Plate II _ ADULTERATIONS OF FOOD, &c

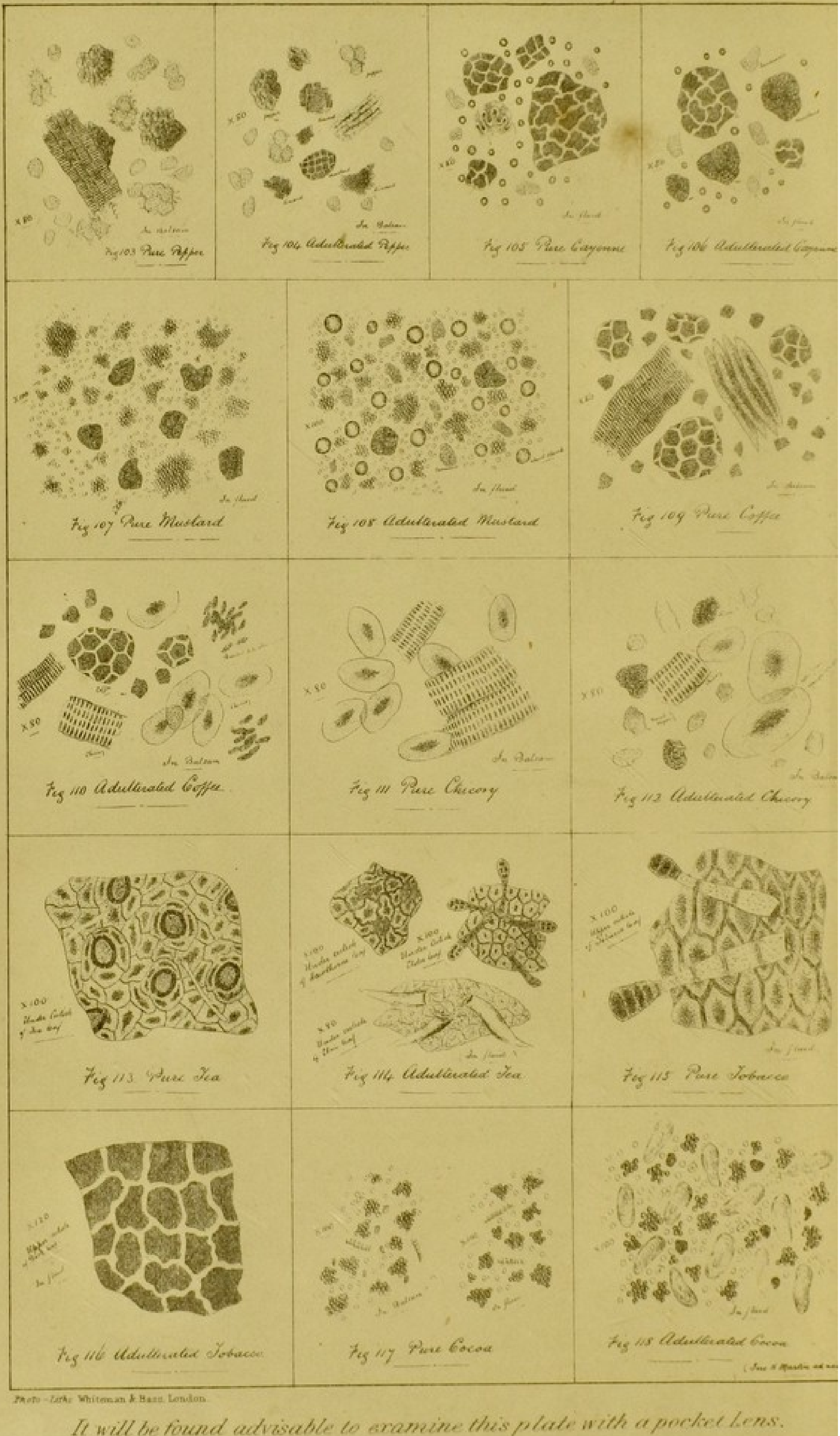

Photo-Litho Whiteman & Bass, London.

It will be found advisable to examine this plate with a pocket Lens.

A MANUAL

OF

MICROSCOPIC MOUNTING

WITH NOTES ON THE

COLLECTION AND EXAMINATION OF OBJECTS

BY

JOHN H. MARTIN,

AUTHOR OF MICROSCOPIC OBJECTS, ETC.

ILLUSTRATIONS DRAWN BY THE AUTHOR.

LONDON:

J. AND A. CHURCHILL, NEW BURLINGTON STREET.

1872.

Dedication.

TO

DR. LIONEL S. BEALE, M.B., F.R.S., ETC.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS,

PHYSICIAN TO KING'S COLLEGE HOSPITAL,

FELLOW OF THE MEDICAL SOCIETY OF SWEDEN, ETC., ETC.

PREFACE.

This work is intended for the use of students and lovers of the science of Microscopy. I desire to draw the attention of my readers to the value of original and practical work; for if any one subject, however small, is made by concentrated attention to bear fruit to the worker, it will be found to contain much that is new to the science. In microscopic mounting the student must not be discouraged at the failure of his first attempts, but gradually try to acquire a knowledge of the principles, with the manual dexterity necessary in their application. The aim of this work is to supply the student with a concise manual of the former, and to assist his progress in the latter, as far as illustrations and words render it possible.

The majority of the drawings have been done by me, most of which are original. My thanks are due to Dr. Lionel Beale, for the loan of Figs. 15, 61, 64, &c.; and also to Drs. Smyth, Matthews, Bloxam, and Rev. W. Law; also Messrs. Jordan, Hardwicke, Cotton and Johnson, Collins, Wheeler, &c.; and to Messrs. Pardon and Son, printers, Messrs. Butterworth and Heath, Miss Powell, and others, for their faithful rendering in the engravings my ideas as drawn on the wood, &c.

JOHN H. MARTIN.

WEEK STREET, MAIDSTONE.
August, 1872.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

APPENDIX.

A MANUAL OF MICROSCOPIC MOUNTING.

CHAPTER I.

APPARATUS NECESSARY FOR MICROSCOPICAL RESEARCH.

1. In a work like this, which will chiefly treat of various methods of mounting, a description of different microscopes, &c., would be foreign to the subject. I therefore leave this by remarking that good working microscopes can now be purchased for about £5 each, many of which contain apparatus sufficient for the use of a beginner.

The apparatus to which I wish to draw the attention of the reader chiefly consists of the section cutter, turn-table, holding screw, apparatus for drying, dissecting, bleaching, &c., most of which are necessary to the student in conducting branches of microscopical study. Works have been published including forms of apparatus, but with the exception of Dr. Lionel Beale's works, not many have been published of late years. Some of the forms of apparatus have been kindly lent, others—which are chiefly original—have been used by the author in his own private study. Drawings have also been added to the descriptions of

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these various forms of apparatus, so as to make them as useful as possible. The larger apparatus will be explained first, and the smaller and miscellaneous articles afterwards.

2. Section cutter, turntable (Matthews's), holding screw, apparatus for drying, dissecting, bleaching, &c. The student must also add, buy, or make, as convenient to him, the following articles:—An air-pump; propagating or bee glasses, three or four; the cup parts of broken wine glasses—the bottoms may also be used as covers; dipping tubes—made by holding glass tubes in a gas jet until soft, and then drawing out to a fine point; test tubes—each of these may have a small dipping tube placed in the cork, so as to reach to the bottom; forceps, one or two; camel's and hog's hair pencils, various sizes; scalpels, two or more; razor mounted in wooden handle; scissors, two pairs—one fine pointed, one common; pneumatic trough, or a large globe or dish for holding waste water, in which to wash slides, test tubes, &c., or use the bottom of the dissecting slab (Fig. 23); needles, three or four sizes, mounted in small cedar handles (see Fig. 14); one large ditto, ground down to a cutting edge (like a chisel), for separating and cutting minute fibres, &c.; twelve collapsible tubes, for Canada balsam, &c.; twelve glass slips with hollowed centres, for use in analysis; a fine thread of spun glass, fixed in a handle, used for isolating minute objects, such as diatoms, &c.; spirit lamp; two hot plates, thick brass, 6 inches by 2 inches, and 7 inches by 7 inches; tripods (two or three), or a retort stand; American paper clips (these can be obtained at most stationers); Liebig's extract of meat jars, more especially the very small ones; small white

porcelain cups (can be obtained of any artists' colourman); watch glasses; wash bottle; platinum wire; spoon and foil; conical glasses, four or five; eight to twelve small bottles, with capillary orifices to hold reagents; glass or porcelain funnel and stirring rods; small homœopathic bottles, any quantity; writing diamond; fine saw, mounted in wooden handle; hones, used for grinding, &c.; small tools, made of corundum (of Mr. Lyon, 43, St. John's Square, London, E.C.); crucibles, a few small ones; files; punches, two or three; small soldering rod; hammer and wooden block for punching, the under side of which is to be covered with india rubber, to deaden noise; pliers, two pairs, one of them cutting; old knives; Pumphrey's ebonite cells and zoophyte clips; glass slips, 3×1 inch, half gross at least; thin glass—1 oz. circles, 1 oz. squares, various sizes, as sold; wire; pill boxes; small pins; cardboard, &c. &c.

The following chemicals, &c., will also be wanted:—Solution of gum Arabic in bottle, with a brush in the stopper of the same; glass bottle, with a glass tube in the stopper, filled with Canada balsam, or the same in collapsible tube; distilled water (with a lump of camphor in it, to prevent any confervoid growth, &c.) in a large stoppered bottle; caustic potass (KHo), strength (by weight), one part potass to eight parts water, in one pint bottle; distilled Canada balsam; gum dammar in tube (see recipe); turpentine; glycerine; benzole; alcohol (pure), and also methylated spirit; essential oil of lemon; syrup; chloride of calcium; lime water; silicate of potass; sulphuric acid (stoppered bottle, labelled Poison); hydrochloric acid (stoppered bottle, labelled Poison); acetic acid;

marine glue; caoutchouc cement (see recipe 5); Berlin black (a varnish); gold size; gutta percha; Bell's cement, &c. Also the following reagents:—Ether; acetic acid; nitric acid; sulphuric acid; hydrochloric acid; ammonia; solution of potass; solution of soda;

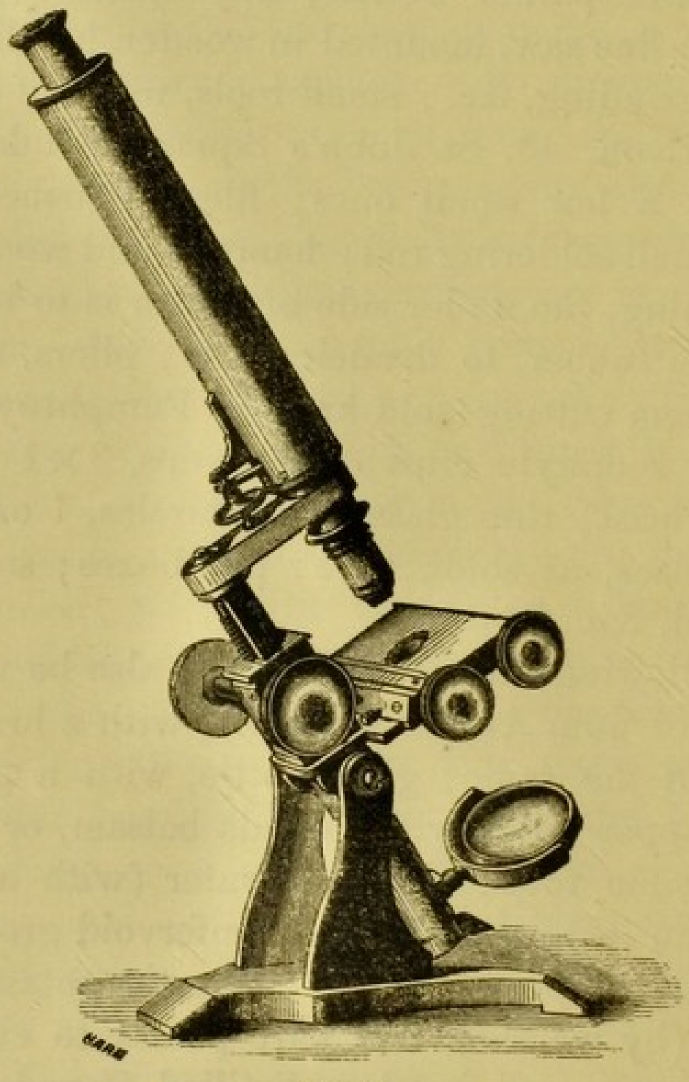


FIG. 1.

oxalate of ammonia; iodine solution; nitrate of silver; nitrate of barium; alcohol; chromic acid; test paper, &c.; and it is also advisable to keep a saturated solution of most of the common salts, such as chloride of zinc, &c.

