triple phosphate and phosphate of lime. From the urine of a gentleman suffering from indigestion in the very hot weather. The deposit was abundant and whitish. It contained no mere granules or well formed crystals. All the forms present in the deposit are represented in the drawing, × 215.

312. 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. Cystine is readily soluble in ammonia; and as the ammoniacal solution evaporates, the characteristic six-sided plates are formed. For the deposit from which the accompanying drawing (fig. 238) was taken, I am indebted to my friend Dr. Sankey, of the Hanwell Lunatic Asylum.*

Fig. 238.



Crystals of cystine, × 215.

Chemical Characters. — Deposits of cystine are readily distinguished from urates by being insoluble in the warm urine or in warm water. They are dissolved by ammonia, and 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.

313. Carbonate of Lime is very rarely met with in a crystalline form in human urine. Not unfrequently it occurs,

* An interesting case of cystine deposit, reported by Dr. Milner Barry, is given in No. II. of the "Archives of Medicine," with analyses of the urine.

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 found forming dense spherical stellar masses, composed of aggregations of minute acicular crystals (Dr. Golding Bird). Fig. 239 represents the appearance of carbonate of lime as it occurs in the urine of the horse, under the influence of reflected light; and in fig. 240 some crystals, viewed in Canada balsam, with transmitted light, are shown.

Fig. 239.



Crystals of carbonate of lime seen by reflected light.

Fig. 240.



Crystals of carbonate of lime in Canada balsam, seen by transmitted light, × 215.

The Chemical Characters of Carbonate of Lime are described in § 141.

314. 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 globules will be found of a brown colour, imparting to the supernatant fluid a smoky hue. When the urine has a decidedly smoky appearance, it will almost invariably be found that the blood is derived from the kidney, but in the majority of cases in which it retains its florid colour, it comes from 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.

Chemical Characters of Urine containing Blood.—Urine containing blood corpuscles must 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 evidently 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 search for evidence of the morbid change. (See section on "Casts of the Tubes.")

315. Large Organic Globules, Exudation Cells, &c.—Large cells filled with oil globules, which are met with in the urine in cases of fatty degeneration, have already been referred to in page 313. 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 in which no oil globules can be detected, in 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.

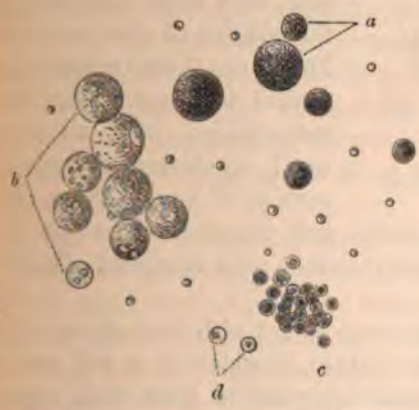
316. Spherical Cells containing Nuclei and Granular Matter.—Cells presenting these characters are not unfrequently met with in specimens of urine, but I have not been able to determine with accuracy the portion of the mucous tract from which they are derived, or their pathological importance.

The cells represented in fig. 241 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 fig. 242 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. Fig. 243 represents a curious form of cell found in the urine

Fig. 241.



Cells from the urine of a case of acute rheumatism. *a*. In the natural state. *b*. Treated with acetic acid. *c*. Cells resembling pus. *d*. The same treated with acetic acid. The small circular bodies are blood corpuscles, × 215.

Fig. 242.



Large cells filled with granular matter in the urine of a case of chronic bronchitis, × 215.

Fig. 243.



Cells found in the urine of a case of renal dropsy, × 215.

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 looked upon as some modification of bladder epithelium.

317. "Small Organic Globules." — Under this name Dr. Golding Bird has described some little bodies smaller than the pus or mucous 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.*

Fig. 244 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 octohedral crystals of oxalate of lime. From their highly refractive properties and chemical characters just referred to, it is probable that they were composed of oxalate of lime.

Fig. 244.



Small globules and octohedra of oxalate of lime, × 215.

There are other substances met with from time to time in urinary deposits, the nature of which it is not easy to determine. If the practitioner should meet with objects, the nature of which he cannot ascertain, he should at once make careful drawings (§§ 76, 77), and take notes of the case in which they occurred. He should make himself familiar with the appearances of all the extraneous substances likely to be met with, so that he may not be misled by these.

Urinary Calculi.