3. *Section Cutter.*—This may be bought at most of the leading opticians, instrument makers, &c., the chief things to notice being that the holding screw is strong, and that it also has guides along which the knife or razor slides; but it is hardly necessary to buy one of these instruments, as they may be made by the student himself at a small cost. A sketch of a simple one that will do its work is here given:—Take a piece of box-wood, or any other hard wood, plane it smooth and to the size—3 inches by 4 inches—then with a centre-bit

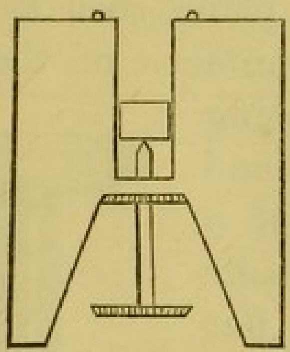


fig 2.

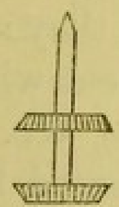


fig 3.

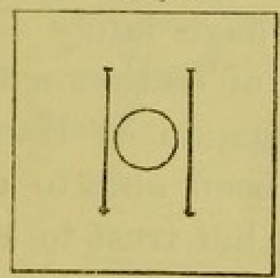


fig 4.

bore a hole exactly 2 inches deep in the centre of one of the smallest sides; on the opposite side also make a hole $1\frac{1}{2}$ inches deep, the diameter being at first 2 inches and terminating at 1 inch (see Fig. 2), then bore a small hole in the centre, so as to connect both holes. Obtain one of Perry's music fasteners, Fig. 3, which fix with marine glue to the under side, but allowing the screw to pass through; then cut a circular piece of wood exactly the size of the tube, and a common screw may be passed through each side of the section cutter, so as to act as holding screws; and on each side of this hole place two strong wire guides, to support the knife or razor in cutting the sections required (see Fig. 4, which represents the top view); the wood, or any other substance requiring to be cut, must then be placed in the tube, the guard piece having been previously put in; the screw must then be slightly turned to force the substance just above the guides (see Chapter ii.), then, with a knife, razor, or chisel, a section of any thickness may be cut, according to the turning of the bottom screw (see Fig. 2). If many sections are to be cut, they may be embedded in a block of deal, and sections cut with an iron plane, such as are used by carpenters, &c. The advantages of the section cutter represented here are—being easily made, light, portable, and cheap. I have lately heard of a new kind of section cutter, made by a gentleman at Hastings, but have not been able to obtain one at present, but trust to do so soon. Another form of section cutter in general use, and to be obtained of most opticians, is Fig. 4 A. It will be seen from the drawing that the instrument is very compact and useful.

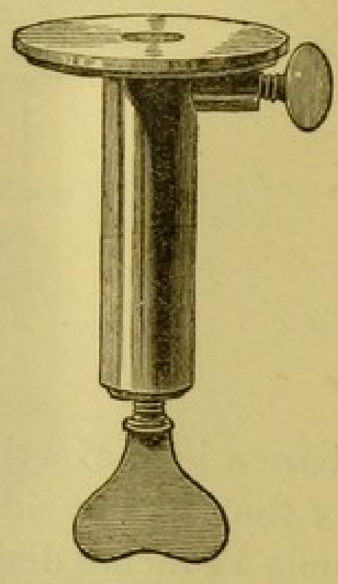


Fig. 4 A.

4. The best turntable that can be obtained, and which has nearly entirely superseded the one formerly devised by Mr. Shadbolt, is simple in the extreme (see Fig. 5). "It consists of two jaws of the average thickness of a glass slide, $\frac{3}{8}$ths of an inch wide, $2\frac{1}{2}$ inches long. Each of these is pivoted on the face of the turntable by a screw through its centre,

each screw being placed exactly equidistant from the centre of the turntable, so that the jaws are separated by a space as wide as an average slide, *i.e.*, a full inch. Outside of that space, on one side of the centre of one of the jaws, is a wedge, fixed by a screw in such a way as to be capable of motion in the direction of its length by a slotted hole. This is all the machinery:

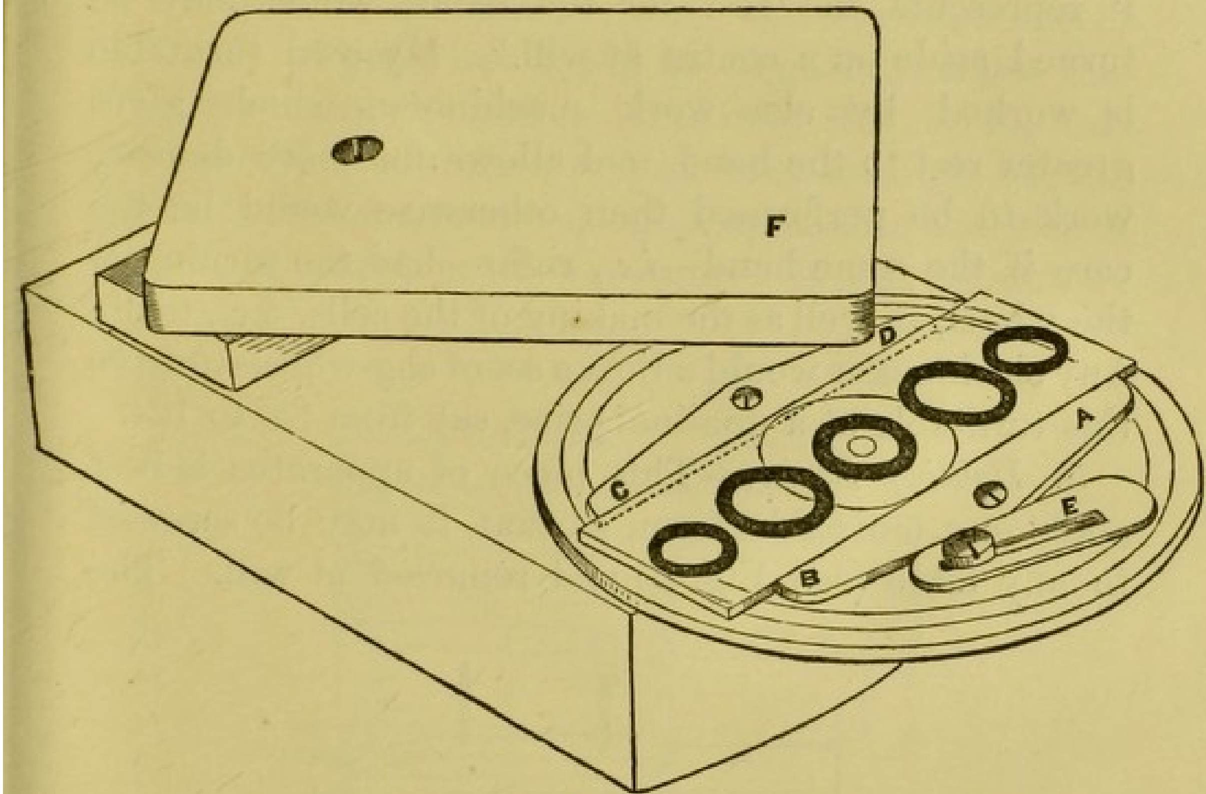


Fig. 5.

A B and C D are the two jaws, E is the wedge. On placing a slip between the jaws, they probably at first do not touch it. If the wedge be then pushed so as to approximate B to C, the jaws move on their centres, so that, however far B may be pushed towards (and moving) C, the other end of C, *i.e.* D, is moved exactly as much in the opposite direction until they approach near enough to grasp the slide by its edges. The length of the wedge must, of course, be such as to provide for about one-eighth of an inch variation in the width of slides. It will readily be seen that the slip may be pushed in either direction eccentrically lengthwise, so as to allow of the formation of any number of cells (see Fig. 5), all of which must needs be central as regards their width, if the instrument has been accurately made, which is a very easy matter. F represents the rest for the hand, which may be turned aside on a centre at will." My own turntable is worked by clockwork machinery, which gives greater rest to the hand, and allows for more delicate work to be performed than otherwise would be the case if the same hand—*i.e.*, right—had the turning of the wheel, as well as the making of the cells, &c., to do. Any clockmaker would adjust a set of cog-wheels to drive this turntable at a nominal price, say from 8s. to 12s.

5. *Holding Screw.*—This piece of apparatus is best made in a moveable form, so that it may be screwed to any table (see Fig. 6) and removed at will. The

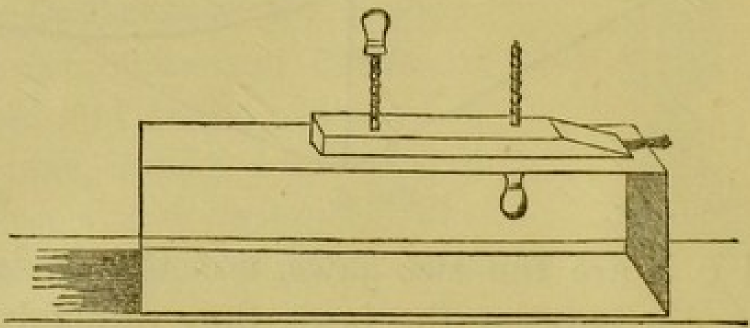


fig. 6.

figure explains its use without much further explanation. It is used for holding pieces of bone, shell, wood, glass, &c., whilst sections are cut with the fine saw; also for holding the glass slip whilst these sections of bone, &c., are being ground thinner by the file. It may be considered as an indispensable instrument to the microscopist.

6. *Apparatus for drying Slides* (see Figs. 7, 8). A great difficulty is often found in drying objects that have been mounted in balsam or dammar; for even if the balsam is good it takes a long time to dry properly, and the various plans that have been devised to remedy this often fail in some point or other; for instance, if the slides are placed on a tray and left in an oven, when the fire is nearly out, to dry, succeeds as far as it goes, but it will be found in practice that they are often forgotten, and the fire is lit, and perhaps valuable slides lost from over-baking; but this difficulty is overcome by using an apparatus like Fig. 8. Fig. 7 is a section of the same. It will be seen by

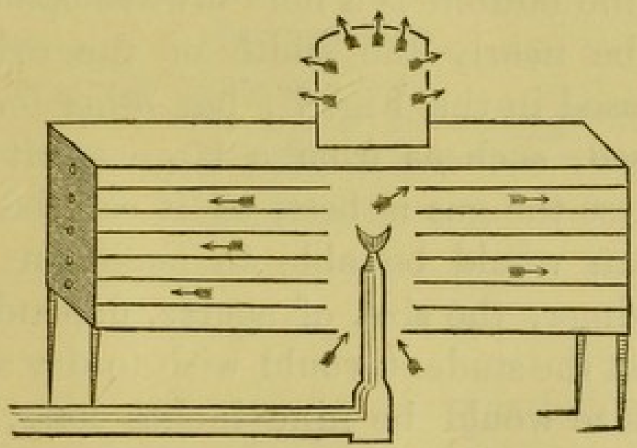


fig 7.