318. Formation of Calculi.—Although urinary calculi are not generally the subject of microscopical examination, or their characters discussed in works on the microscope, it is very important to remember that there was a time when the calculus was a microscopic object, when appropriate treatment would perhaps have expedited its removal before it had grown to a sufficient size to give rise to the least inconvenience. Urinary calculi are seldom if ever formed unless the urine has for a considerable period deposited a

* "Urinary Deposits," fifth edition, page 371.

sediment consisting of the material of which the calculus is made up, and containing numbers of minute calculi. If we had been able to detect at a sufficiently early period the *tendency* to the formation of these deposits, there is no doubt that in a vast number of cases we could have prevented the formation of a calculus. When there is an hereditary tendency to these disorders, there is little doubt that careful examination of the urine, especially in infants and children, would be of the greatest use practically, for if we found a deposit, means for preventing its formation would, at least in many cases, at once suggest themselves. The means employed of course vary according to the nature of the deposit, and acids, alkalies, and large quantities of fluids are used according to circumstances.

I have lately had my attention very forcibly directed to the formation of urinary calculi, in consequence of having met with specimens of perfectly formed, but microscopical calculi in urine. It is not at all uncommon to meet with microscopic uric acid calculi,—aggregations consisting of uric acid crystals, which, if retained, would necessarily receive deposits of fresh material on the outside, until small calculi, varying in size from a mustard seed to that of a pea or larger, which are so often expelled, are formed. If such calculi are not removed from the organism, they of course increase in size until too large to pass down the urethra.

Microscopical calculi of triple phosphate and phosphate of lime are by no means uncommon, but until lately I had never had an opportunity of watching the formation of calculi composed of oxalate of lime. Fig. 245 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 each other. 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 is developed, which clearly consists of a microscopic mulberry calculus, and if retained, will gradually increase in size. Two small calculi of this description are represented in figs. 2 and 3 of the plates containing specimens of calculi in "Illustrations of Urine, Urinary Deposits and Calculi." When such calculi reach the bladder, they doubtless sometimes increase gradually by the deposition of oxalate of lime upon their exterior. Such small bodies would easily become entangled in the mucous membrane of the bladder, and might remain in the pelvis of the kidney without exciting any disturbance until they had grown so large as to cause great inconvenience. The 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.

Fig. 245.



Collection of dumb-bell crystals firmly adherent to each other. Such a mass might very easily become converted into a small calculus by the deposition of material of similar constitution in the intervals, × 215.

Microscopic calculi, composed of phosphate of lime, and calculi from the prostrate gland are also represented in the same plate of the "Illustrations." The chemical examination of calculi is conducted in the same way as that of urinary deposits of corresponding composition. See also "Tables for the Examination of Urine."

On the Preservation of Urinary Deposits.

It is very desirable to be able 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 lithates may, however, be mounted as dry objects, but they of course exhibit different characters when examined in fluid.

319. 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 each other, 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.

320. 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 minute or two 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 fine-pointed wire, previously warmed. 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.*

321. Preservation of Urinary Deposits in Aqueous Solutions.—For the preservation of urinary deposits, the most important method is that of putting them up in some preservative fluid, for in this manner alone can the characteristic appearances 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 the two former methods are of great advantage in examining the structure of some crystals, they are ill adapted for preserving 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.

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 some cases diluted with a little water. 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

* "How to Work with the Microscope," page 65.
† Ibid, Lecture iv.

the creosote and naphtha solution most successfully for the preservation of casts and various kinds of epithelium, &c.

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.

322. Method of Separating the Deposit from the Urine, and placing it in the Preservative Fluid.—The most simple manner of mounting deposits by the use of 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. 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 be 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, lithic acid, oxalate of lime, lithates of soda and ammonia, and other substances, whose characteristic appearance is not altered by aqueous fluids. If lithic acid, oxalates, phosphates, or other crystals, are to be put up as objects for examination with polarized light, they should be mounted in balsam or turpentine.

323. 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 rapidly. 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.

On the subjects treated of in the present chapter, the following works may be consulted:—"Urinary Deposits," by Dr. Golding Bird, fifth edition, edited by Dr. Birkett. "Diseases of the Kidney," by Dr. Johnson. "Brightsche Nierenkrankheit," Braunschweig, 1851, by Dr. Frerichs. "Medical Chemistry," by J. E. Bowman. "Physiological Chemistry," Lehmann, translated by the Cavendish Society. "Traité de Chimie Anatomique et Physiologique," Robin and Verdeil. "Lehrbuch der Zoochemie," Heintz, Berlin, 1853. Schmidt, op. cit., chapter iii. "Tables for the Examination of Urine," and "Illustrations of Urine, Urinary Deposits, and Calculi," by Dr. Beale. Papers in the "Archives of Medicine," edited by Dr. Beale.

CHAPTER X.

OF MORBID GROWTHS. — *General Characters of Morbid Growths.*—MORBID GROWTHS WHICH RESEMBLE HEALTHY TISSUES IN MINUTE STRUCTURE.—*Fibrous Tumours.—Cartilaginous and Bony Growths.—Enchondroma. Myeloid.—Fatty Tumours.—Vascular Tumours.—Phlebolithes.* —MORBID GROWTHS HAVING A STRUCTURE DIFFERENT TO THAT OF HEALTHY TISSUES.—*Cystic Growths.—Colloid Tumours.—Cholesteatoma.—Recurring Fibroid Tumours. —Epithelial Growths. — Melanoid Tumours. — Fungus Hæmatodes.—Cancer.—Examination of Morbid Growths. —Preservation of Morbid Growths.*

I FEEL that to do even scanty justice to the subject of morbid growths, would occupy more space than can be allotted it in this work; at the same time, it cannot be entirely passed over.

I propose, therefore, to make a few remarks upon the nomenclature of morbid growths, and to refer to the most important microscopical characters of some of those which very frequently come under the observation of the practitioner, without attempting to give a detailed description of any. Upon this subject the reader should consult the works in the note.*

324. On Naming 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 possible to

* 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."

give a definite name to any morbid growth, but since the minute anatomy of these structures has been carefully investigated many of the received names were found inappropriate, and as fresh pecularities were discovered, attempts have been made to introduce new ones. Most of these names are highly objectionable on many grounds, and such terms as *encephaloid, colloid, myeloid, 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 arrange it in a distinct class which can only include growths agreeing exactly with each other in all important characters and vital endowments. 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 attempting to assign to it a name, such as, *scirrhus, fibrous sarcoma*, &c. This is especially important in the use of a word like *scirrhus* which has been the means of introducing much carelessness in the nomenclature of tumours. There can be no doubt that many tumours have been called *scirrhus* which were merely *fibrous* and vice versâ. As a consequence, confusion in the use of the terms *malignant* and *benignant* has resulted, and from this slovenly method of classification we can hardly anticipate any but the most erroneous conclusions from statistical inquiries applied to investigating the frequency of the occurrence of these growths, their association with other conditions and questions which can only be determined by researches of this nature. 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 exists, especially as the meaning of the term we use will, in all probability, be much altered in the course of a few years.

325. 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 rapid 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 extremely numerous, the morbid growth is found to possess a structure of a much more complicated 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; and 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.

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

Fig. 246.



Hypertrophied areolar tissue, showing coarse, white, fibrous tissue in great quantity, × 215.

Fig. 247.



Fibres of yellow elastic tissue, from the scrotum of a man, operated on by Mr. Fergusson. In this case the areolar tissue had undergone considerable hypertrophy, × 215.

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. Fig. 246 shows 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 Mr. Fergusson. Upon the addition of acetic acid to the preparation, the fibres of the yellow element, fig. 247, became very distinct. By a rapid and irregular development of epithelium in various parts, either of the cutaneous or mucous surface, which extends inwards, and gradually invades 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. From their general resemblance to true cancer, Dr. Bennett has grouped these growths under the term "*cancroid*."

The truly *cancerous* growths frequently commence deep in the substance of a tissue, and gradually make their way towards the surface: they arise from a peculiar condition of the system generally, which we know, in many instances, to be hereditary, and they often exist 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 an inherent power of multiplication, and there is reason to believe 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 of other tumours, which shall 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 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

ct to find a hard, condensed, and fibrous tumour; but e growth commences immediately beneath the surface he peritoneum, or in a like situation, where it will unter little resistance, a tumour of a very different cha- r will be produced. In the latter case, a soft, spongy ture will probably be formed, in which the cells bear a larger proportion to the fibrous element than in the r instance.

BOID GROWTHS WHICH RESEMBLE HEALTHY TISSUES IN MINUTE STRUCTURE.

26. Fibrous Tumours. — There are a vast number of id structures which may be said to be *fibrous*, which, ver, 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 cells may be detected, while others seem to be composed of fibres e. Much difference in structure is often observed in rent parts of the same tumour. In many cases this is e ascribed to age.

Fig. 248.



×215

ated fibrous tumour, from the tongue, × 215. *a*. Part the cells are very distinct. *d*. Fibres seen to be con- with the cells. *c*. Small lobule only containing a few nd showing the manner in which the tumour grows. 643.

Fibrous tumours may be connected with the skin, mucous ibrane, glands, muscle, nerve, bone, cartilage, and other ures. They may arise from the normal fibrous tissue ie part itself, or they may be developed in a new material sed into the original tissue of the part. Some are exceed-

ingly 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. 248 is an example of a rare form of fibrous tumour, in which the nuclei are 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.