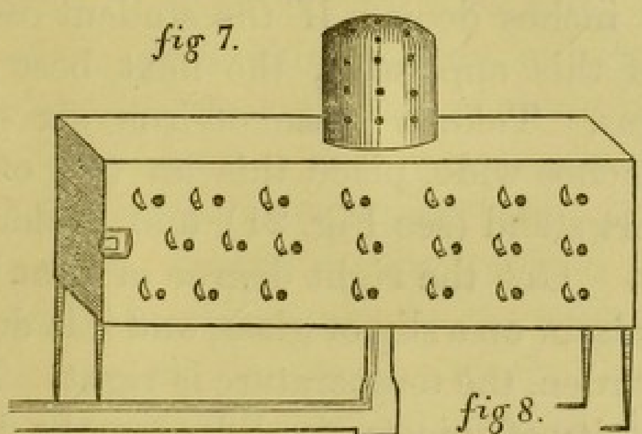


fig 8.

this plan that the temperature can be entirely regulated at will. The apparatus consists of a tin oven open nearly from end to end in the centre, and having a chimney with outlets for the hot air (see the direction of the arrows in Fig. 7); on each side of this open centre are ranged a series of shelves made of tin; but for some delicate preparations a few shelves might be of wood, as it is a bad conductor of heat. These shelves, of course, can be taken in and out and run on ledges prepared for them. Again, in the door and the sides of the oven are a number of air-holes, which can be covered with their accompanying flaps when it is desired to increase or lessen the temperature. The oven may be made without these side holes if desired, but it will be found better to have them. The oven stands on four legs, and in the centre of the bottom is a hole always open; this hole ought to be nearly the width of the oven. A gas branch is used in the Fig. 7; but other forms of heat can be used, such as from a large spirit-lamp, &c.; but of course the gas is best, as it can be regulated. Any tinman would be able to make an oven from these drawings; the size, of course, depends upon the number that the student would wish to dry at one time. A useful size would be nine inches long, six inches wide, four inches deep. If the student cannot afford the cost of this apparatus, the next best plan is to dry over gas. Take a piece of iron six inches long by three inches wide, place this on one of the rings of the retort stand (see Fig. 21), and under this bring the gas jet. Get the right degree of heat by placing a drop of balsam on a slip of glass, and if it does not boil but only harden, the temperature is right. For drying off the majority of objects, six slides may be dried on the plate at one time, occasionally changing their position. After drying they may be finished as described in chap. iii.

7. *Cell for the examination of Insects, Animalculæ, &c.*—This form of cell (Figs. 9, 10) will allow for the investigation of nearly every form of minute life. It may also be used for the formation of crystals under the microscope (see Fig. 9); but its chief use will be for observing the action of the various gases on

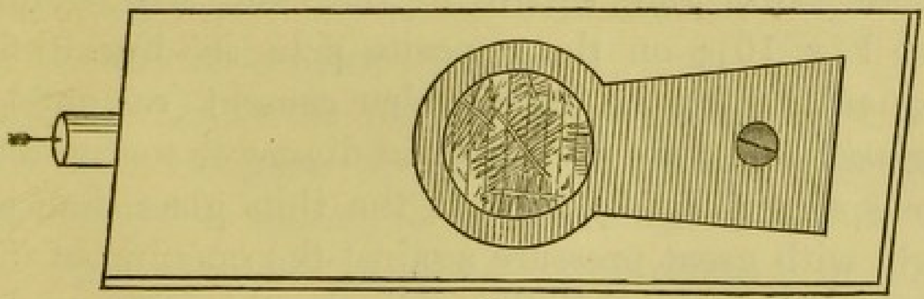


fig 9.

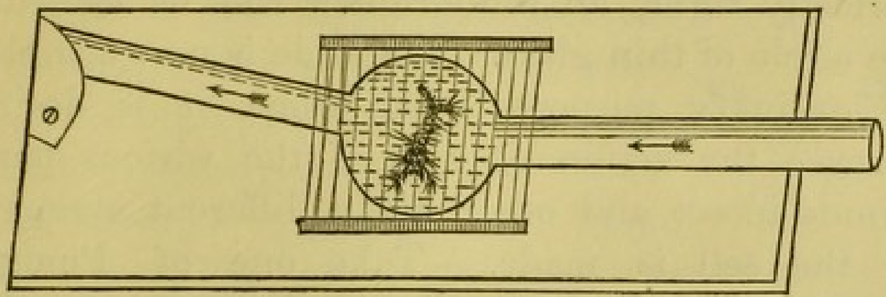


fig 10.

organic life. The cell may be made as follows:—Cut a piece of ebony or boxwood 3 inches long, $1\frac{1}{4}$ inches wide, $\frac{3}{8}$ths of an inch thick; bore a hole $\frac{7}{8}$ths of an inch in diameter through the centre of this slip with a centre-bit; make a furrow or groove on each side of this hole to receive two pieces of glass tubing $\frac{1}{8}$th of an inch in diameter, the orifices of which shall meet exactly in the centre of the hole (see Fig. 10); with the cement (see recipe 6) fix the tubes in this position; smooth all the edges whilst the cement is warm, especially where it surrounds the orifices of the tubes leading into the large central hole; then cut from a glass tube $\frac{7}{8}$ths of an inch outside diameter, two pieces $\frac{1}{8}$th of an inch thick; cement these into the hole, one on each side of the slip, so that their edges may come flush with the surface of the wooden slip; on the upper side of the wooden slip, and on each side of the hole, fix two runners with a bevelled inner edge to allow for a thin glass square of the exact size to slide in (see Fig. 10); on the opposite side (see Fig. 9) fix permanently with the india-rubber cement (recipe 5) a thin glass circle $\frac{7}{8}$ths of an inch in diameter to the steel clip or spring (Fig. 9), so that the thin glass shall be brought with great pressure against the opening of the hole; and to allow of the cell on this side to be perfectly tight, an india-rubber ring is cemented to the circle of thin glass. The slide is now complete for all ordinary purposes; but when it is desired to observe the action of any of the various gases on minute insect and other life, a different arrangement of the cell is made. Take one of Pumphrey's ebonite cells, $\frac{13}{16}$ths of an inch in diameter, and slightly over $\frac{1}{16}$th in thickness; rough the surface of this with a file. Take another smaller cell, $\frac{5}{8}$ths of an inch in diameter, and little over $\frac{1}{16}$th in thickness; cement this to the larger cell with the india-rubber cement, so that it may be exactly in the centre of the other; then over the smallest hole, which is in the smallest cell, cement with the same cement a thin glass cover half an inch in diameter (see Fig. 10, *a*); when thoroughly dry, fill in the groove with the electrical cement (recipe 6), and file the cell down into a truncated cone shape (see Fig. 10, *c*). Make two of these cells, and when it is desired to make an observation on any animalculæ, a small drop containing them is placed on the inner side of one cell, and whilst kept in a horizontal position on a table the wooden slip (Fig. 9) is brought down on it. The spring containing the thin glass circle being previously unscrewed and taken off, the cell being of a wedge shape, will no doubt fit tightly; if it does not, it must be cemented into this position with the aid of electrical cement (recipe 6); the other cell must be placed in the other hole and the glass brought down upon the drop of water, so as to retain it between the thin glasses by the aid of capillary attraction. If these cells are found to be of too large diameter to allow of their being brought sufficiently near to each other, the diameter of each truncated cone-shaped cell (Fig. 10, *c*) must be reduced by filing; they may then be brought as near together as desired; but of course this depends upon the diameters of the cells. When it is desirable to observe larger objects than these cells will allow of, the orifices of the tubes leading into the large cell must be closed with cork, or what is still better, a round stick of cedar wood run into the tubes from the outside; these may also be used for cleaning the tubes. But if it is desired to keep the object alive in water for some hours, a fine wire netting or mesh must be kept over the orifices of the tubes leading into the cell; a constant stream of water may then be directed through the cell, beginning at the tube on the right hand of Fig. 10 (see the direction of the arrows and flowing out at the opposite tube.) India-

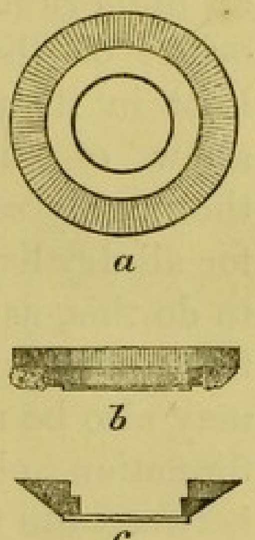


fig. 10.

rubber tubing is used to connect this cell either with the reservoir of water on the shelf (see Fig. 24), or with the gas holder (see Fig. 17). Gas may be passed through the cell exactly in the same way as water; but if the living object is contained in water, an india-rubber stopper must be placed over the outer orifice of the left-hand tube (see Fig. 10), which is kept in its place by a screw flap. This is done to allow of the water contained in the cell to be thoroughly saturated with the gas under pressure; but for all dry living specimens it is generally unnecessary to do this, as the gas may be passed through the cell freely flowing out at the other tube. Some crystals may also be made in this cell, and the process of their formation observed under the microscope. Place between the two truncated cone-shaped cells a drop of hydrochloric acid (HCl); open the outer orifice of the left-hand tube by removing the india-rubber stopper; then connect the other tube with a retort containing ammonic chloride (NH_4Cl) and quicklime (CaO); place this retort in a retort stand (see Fig. 28), and subject it to a moderate heat over a spirit-lamp or a gas-jet, when the ammonia gas is given off freely. In using this and all other gases, with the exception of oxygen and hydrogen, let the waste tube, which is fixed on to the left-hand glass tube (Fig. 10), be conducted, if possible, into the outer air through a small hole in the window of the room. As the ammonia passes through the cell it mixes with, and has an affinity for, the hydrochloric acid which is in the cell, and gradually crystals of ammonic chloride (NH_4Cl) are formed. The process of their formation is of an exceedingly interesting character, they having been formed from the union of gases—ammonia, chlorine, and hydrogen—the molecules of which are of course invisible.

8. *Bleaching Apparatus* (Fig. 11).—This piece of apparatus does not require much description. It consists of a chemist's gas cylinder, 16 inches high, $2\frac{1}{2}$ inches in diameter; this is open at the top; nearly at the bottom a hole is drilled to receive a piece of glass tubing (Fig. 11); a test-tube 8 inches long, $1\frac{1}{2}$ inches diameter is then suspended with a rod and line (see Fig. 11). In the centre of this open cylinder three discs of wood, with holes bored through them and fixed upon a central rod, are then fitted to the tube, so that they may be taken out and in with pleasure, but at the same time fit tightly; the cylinder is then half filled with water—the objects that are required to be bleached have been previously placed in the inside of the test-tube upon one of the wooden perforated discs. Chlorine gas (recipe 23) is then passed through the tube, which must be at least half an inch up the test-tube; all the waste chlorine gas is absorbed by the water. Many objects require to be slightly damped previous to subjecting them to the action of this gas, otherwise they will not bleach properly.