The observer should examine the tumour in several parts. Sections may be made by Valentin's knife, an ordinary scalpel, or strong knife, according to the consistence of the tumour.

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 *fibrosarcomatous, fibrocystic sarcoma,* &c., and to give a simple description of what has been seen with drawings, whenever it is possible to make them.

Fig. 249.



Section of the thickened pylorus, showing bands of pale muscular fibres cut across, × 215.

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. Fig. 249 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.

327. Cartilaginous and Bony 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. When softening, which sometimes occurs, has taken place, the tumour much resembles soft cancer. According to Professor Bennett, the cells may be distinguished from cancer cells by the action of acetic acid, which produces a marked difference between the cell wall and nucleus of the cancer cell, but affects the entire cartilage cell alike. Enchondroma occurs in connection with various bones, and occasionally with fibrous textures not in the neighbourhood of bones, as for instance, in the testicle.

The characters of *enchondromatous* tumours have been described in § 189, and those of *myeloid* tumours in § 192, to which the reader is referred.

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* (page 173) generally originate in bone. 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.*

* "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.

Both cartilaginous and bony growths sometimes recur after removal, and become developed in various parts of the body like 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 in consequence of the original formation of a tumour connected with bone. I examined an interesting case of the occurrence of cartilaginous tumours in the lungs some time since. The original tumour was developed in the thigh, which was amputated by Mr. Fergusson. The tumours in the lung exactly resembled the original growth in structure.*

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.†

328. 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. 250 shows the structure of a large fatty tumour connected with the testicle, which was removed by Mr. Fergusson. This tumour was as large as the head, and was in part fibrous and partly fatty. 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. Some fatty tumours which contain a quantity of fibrous tissue as well as adipose vesicles, are termed *steatomatous*. Steatoma is also applied to encysted tumours originating in

Fig. 250.



Large fat vesicles, with crystals of margarine, from a large tumour connected with the testicle, removed by Mr. Fergusson, × 130.

* "Transactions of the Pathological Society," Vol. v., page 321, 1854.
† "How to Work with the Microscope," page 67.

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.

329. Vascular Tumours are those which consist principally of small vessels. Aneurisms by anastomosis are of this character. The tumour contains besides vessels a certain quantity of fibrous tissue. Many of these tumours consist principially 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.

The microscopical examination of aneurisms and tumours connected with the larger vessels is conducted in the same manner as the examination of the coats of the vessels in health.

330. 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.

MORBID GROWTHS, HAVING A STRUCTURE DIFFERING FROM THAT OF HEALTHY TISSUES.

331. 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 produced in several different ways.

1. If the duct of a gland be obstructed, the secretion accumulates behind the occluded point, the tube in consequence dilates 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 of the sebaceous, mammary, salivary, and other glands are formed, and in some cases the whole kidney has been converted into one large cyst from obstruction of the ureter.

In the same manner the uriniferous tubes give rise to the development of cysts 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 thus formed 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.*

* See "Archives of Medicine," No. I., page 33.

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.

The walls of these 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 character and number of the cells vary much.

The characters of the fluid found in many cystic growths is described in § 269.

332. 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 Mr. 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

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* 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.

333. 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

Fig. 251.



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.

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

* See § 169, page 146.

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 fig. 251, which was kindly sent me by Mr. Simon.*

As the reader may have inferred from what has been already said, there are no specific characters which will enable us to say in every case if a growth be *malignant* or *benignant;* neither are there any characters by which the so-called *true cancer cell* can with certainty be distinguished from every other kind of cell. There are many forms of bony, cartilaginous, and fibrous tumours which are developed in different parts of the body, and which return if extirpated. These may fairly be termed *cancerous* or *malignant.* There appears, indeed, to be a class of growths between the so-called benignant and malignant tumours,—or in other words, in examining the structure of tumours, one cannot fail to observe a gradual transition from the slow growing and harmless tumour containing scarcely any cells, to the rapidly increasing, and perhaps soft, spongy, malignant growth, consisting almost

* 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.

entirely of cells and vessels. The so-called *recurring fibroid tumour* and certain forms of *epithelial growths* are examples of this, and while they do not possess all the characters comprised in the term *malignant*, they cannot be looked upon as *benignant*.

334. Recurring Fibroid Tumours.—This term has been applied by Mr. Paget to a form of fibrous tumour which returns after extirpation. They are hard and firm, and consist of elongated cells and long fibres prolonged from small cells arranged in an arched manner. It is interesting to notice, that when removed, the new growths, according to Mr. Paget, exhibit a greater resemblance to truly cancerous tumours than the original growth.

Fig. 252.



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.

Fig. 252 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.

335. 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 Professor Paget.*

* See also Bennett "On Cancerous and Cancroid Growths." Lebert, "Traité pratique des Maladies Cancéreuses et des affections curable confondues avec le Cancer." Paget, "Lectures on Tumours," 1853. Walshe, "The Nature and Treatment of Cancer."

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 secretion of the epithelial cells of the cuticle; and the tubercles, which occur on the external generative 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 edges become indurated, and as the disease gradually advances, it proceeds from the surface, and invades deeper structures.

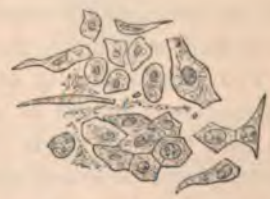
If a thin section of one of these growths be examined, interspaces will be observed (fig. 253), from the walls of which the cells appear to grow. The cells often seem to be arranged in laminæ; they do not vary so much in size and form as the cells of true cancer; the nuclei do not differ much in size; they rarely contain many nucleoli, and usually

Fig. 253.



Epithelial cancer, × 42.

Fig. 254.



Cells from an epithelial cancer, × 215.

adhere to each other by their margins, fig. 254; 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.

336. 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

colour. The colouring matter consists of minute granules or small masses, varying much in shape and size, which are often found within the cells in cases where the tumour is of a sarcomatous character. Many true cancerous tumours contain much pigment, and are said to be melanotic.

The lungs and bronchial tubes of colliers often contain a large quantity of black material introduced into the lungs during their work. In this condition the term *false melanosis* has been applied.

337. Fungus Haematodes is applied to any soft, highly vascular, bleeding, fungoid growth. Many tumours, which would have received another name at an early period of their growth, at length assume these characters, and would be spoken of as *fungus haematodes*. Some are composed principally of cells with large and various vessels, while in others the cellular element is almost entirely absent.

338. Cancer.—A cancerous growth may be described as consisting of a fibrous matrix, fig. 264, more or less abundant, and arranged so as to form areolæ, or interspaces, upon the walls of which the vessels ramify. These interspaces contain cells in considerable number, suspended in a more or less viscid fluid, with a finely granular matter.

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 true cancer. Neither the character 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 a microscopic examination, that we shall be enabled to 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 arise under notice from time to time in which the most careful and experienced observers may be unable, from a microscopical examination, to determine the nature of the tumour.

A 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. A section of a fatty tumour cannot often be distinguished from a section of ordinary adipose tissue: many fibrous tumours

Fig. 255.



Drawings from a case of cancer diffused through the entire liver. Sent by Mr. Robert Ceely, 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.

resemble ordinary fibrous tissue. Epithelial growths frequently appear to be made up entirely of cells, which cannot be distinguished from healthy epithelium. Again, there are certain large tumours of the mamma, which, in intimate structure, are found to be composed entirely of the ordinary gland tissue.

Cancerous tumours have been divided into three principal varieties by Dr. Walshe, determined by the relative quantities of the viscous juice, fibrous, or cellular elements present.

"If the fibrous element be in excess, it constitutes scirrhus, or hard cancer; if the cells be numerous, encephaloma, or soft cancer; and if the fluid abound, and be collected into loculi, or little cysts, it is called colloid cancer."—BENNETT.

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 (fig. 256).

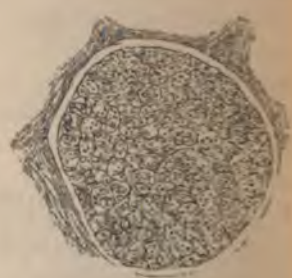
Upon examining a thin section made with a Valentin's knife, the relation of these structural elements to each other may be observed. The fibres will be seen to form meshes or interspaces, in which the cells and fluid are contained (fig. 256*a*). In some instances the fibres resemble those

Fig. 256.



From a cancerous tumour. *a*. Portions of fibrous matrix. *b*. Cells, many of them containing smaller ones in the interior, × 215.

Fig. 257.



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.

1000ths × 215.

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.

The cells vary much in size and form: they may be perfectly round, or prolonged at either end into delicate fibres, or of most irregular outline (figs. 256, 257).

They usually contain one nucleus, but very often two are met with, and not unfrequently many more may be observed. The nuclei of different cells often differ much in size. The nucleus generally contains several granules, and much granular matter exists between it and the cell wall. Cells are often observed which contain several smaller ones in their interior; these have, on this account, been termed "mother-cells" (*b*). 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. 257 is a beautiful example of a very young cancerous tumour, showing the manner in which the tumour grows by the multiplication of the cells.