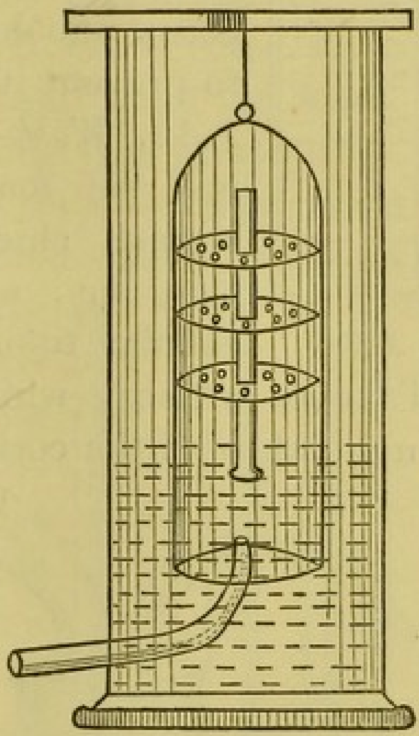


fig 11.

9. *Test Bottle* (Fig. 12). — In micro-chemical

analysis of substances a drop only of any reagent is required; these bottles are used for this purpose. If the student can afford it, he should have at least twelve of these bottles; they may be procured of Mr. S. Highley. After they are filled with the reagent, a drop of glycerine should be rubbed on the glass stopper to prevent it sticking.

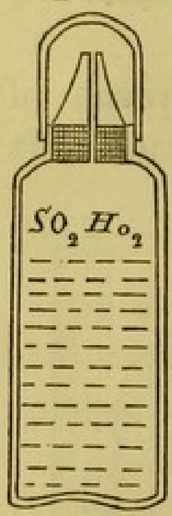


fig 12.

10. *Wash Bottle* (Fig. 13).—This bottle will be found very useful to the microscopist, chiefly for washing delicate cuticles, &c., after their separation from the cellular tissue; the bottle is easily made. Take an ordinary wide-mouth bottle, bore two holes in a cork with the cork-borers used by chemists, then cut two pieces of glass tubing, one about 4 inches long (it is advisable to have this of a larger bore than the other, see Fig. 13), the other 8 or 9 inches; the cut edges of both pieces must be held in the flame of the spirit-lamp until smooth, and one end of the longest piece drawn out to a fine point, which must be broken so as to expose a very small hole (see Fig. 13); the tubes must then be bent gradually in the flame of the spirit-lamp, until the curves represented in the drawing are gained, after which they must be

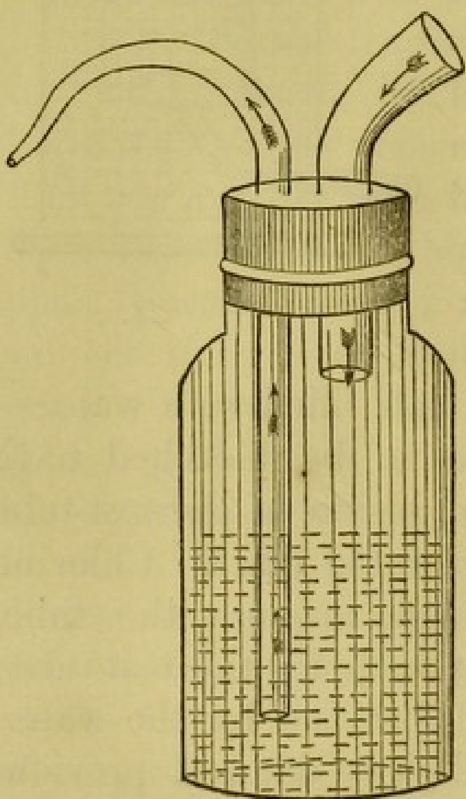


fig. 13.

cemented into the cork with marine glue and a coating of the india-rubber cement (Recipe 5) applied over all, so as to totally exclude the air; the bottle may then be half filled with distilled water, and used by blowing into the shorter piece of tubing, when a fine stream of water will immediately issue from the orifice of the other tube; this stream must then be directed upon the object to be washed. A small kind of wash-bottle may also be used for injecting (see Chapter 5).

11. *Dissecting Needles* (Fig. 14).—These form some of the most useful tools that can be used in microscopy; they are generally fixed in cedar-wood handles, but a crochet handle, made so that the needles can be removed, will be found the most useful. The needles are ordinary needles, made flexible by holding them in the flame of a spirit-lamp or gas jet, and then bending them to the required shape. Some useful forms are drawn at Fig. 14. To harden them make red-hot, then cool in oil, after which they may be fixed in the cedar handles, or a stock of them kept in a small box. Thick needles, if broken off about one-third of their length, and the broken part made red-hot and hammered flat and hardened, and then sharpened on a hone, make very good knives for minute dissection; small chisels may also be made for cutting fibres, &c., by grinding down a broken needle to a cutting edge (see Fig.

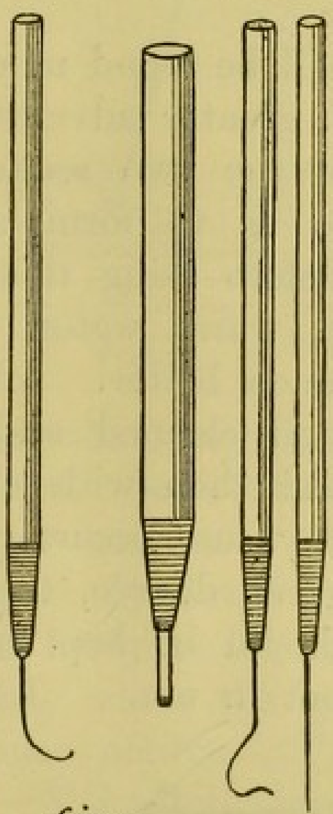


fig 14.

14). The use of these small tools is chiefly gained by experience.

12. *Valentine's Knife* (Fig. 15).—These knives are used for cutting thin sections of soft substances; they generally have two blades flat on the inner side, but lately they have been made with three, the middle blade having nearly parallel surfaces; this

Fig. 15.

will be found much more useful than the older form, a greater advantage being gained by its allowing of the two sections to be opened and spread out so as to form a larger surface for examination. Before using this knife the blades must be dipped in warm water, as when they are wet they cut much better. After it has been used it should be well cleaned and wiped with a soft handkerchief, and then with chamois leather if necessary, for if any rust occurs on the blades it will prevent, in a great degree, their cutting well. The instrument should be kept in a small and separate case when not in use.

13. *Gas-jet and Stand* (Fig. 16).—This wood-cut illustrates a useful form of gas stand made of iron. It will be found for all ordinary purposes to be even better than using a spirit-lamp; but for testing, a

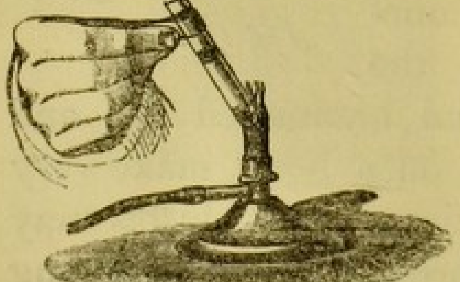


Fig. 16.

purer flame will be required, in which case the spirit-lamp (Fig. 26) is the best.

14. *Gas-holder* (Fig. 17).—Various gases, which are not soluble in water, may be collected in this apparatus as follows: the india-rubber tubing on the right hand side of the engraving must be fixed to the mouth of a retort (see Fig. 28), the gas is then generated and passed through the tube into the holder (the receiver in Fig. 28 has of course been previously taken off); the hole where the glass tubing enters the holder (Fig. 17) must be well cemented over to prevent any escape of gas, and when oxygen or any other gas that may be in the holder is wanted, the cement must be loosened, and the tube drawn up $\frac{2}{3}$ of the height of the jar, then re-cemented; the tubing fixed to the gas cell, Figs. 9, 10, page 11, and the weights applied according to the pressure required, when the gas will flow with an even and regular action. The apparatus is made as follows:—Take two large confectioner's glass jars, one slightly larger than the other; to the top of the smaller one cement a wooden hook (see the fig.) of such a size and shape as to allow circular leaden or iron weights to pass over it; on the right side of this drill a hole in the top of the glass jar; into this hole cement a strong

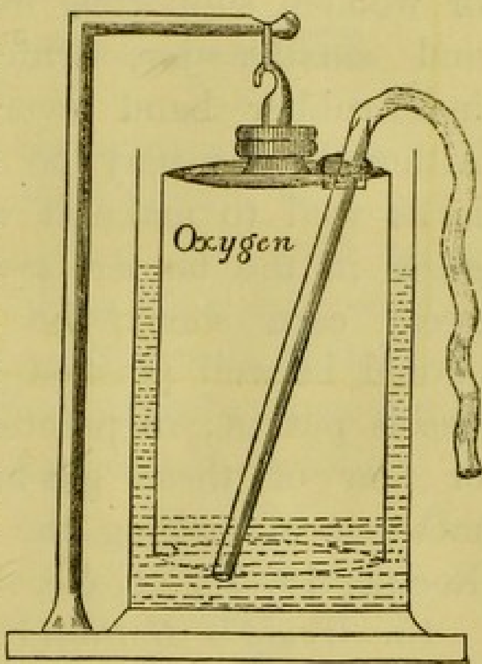


fig 17.

cork previously bored to receive the piece of tubing, which insert and make air-tight with cement (if best cork is used this is scarcely necessary); see Recipe 6; on the left-hand side of the stand fix a strong wire or wooden supporter, from which suspend the inner and smaller jar, which is done by placing an india-rubber band over the hook (see Fig. 17). Although gas may be stored in this apparatus, it is as well to make it when wanted. In changing gases in the holder, say from oxygen to hydrogen, great care should be taken that the smaller jar should be well purified by washing before the other gas is put in; in practice it is as well to have three or four of these gas-holders if possible. For the methods of making the various gases see Appendix, Recipes 19, 20, 21, &c.

15. *Woulff's Bottle* (Fig. 18).—This form of bottle is generally used for generating and washing gases, &c.; the india-rubber tubing is fixed to the glass tube (which conducts the impure gas), the orifice of which is carried beneath the water, and the pure gas issues from the other and shorter glass tube, and is carried by another piece of india-rubber tubing into the gas-holder. The wood-cut represents, not the washing of a gas, but the generation of hydrogen from zinc filings by the aid of sulphuric acid (So_2Ho_2) and water. This bottle may also be used as a wash-bottle, in which case the thistle tube A represents the blowing tube, and B the tube for the issuing jet of water.

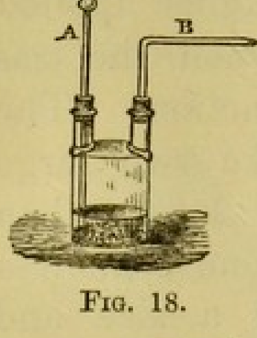


FIG. 18.

16. *Glass Tube drawn out* (Fig. 19).—This drawing

represents the method of drawing a glass tube to a capillary hole or orifice, which is done by holding the tube in the flame of a spirit-lamp; if a piece of platinum wire has been previously passed into the

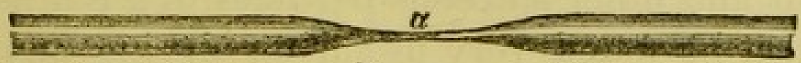
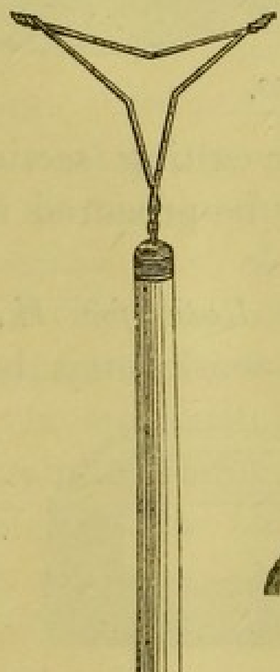


FIG. 19.

tube, upon drawing it apart the wire will remain in the glass, which forms a handle, and will be found a useful tool for picking out cuticles, &c., after being treated with nitric or other acids, as they have but little action upon the platinum. The size of the hole is of course regulated by pulling the tube apart either slowly or quickly; this is soon gained by practice.

17. *Triangle for Testing, &c.* (Fig. 20). — The drawing shows how it is made, *i.e.*, of two pieces of



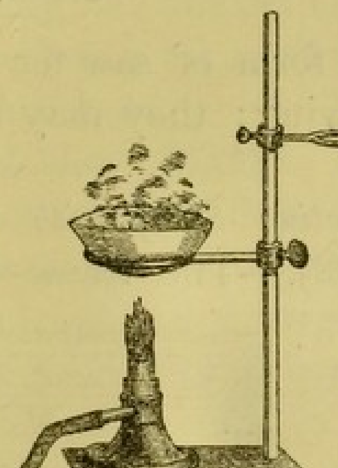


fig 21.

fig 20.

iron wire inserted into a handle and twisted; these are again twisted with a shorter top piece of wire, so as to form a triangle. It is chiefly used for holding a piece of platinum foil or mica over the spirit-lamp when it is required to test the organic or inorganic nature of any object (Chapter 7); or in burning diatoms and other siliceous particles to a red heat. It will also be found very useful for drying any object on the thin glass covers.

18. *Retort Stand and Gas-jet* (Fig. 21).—The stand should be supplied with at least three or four different sizes of rings to allow for the various vessels that may be wanted; the figure represents the process of boiling any substance in an evaporating dish over the gas-jet.

19. *Fine Saw for Cutting Sections* (Fig. 22).—Watch-spring saws are sold for microscopical work;

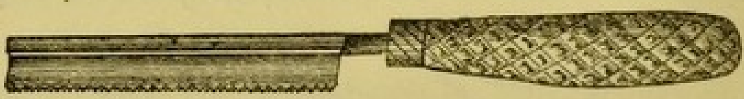


FIG. 22.

but the best form of saw for cutting sections is made like the drawing; they may be procured at the large tool shops.

20. *Dissecting Slab, with Bath for Waste Water, &c.* (Fig. 23).—The frame-work may be made of

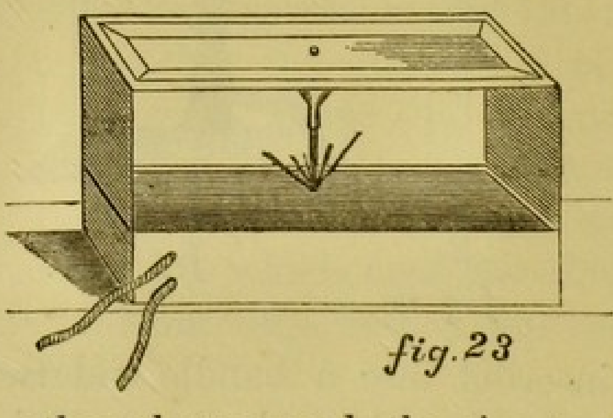


fig. 23

deal or any other cheap wood, the size to be one foot long, five inches wide, six inches high. Into the top slab, which should be about one inch thick, a shallow trough made of glass or slate—glass being the better of the two—is embedded (see drawing); in the centre of this a large hole is drilled to allow the waste water to run into the bottom bath, which bath may be made of slate. India-rubber tubing leading from this is conducted, if possible, through the wall into the outer air, and so allowed to run into a drain or waste ground; the flow of the waste water through this tubing is checked by the aid of spring-clips. Small slabs of variously coloured gutta-percha (Recipe 62) may be fixed to the upper trough, the advantage of the colours being that many dissections are better made on a suitable coloured slab than on any ordinary colour; if the gutta-percha is found to be too hard, a small piece of tallow may be melted down with it—this makes a slab much superior to wax or cork. In nearly all dissections plenty of water must be used, care being taken that the bottom bath is not allowed to overflow.

21. *Apparatus for cleaning Diatoms* (Fig. 24).—This is a modification of an older form of apparatus, used for separating diatoms according to their specific gravity. On the shelf is placed a large tin or other vessel containing pure water—old Australian meat tins may be used for this purpose. To this vessel is attached a piece of india-rubber tubing. A large confectioner's glass jar of good depth is taken and mounted on a wooden stand, or it may be used as it is; to the top of this fix a cork or wooden cover previously bored, to admit four pieces of glass tubing, three small, one large (see drawing); the small size

should be about $\frac{1}{8}$ of an inch bore, and the larger and longest piece at least $\frac{3}{8}$ of an inch bore; fix these into their position in the wooden cover with the cement (Recipe 6), then place on the cover in its right position, and seal and cement it so as to make

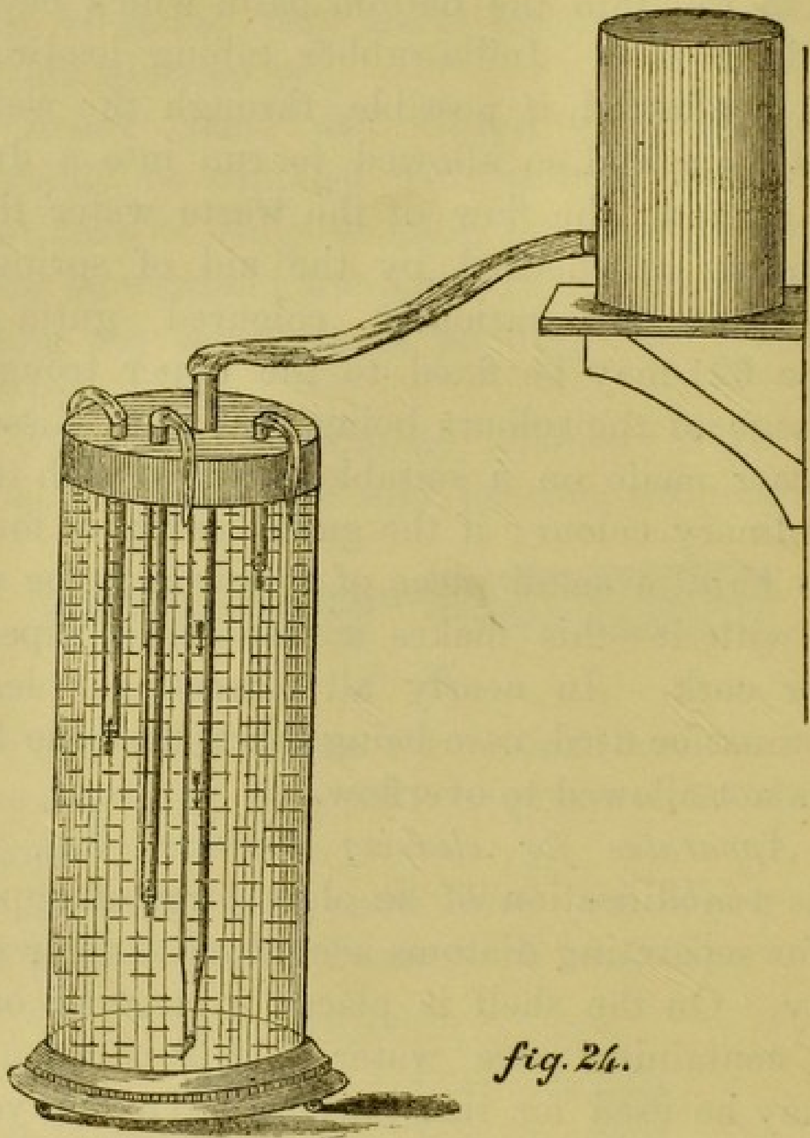


fig. 24.

it water and air-tight. Now connect the apparatus with the vessel on the shelf by the aid of the india-rubber tubing; fill the tin with water and let it pass into the glass jar and flow out at the orifice of the three tubes placed in the wooden cover; when an even flow of water is obtained, take three pieces of glass tubing, each having a capillary orifice; fix these to the projecting ends with small pieces of india-rubber tubing. Now take a quantity of the cleaned diatoms (see Chapter 5), which put into the vessel on the shelf and let them pass gradually into the glass jar, the water flowing all the time from the three small tubes; after a short time has passed, examine a drop of water by evaporating it on a glass slip, and if any diatoms are present they will be found by using the $\frac{1}{4}$-inch power of the microscope. If present, collect the water as it flows from each tube into three separate glasses, which must be allowed to stand some time for the diatoms to settle in the form of a deposit. In each glass diatoms will be found of a different size and specific gravity; by this plan foraminifera and other objects which water does not injure may be separated according to their specific weights.

22. *Finder for Foraminifera, &c.* (Fig. 25).—A finder similar to Maltwood's will be found very useful for

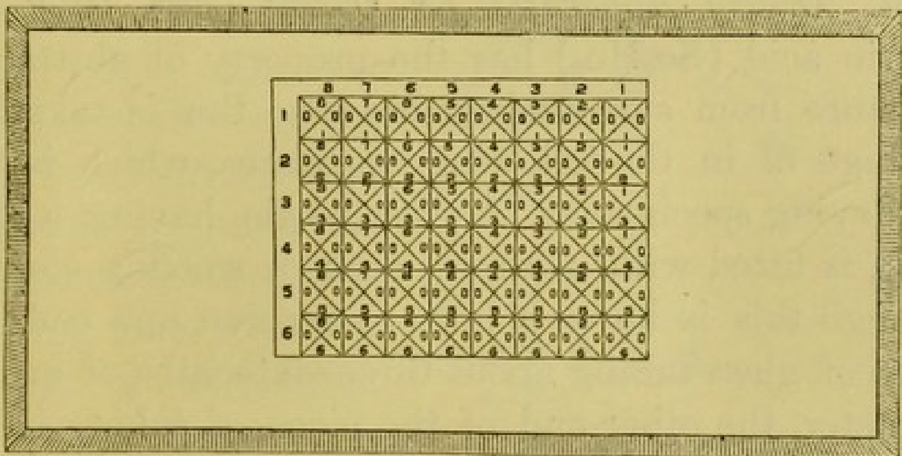


fig 25

separating any special form of foraminifera or diatom from the surrounding mass. It is made as follows:—Rule with a writing diamond any number of lines from six and upwards, cross, recross, &c., with other lines, and number the spaces as in the fig. When it is desired to find any particular diatom place the finder under the microscope, and note the number and square in which it lies, then take it from the stage of the microscope, and with a fine camel's hair brush, moistened at the tip, pick it out from the surrounding forms. This is easily done, for if the lines and figures have been neatly and clearly drawn the exact number will be seen with the naked eye. For the method of arranging the figures, &c., see the drawing.

FIG. 26.

23. *Spirit Lamp* (Fig. 26).—This is chiefly used when greater heat and cleanliness are required, for it does not deposit soot like the gas jet, which is important in testing and other purposes. They may be procured at any chemist's shop.