The characters of the growth entirely depend upon the locality in which it grows, 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, and growing very rapidly, 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 which a milky juice is poured out from the cut surface, and which, upon microscopical examination, is found to consist principally of cells exhibiting the above general characters, 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, either upon the skin or a mucous membrane, or in the duct or follicles of a gland. The chief differences to be observed in the minute structure of these 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 often cohering by their edges, which generally form straight lines; three or four cells being frequently found united together.
Cells not connected together at their margins; their edges seldom forming straight lines.	
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.

339. Examination of Morbid Growths.—The fluid, if any exists on the free surface of the tumour, should be first separately 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 seen 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 about 200 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 granular matter, nuclei, &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 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 to take every opportunity of looking for very minute cancerous tumours. 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 entered in a note book kept for the purpose.

Sections of most tumours, provided they do not contain osseous deposit, are advantageously made with a Valentin's knife. In examining the cells it is better to wet them with a little serum or gum-water, for sometimes if water alone be employed, they become distended and burst.

Lastly, the influence of certain chemical reagents upon the sections and portions scraped from the cut surface 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.

340. Preservation of Morbid Growths.—It is exceedingly difficult to give directions upon the preservation of morbid growths. The structures will require different 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* preserves many delicate structures

* "How to Work with the Microscope," page 36.

very efficiently, but after some specimens have been immersed in it for a long time, a number of minute oil globules sometimes make their appearance. 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. Thin sections put up in cells do not usually keep perfectly well. I have been many times disappointed in consequence of excellent specimens of cancerous tumours which had retained their characters for four or five years at last becoming disintegrated.

CHAPTER XI.

ANIMAL AND VEGETABLE PARASITES. — *Examination of Entozoa.—Tape Worm.—Hydatids, Echinococci.—Trichina Spiralis.—Strongylus Gigas.*—EPIZOA.—*Entozoon Folliculorum or Demodex.*—EXAMINATION OF VEGETABLE PARASITIC STRUCTURES.—ALGÆ.—*Sarcina Ventriculi or Merismopædia Ventriculi.—Other Forms of Algæ.—Leptothrix Buccalis.*—FUNGI.—*Penicillium Glaucum.—Achorion Schœnleinii.—Tricophyton Tonsurans.—Apthæ, Muguet.—Fungus from External Meatus of the Ear.*

ANIMAL PARASITES.

UNDER this head, I shall only attempt to refer to the structure and mode of examination of a few of those parasites most frequently met with in the human body. There are many species which are only occasionally observed and which will not be alluded to here. For a complete account of the animal and vegetable parasites of the human body, I must refer the reader to the elaborate work of Küchenmeister, translated for the Sydenham Society by Dr. Lankester.

341. 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.

Entozoa may be mounted in preservative fluids, or dried and placed in balsam.

342. Tape Worm.—The common English tape worm (Tænia solium) 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 probably 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 head of the tape worm is not easily procured. It 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.*

The broad tape worm (*Bothriocephalus latus*) is seldom

* *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 were treated by the physicians of King's College Hospital, when I was house physician, 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 for the oil to be suspended in a large quantity of water. I have since obtained many entire worms in this manner.

met with in this country. It may be examined and preserved in the same manner as the common tape worm.

343. Hydatids, Echinococci.— Hydatids are not unfrequently met with 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 external surface is smooth, but the internal appears more transparent and granular. The granular appearance 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. The echinococci grow from all parts of the internal surface of the vesicle. Many soon become detached

Fig. 258.



Echinococci, × 42.

Fig. 259.



a *b* *c*

Echinococci. *a*. With the hooks extruded. *b*. With the neck and suckers withdrawn. *c*. Hooklets free, × 215.

from the wall of the cyst and die. New cysts are developed within the parent one, upon the inner surface of which echinococci are also found. The mode of production of these

daughter cysts has not been conclusively determined, but it is probable they are formed from the inner wall of the parent cyst.* Two species of echinococci have been described, *E. hominis* and *E. veterinorum*, but the former has been found in cattle and the latter in man.

Fig. 258 represents the appearance of echinococci magnified with an inch object-glass, and in fig. 259 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.

A thin section of the walls of the cyst shows a laminated appearance, and 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.

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 cysts. This fluid concentrated by evaporation is 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 to be treated with alcohol and repeatedly recrystallized.†

The character of the claws (fig. 259c) should be particularly noticed, as their presence is characteristic of echinococci.

Hydatids are occasionally expectorated; usually in con-

* See also a communication by Dr. Hyde Salter, in the fifth volume of the "Transactions of the Pathological Society," page 303.

† Holste, "Lehrbuch der Zoochemie," page 220.

sequence of the cyst in the liver opening into the base of one lung. The appearance of the cysts in the sputum will generally 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.