24. *Drying Apparatus for Objects* (Fig. 27.)—Sulphuric acid (So_2Ho_2) has the property of abstracting moisture from surrounding objects; this is taken advantage of in the following apparatus, which is used for drying specimens. A glass bottle, having a large neck, is fitted with a strong cork or wooden stopper; through this is bored a hole to receive one end of a piece of glass tubing about three-sixteenths of an inch diameter, the other end of the piece of tubing is bent at right angles, and then bent again in a circular manner, so as to form a ring, in which a small evaporating dish may be placed (see drawing). This is to

contain the object that is to be dried. Sulphuric acid is now poured into the bottle until it is about a quarter full. The lower surface of the cork or wooden stopper is protected from the corrosive action of the acid—the strongest being used—by using a cement made of colloid silica, &c. (see Recipe 69.) Three or four coatings of this cement must be applied, one after the other, as they dry—it is then ready for use. The stopper should fit well but not too tight, as the object might be jerked out of the holder whilst removing it from the bottle.

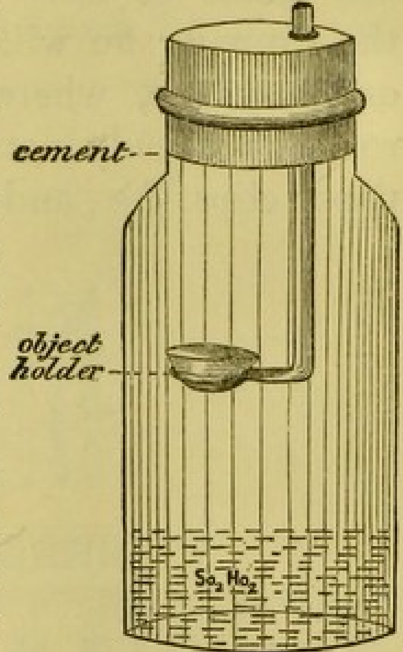


fig. 27.

25. *Apparatus for Making Gases, Distillation, &c.* (Fig. 28).—Stoppered retorts will be found the best in the long run for making gases and for use in distillation. For though dearer than Florence flasks, yet the increase in price is more than balanced by their increased usefulness. The drawing represents the process of distillation. When it is required for making gases, india-rubber tubing is fixed to the retort in place of the receiver, which is on the right hand side of the drawing.

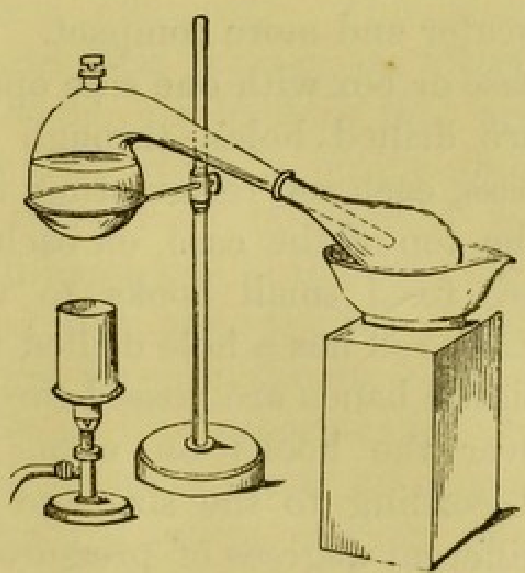


Fig. 28.

26. *Apparatus for Giving Different Degrees of Pressure to Objects whilst Drying* (Fig. 29).—If the student can make or have made a piece of apparatus like the drawing he will find it much superior, even for ordinary use, where pressure is required, than the rough and ready methods of small wire clips, American paper clips, &c., and at the same time it will be much

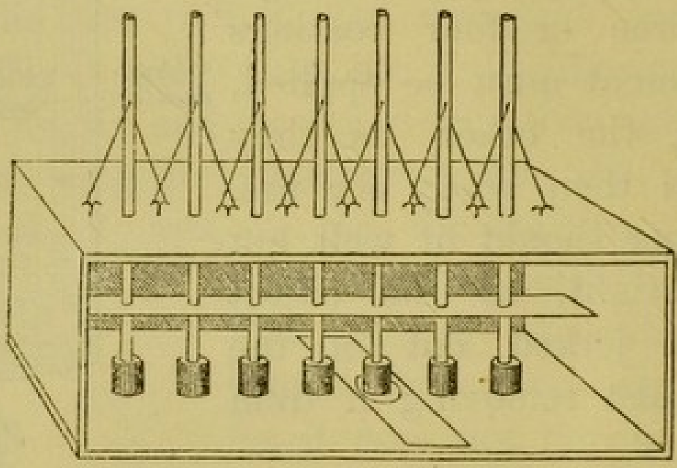


fig.29.

neater and more compact. The drawing represents a case or box with one side open. In the top of this case are drilled holes, through which the pressure rods pass, each rod terminating in a soft velvet cork. On the top of the case, on each side of the pressure rods, are fixed small hooks to receive the elastic bands. Each rod has a hole drilled through it at the top; the elastic bands are passed through these holes, and then over the hooks on either side (see the drawing). According to the size and strength of these bands, different degrees of pressure are obtained. The most convenient size will be found to be about ten inches long, four inches wide, and five inches high. This size case will take eight or nine slides at once. In the drawing a slide will be seen in the right position, under one of the pressure rods.

27. *Air Pump* (Fig. 30).—This form, which is sold by some of the opticians, will be found the most con-

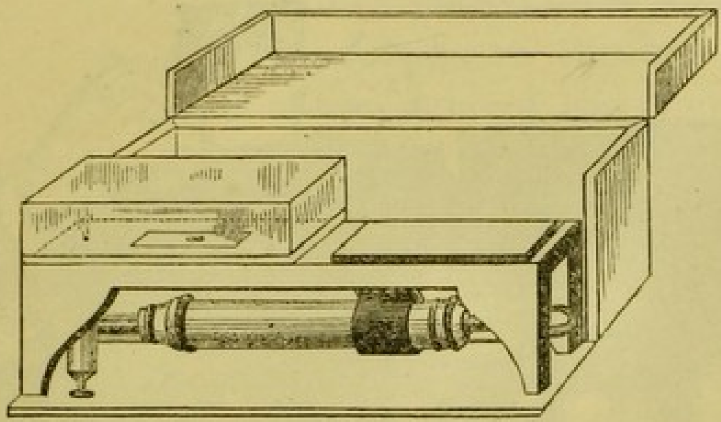


fig. 30.

venient, but care should be taken to test its air-tightness before it is bought, as this form is liable to get out of repair. On referring to the drawing a slide will be seen under the glass cover ready for the exhaustion of the air. The piston is worked until a good vacuum has been obtained. The slide should be allowed to remain thus for ten or fifteen minutes, after which, if all the air bubbles that are contained in the balsam or fluid which is on the glass slide are not gone, the valve may be opened by turning the screw on the left-hand side of the drawing, to allow the air to rush in; then close the valve, and repeat the exhaustion of the air until the air bubbles are entirely gone. The use of this apparatus is only necessary when the object contains much air; in a general way the air bubbles will escape of their own accord.

28. *Lawson's Dissecting Microscope* (Fig. 31).—This being a binocular microscope will be found much less

fatiguing than the ordinary compound instrument. A larger range of field is obtained, and much more room for working. Scissors, needles, scalpels, &c., necessary for dissections are sold with it. It forms, when closed,

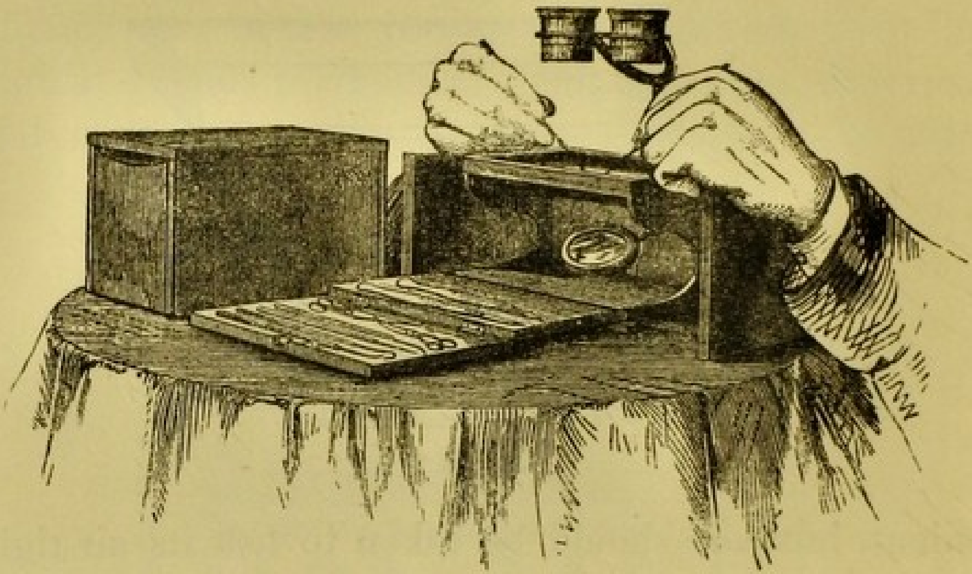


FIG. 31.

a box about six and a half inches long by four inches wide, and it will be found much the best dissecting microscope, especially for beginners.

29. *Apparatus for Drawing, &c.* (Fig. 32).—This

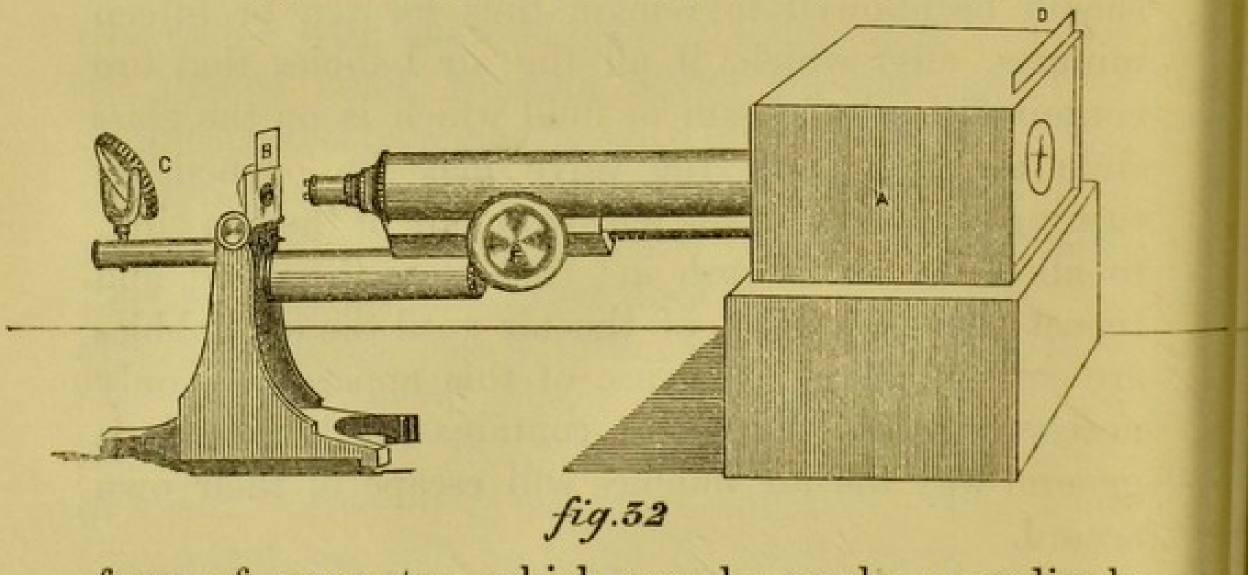


fig.32

form of apparatus, which can be made exceedingly cheap, will serve for two or three different purposes, *i.e.*, for drawing objects, for taking photographs of objects, and for showing any object to friends without their having the fatigue of looking through the tube of the microscope, which to unaccustomed eyes is rather fatiguing. "A is a deal box placed on a square block of wood of the right thickness; in this box we cut a circular hole to allow of the tube of the microscope to pass in; we next fix the object which is to be drawn or photographed upon the stage at B, and throw the full power of the sun's rays directly upon it by means of the reflecting mirror C. If the object is very small a condenser must also be used between the mirror and the stage, so as to condense the rays upon the object. Taking our stand behind the camera, and sliding a ground glass focusing plate into the groove at D, we will cover our head with a black cloth, well known to all lovers of the art, and bring a clear image of the object upon the surface of the plate by means of the screw at E. Our arrangements are then complete: the ground glass represents with perfect fidelity the relation of the retina to the picture under ordinary circumstances, and we have but to make it highly sensitive to the decomposing influence of light to produce the desired result. Replacing this artificial retina, therefore, with collodionised glass, and allowing it to be exposed to the sun's rays for some few seconds, we have only to remove and develop, in the ordinary way, the picture which will have been formed. This is an outline of the process, but in practice scarcely any branch of photographic manipulation requires greater skill, delicacy, and patience than this. One great source of failure which besets the amateur is the singular though well-known fact that the visual and chemical foci of a lens do not absolutely coincide; or, in other words, the focusing which would give a completely defined picture to the eye upon the ground glass slide D, will produce a blurred and hazy image on the collodionised plate. One or two trials will soon establish the correct focal length: the negative may then be taken, and any number of positives taken from it." If it is desired to draw the object, instead of photographing it, a piece of thin tracing paper must be fixed to the ground glass slide by the aid of gum at the corners of the paper. The object is drawn on it, and a retracing from this on to white paper must then be executed in the usual manner. The same arrangement will do for showing objects to a number of people at once, only in this case a strong light must be used—Fiddian's lamp is about the best. The light must be enclosed and carried through a tube, or the stage of the microscope and the lamp may be enclosed in another box.

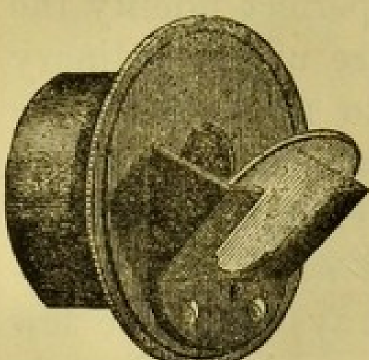


Fig. 33.

30. *Neutral Tint Glass Reflector* (Fig. 33).—This is the cheapest form of apparatus for drawing; it is used with the microscope in a horizontal position in the same manner as the camera lucida (Fig. 34.)

31. *Camera Lucida as used for Drawing* (Fig. 34).—To draw an object the camera lucida is fitted to the eye-piece, the cap having been taken off. The microscope is then placed in a horizontal position, and the body of the instrument must be raised until the prism of the camera is ten inches from the paper, which must be placed upon a flat

surface like a table (see the drawing.) In using the camera one eye only must be used; half of the pupil of this eye must be directed over the edge of the prism, when the object will appear upon the paper, and may

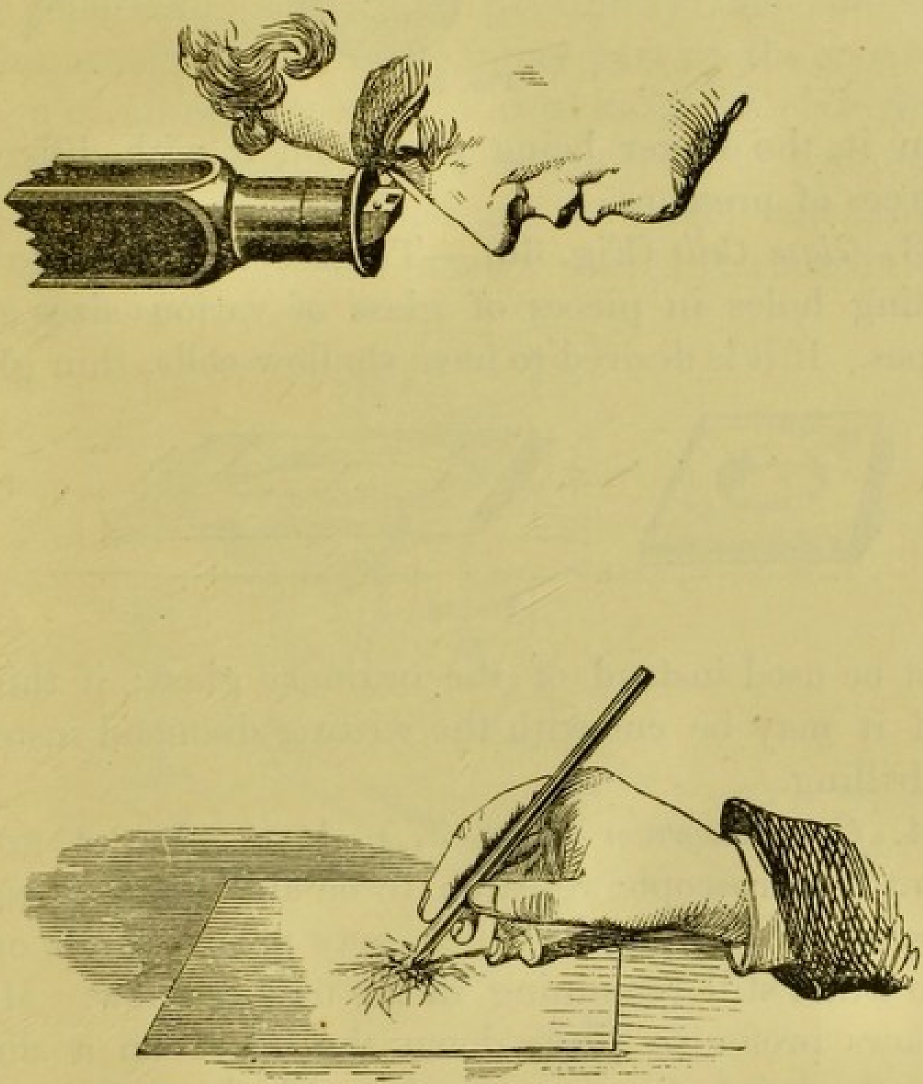


Fig. 34.

be drawn with a pencil. If any number of drawings are to be made, it is as well to use the drawing paper pads sold by Messrs. Winsor and Newton.

32. *Pipette* (Fig. 35).—This is used for collecting small quantities of diatoms, &c., after they are deposited at the bottom of any glass or other vessel. It is as well to have a small piece of india-rubber sheeting

over the top. In use this will be found to assist in preventing the speed at which any deposit will run

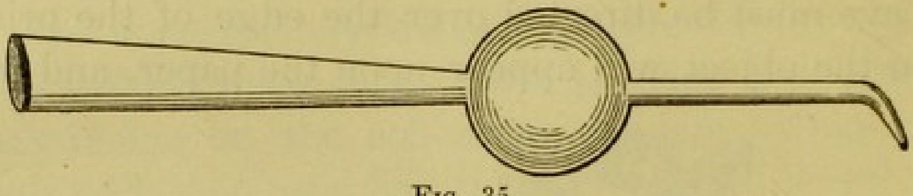


FIG. 35.

from it, the finger being placed on it with different degrees of pressure.

33. *Glass Cells* (Fig. 36).—These cells are made by drilling holes in pieces of glass of various sizes and shapes. If it is desired to have shallow cells, thin glass

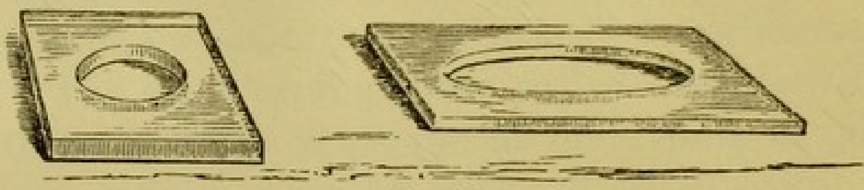


FIG. 36.

must be used instead of the ordinary glass; if this is used it may be cut with the writing diamond instead of drilling.

34. *Compressorium* (Fig. 37.)—It is often a great help to microscopic research to be able to apply compression to any object which may present itself on a slide while still remaining in the field of view. Most workers prefer to press down the cover on a slide, with the point of a porcupine's quill, &c. In many cases the object is too much crushed, or the cover broken, or it slips out of the field of view, and it is often nearly impossible to find it again. The compressorium here represented will, I think, be found to possess many advantages, and its use will get rid of all the difficulties indicated above. "It consists of two parts—the stage and the compressor. The stage,

A, B, C, D, is a flat brass plate, with a circular opening bevelled beneath, so as to allow any kind of condenser to be applied below, and with two small short pins projecting below at A and B (not seen in the diagram), and which fit tightly into the small holes usually made in the upper part of the moveable stage of all microscopes, so as to keep the plate firmly fixed to the stage of the microscope. The compressor (K, I, H, M, N) is turned off the stage, and remains in that position when not in use. It consists of a

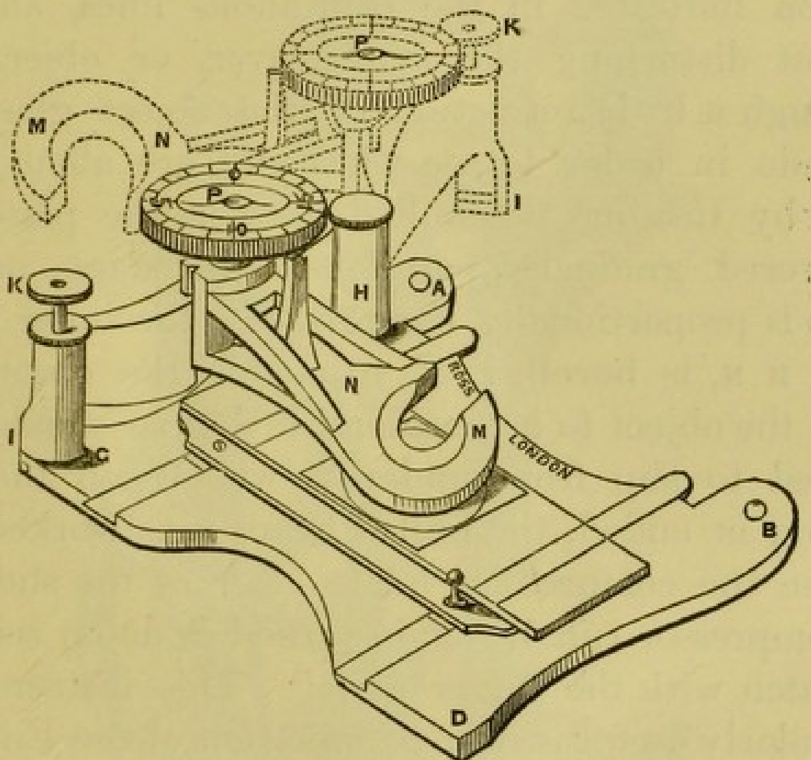


FIG. 37.

stout arch of brass, terminating in two feet; one, H, on which it pivots, and which should be made stout and strong; the other foot, K I, ends in a shoe, with a spring catch, I, and which, when the compressor is turned round on the pillar, H, fits into the notch, C, and can be released by the finger acting on the pin, K; the compressing plate, M N, is acted upon by the milled head, P, and can be lowered and raised to any extent required by a micrometer screw to which it is attached. With the compressorium fixed on the stage of the microscope (the compressor turned off as in the dotted lines), every kind of microscopic work can go on just as well as if the compressorium were off the stage; in fact, it is not at all in the way. However, when anything requiring compression turns up in a microscopic research, the compressor part can be pivoted round the pillar, H, so as to occupy the position indicated in the continuous lines, and that without disturbing the slide, cover, or object glass (although a little retraction of the object glass may be made in order to see what you are about); and then, by turning the milled head, P, the plate, M N, is lowered gradually parallel to the stage, and the object is proportionally compressed; the inner part of plate, H N, is bevelled off to enable the observer to follow the object to a considerable degree should it be inclined to slip from under view. When the compression is ended, the milled head, P, is worked back to raise the compressing plate clear of the slide, and the compressor can be again turned aside on releasing the catch with the finger at K." This instrument is particularly useful in the examination of the Entromostraca Rhizopoda and Rotatoria—in fact, in nearly every department of microscopic work; it will also save a vast amount of trouble. This instrument is sold by Mr. Thomas Ross, London.