The echinococci may be preserved in the creosote solution, or in preservative gelatine. The hooks may be readily preserved moist in fluid, or dry in Canada balsam.

344. The Trichina Spiralis is a rare species of entozoon contained in small cysts, which are sometimes found in the voluntary muscles. It was first described by Owen in 1835, although it had been seen previously by other observers. The worm is found in the voluntary muscles. The trichina spiralis is to be regarded as the brood of the *tricocephalus dispar* engaged in migration. A beautiful specimen of the trichina was given me some time ago by my friend Dr. Saunders.

345. The Cysticercus Cellulosæ, like the Trichina, also infests the muscles. The ordinary habitat of this entozoon is the muscular tissue of the pig and *Tænia solium* is almost unknown when pig meat is avoided. Direct experiments by Küchenmeister have proved that in the human intestine, the cysticerci cellulosæ become converted in the course of eight and forty hours into small tœniæ solium. This cysticercus has been met with in several cases in the human eye, in the anterior chamber, in the vitreous, and beneath the retina, and in some instances it has migrated into the brain.

346. Other Entozoa.—The common *fluke* (*Distoma hepaticum*) forms a very interesting object for examination. One species may generally be met with in the bile-ducts of the ox and sheep. The small thread worms (*ascaris vermicularis*) are common in children, and are met with chiefly in the rectum. The *tricocephalus dispar* is met with in the cœcum and colon and is developed from a *trichina*. The *ascaris lumbricoides* or great round worm, is usually found in the small intestine.

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 membraneous 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.

Epizoa.

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*). The first is rather difficult to procure. 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; but this Acarus will only be found in a few instances. The male is much smaller than the female. 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 passed 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 per-

Fig. 260.



Entozoa folliculorum, from the external auditory meatus. *a*, *c*. Short variety. *b*. Long variety, × 215.

formance. 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 allowed to dry slowly on a glass slide, when it may be mounted in Canada balsam.*

347. The Entozoon Folliculorum is generally present in the follicles of the skin of the scalp, 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. 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.†

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.

Vegetable Parasitic Structures.

There are certain vegetable structures of a very low organization, 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, while others are met with in the recent fluid secretions, or become developed after the secretions have left the body. All these vegetable parasites belong to the class *Cryptogamia*, and to the orders *Algæ* and *Fungi*. A few of the most important species will be briefly referred to.

Algæ.

348. Sarcina Ventriculi‡ or Merismopœdia Ventriculi. — This alga was originally discovered by Goodsir, in 1842,

* "Küchenmeister's Manual," Sydenham Society, page 25.

† Todd and Bowman's "Physiology," Vol. i., page 425.

‡ M. Robin has arranged it under the genus Merismopœdia (Meyen), and he calls it Merismopœdia ventriculi.

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 (fig. 261).

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 tendency to fermentation.

Fig. 261.



Vomit containing sarcinæ. *a*. Sarcinæ ventriculi. *b*. Starch granules partially dissolved and rendered transparent. *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.

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.* 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.

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.

Various plans of treatment have been employed to prevent the development of this *alga*, 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.

* For the opportunity of observing the sarcina in one of these cases, I have to thank my friend Mr. Brown, of Lichfield.

Cases of this disease, with remarks, will be found in the clinical lectures of Dr. Todd and Dr. Budd.*

In all the cases 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 with a great number of oval torulæ, which vary considerably in size and form in different cases (fig. 261 *c*). 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.

349. Other Forms of Algæ are found in different situations; for instance, in the cavity of the mouth, especially towards the back, 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 (*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

Fig. 262.



Leptothrix buccalis, from the back of the tongue and tartar of the teeth, × 403.

* "Medical Times and Gazette," May 2nd, 1851.

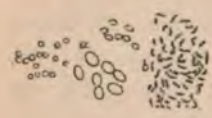
very long filaments, consisting almost entirely of this alga (fig. 262); it is very abundant between the teeth, and the so-called tartar is partly composed of it.

The vibriones, met with in urine and other fluids (§ 294), are doubtless very closely allied to this growth.

Similar vegetable growths 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.†

Many of these algæ require for their examination very high powers, and it is necessary to place a very small portion under the thin glass. Glycerine is a very favourable medium for examining them in. The glass cover should be as thin

Fig. 263.



Vegetable organisms met with in urine. *a*. Different forms of fungi. *b*. Vibriones, × 215.

Fig. 264.



Penicillium glaucum, from acid urine, × 215.



Penicillium glaucum, × 215.

as possible, for often their characters are not very clearly made out unless a twelfth or sixteenth object-glass be employed. Sarcinæ may 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 very thin stratum for examination.

* Quoted in Küchenmeister's "Animal and Vegetable Parasites," translated for the Sydenham Society, by Dr. Lankester, Vol. ii., page 135.

† "Transactions of Microscopical Society," Vol. i., page 92, old series.

To examine the 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.

Fungi.

350. Penicillium Glaucum.—Figs. 263, 264 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.

The characters of this and the sugar fungus have already been referred to in the chapter on "Urine."

351. The Achorion Schœnleinii usually appears as elongated vesicles, of a more or less oval form (fig. 265*a*), 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. 265), and may be found in abundance in the little honeycomb-like masses, termed favus crusts.

Fig. 265.



Achorion Schœnleinii, after Robin. a. Mycelium. b. Receptacle, containing spores.

The *favus* consists of a little cavity filled with spores of the fungus, granules, and epithelial cells (fig. 268). 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

Fig. 266. Fig. 267.



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.

Fig. 266.—*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. 267.—Fungi from the same specimen, × 403.

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.

There are several other species of fungi infesting the hair.

352. Tricophyton Tonsurans.—This fungus is found in the form 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.

Other species are found in the epithelium of the skin. That condition of the skin termed *Pityriasis versicolor* depends upon the epithelial cells in the coloured situations being infested with spores of another of these minute fungi. Cases have occurred in which a previously healthy individual has been infected with the disease, after having slept with a patient suffering from this affection.

Parasitic plants are met with in the following skin diseases :—

1. Tinea tondens.
2. Tinea favosa.
3. Mentagra.
4. Pityriasis versicolor.
5. Porrigo decalvans.
6. Plica polonica.

353. 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

Fig. 268.



Portion of a favus crust with achorion Schœnleinii. *a*. Mycelium. *b*. Receptacle. *c*. Spores.

Fig. 269.



Oidium albicans, after Robin.*

membrane, which is sometimes formed 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

* "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.

of *aphtaphyte* and *cryptogames du muguet*. It is placed under the genus Oidium, and termed *Oidium albicans* by Robin. The appearance of this fungus is shown in figs. 269, 270. This fungus is also found in vomited matters.

354. Diptherite 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. Other authorities are of opinion that where the fungus is found, its presence in the false membrane is explained by supposing that this is a nidus very favourable to its develop-

Fig. 270.



Fungi in various stages of growth, with epithelium of the mouth, expectorated by a patient in the last stage of phthisis, × 215.

ment. In those cases of diptherite which came under my notice, there was no vegetable growth in the viscid matter removed from the fauces.* The microscopical characters of the false membrane are described in page 279.

355. Fungus found in the External Meatus of the Ear. Aspergillus?—The vegetable growth represented in fig. 271 was removed by Mr. Grove from the external meatus of a gentleman in good health, who had been suffering from

* 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.

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.‡

356. 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.

Fig. 271.



Fungi from the external ear. Aspergillus? × 215.

Meissner describes a fungus which he found amongst the cells of the nails of an octogenarian. The nail was rendered transparent by caustic soda. It was permeated in every part by the fungus.

The examination of these vegetable growths in the microscope presents no difficulty; but without care they may

* 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.

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 be 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 500 to 600 is required. Many of them may be preserved in glycerine.

On the subjects discussed in chapter xi., the following works may be consulted:—

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, "Récherches sur la Nature et 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 "Manual of Animal and Vegetable Parasites," translated for the Sydenham Society, by Dr. Lankester.

APPENDIX.

161a. 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. 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 (Cloetta†). Frerichs and Städeler have detected leucine in the blood, urine, and bile of patients suffering from typhus, small pox, and other exanthemata. 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 patients who have died of jaundice. Frerichs has given several figures of leucine crystals in the liver and also in the urine.§

No satisfactory tests for leucine are yet known. If it can be obtained pretty pure by repeated recrystallization, the

* These sections should have followed § 161, but were inadvertently omitted.

† "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.

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 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, 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.

161b. Tyrosine crystallizes in long white needles, and is hardly soluble in cold water. It is readily dissolved by alcohol, ether, boiling water, the mineral acids, and alkalies. According to Hoffmann, if nitrate of protoxide of mercury be added to tyrosine, a reddish precipitate is produced, and the supernatant fluid is of a very dark rose colour. This test indicates the presence of mere traces of tyrosine.

Tyrosine is probably formed in the liver with leucine.

It has been detected in many of the animal fluids, and has been found in the urine by Frerichs.

Tyrosine may be prepared 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.

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ERRATUM.

Page 39, for "Plates I. and II. are examples" *read* "The frontispiece is an example," &c.

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