35. *Machine for Cutting Rock Sections, &c.* (Fig. 38 and Fig. 38a.)—"As will be seen from Fig. 38 and the diagram on p. 38, this machine consists of a wooden framework, *a a*, supporting a crank-axle and driving-

wheel, two feet diameter; the top part of this frame consists of two cross-pieces, *a′*, fixed about an inch apart, as in the bed of an ordinary turning lathe; into the slot between them is placed a casting, B, carrying the bracket for the angle-pulleys, C; this casting is bored to receive the spindle, D, which, by means of the treadle, is made to revolve at the rate of 400 or 500 revolutions per minute. It is also

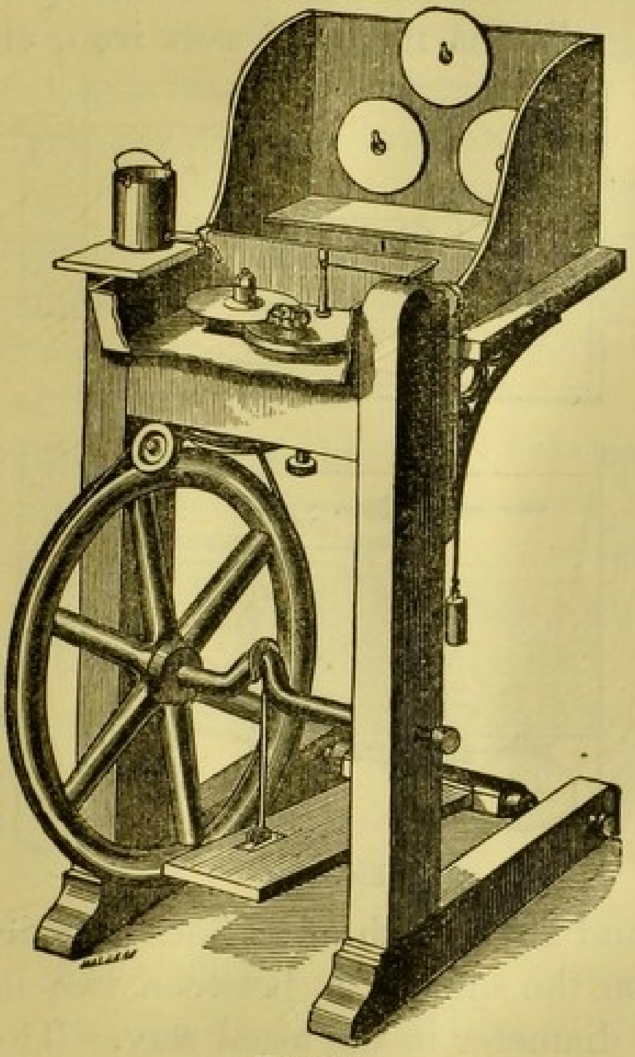


Fig. 38.

bored to receive another spindle, E, to the top of which is fixed a metal plate, F, for carrying the small cup, H, to which the specimen is attached by means of prepared wax. This means of mechanically applying the work to the slicer is far preferable to holding it in the hand in the ordinary way; the requisite pressure against the cutting disc is regulated by the weight, G, and the thickness of the slice by the thumb screw, K, on which the spindle rests. By this means it is possible to cut tolerably thin and parallel slices—the thinness, of course, varying according to the strength of the rock which is being operated upon. The slitting disc is made of soft iron, eight inches

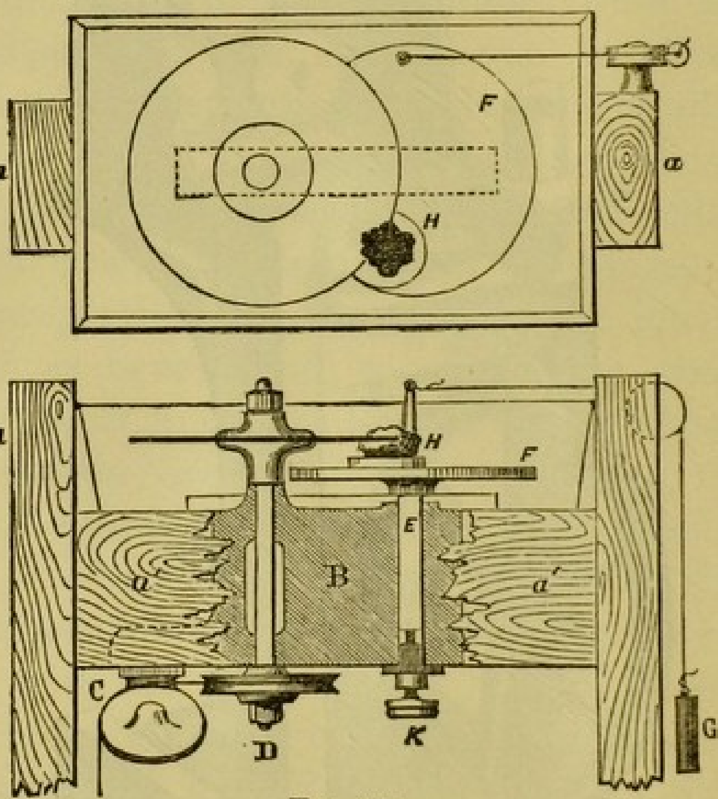


Fig. 38a.

diameter, and about $\frac{1}{50}$th of an inch in thickness, and it is fixed on the spindle, D, between two brass plates four inches diameter in the usual way. The operation of charging the edge of the disc with diamond powder requires some little care. Having reduced the diamond to the requisite degree of fineness in a hardened steel mortar (so fine that no sparkling is perceptible on exposure to light), a few grains are placed in a watch glass, made into a paste with a drop of sweet oil, and applied to the edge of the disc with a quill; while the disc is being slowly revolved by hand, it must be gently pressed in with a small roller of glass or hard steel, until the particles of diamond powder are securely bedded in the edge of the metal, care being taken to avoid getting any of it on the sides of the slicer. In cutting it is necessary to steady the work with the hand, and not to trust for pressure entirely to the suspended weight. The work must be constantly lubricated with oil; spirits of turpentine will, however, answer the purpose. When it is possible to obtain a sufficiently thin piece of the specimen by a dexterous chip with the hammer, or other means, the operation of slitting may of course be dispensed with.

Having prepared suitable slices of about $\frac{1}{16}$th or $\frac{1}{8}$th of an inch in thickness, it is necessary to reduce them still further by grinding with fine emery and water on a lead 'lap,' which is made to revolve on the spindle D. The lap is eight inches diameter, and about $\frac{3}{8}$ths of an inch thick in the centre, cast with rounded edges and slightly convex sides; this form facilitates the grinding of a uniform thinness, there being always a tendency on a flat surface (which soon wears hollow) for the edges of the section to grind away before it is sufficiently thin. One side of the section can easily be ground and finished by holding in the hand, and this being done, it must be cemented with hard Canada balsam to a small square of plate glass: in order to grind the other side it is as well to protect the corners of the glass with small pieces of zinc whilst the operation of grinding is going on. When the sections are to be mounted in balsam it is not necessary to polish them; the only finish required is to rub them on an Arkansas stone until the scratches, &c., are removed." (See also Rock Sections, Chapter 5.)

36. *Trough used for observing the circulation of blood in Tadpoles, &c.* (Fig. 39.)—"The tadpole trough shown

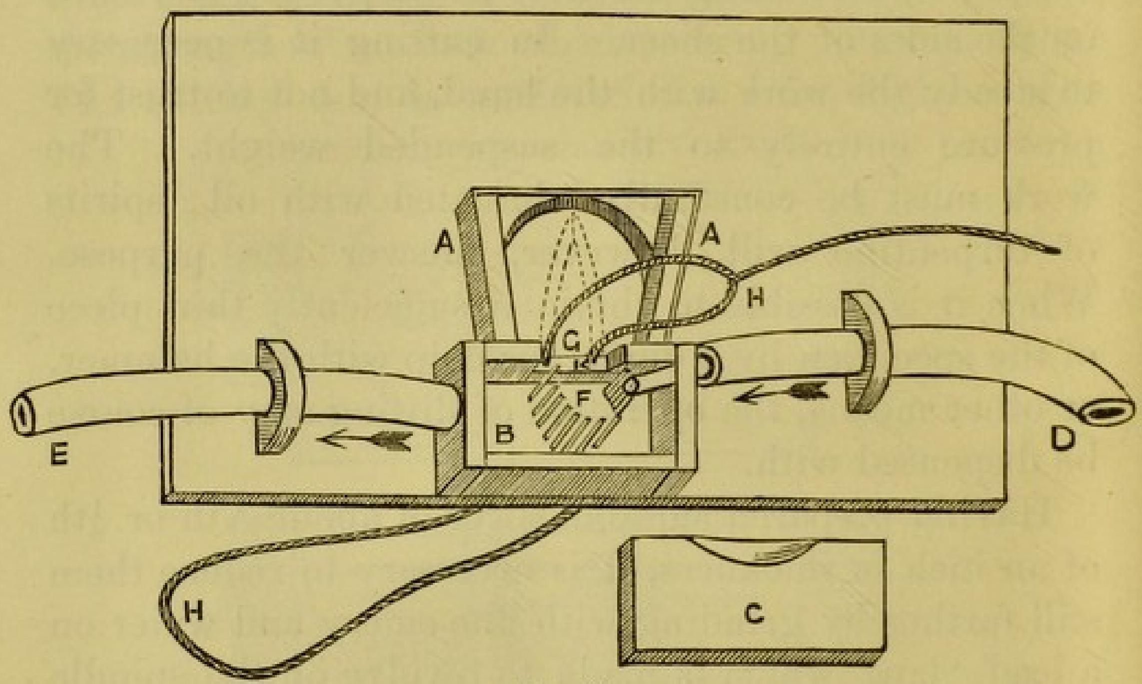


FIG. 39.

in the engraving will be found very useful. A A, is a glass stage raised a quarter of an inch above the plate, and having beneath it an aperture in the plate. B, is trough entirely covered in, the cover of which, C, is here removed to show the interior. The trough is kept constantly full of water by the supply-pipe, D; this water may be conveyed from a small reservoir of water kept on a shelf, like in Fig. 24, page 24. E, is the waste-pipe; F, is a little cage made of pieces of pin-wire, and of such a size as to hold easily the head of a full-sized tadpole. The apparatus being placed on the stage of a microscope inclined at an angle of 45°, a tadpole is deposited from a small teaspoon on the lower part of the glass stage (about the point G.) The head immediately falls into the cage, F; the tadpole turns on its side, the tail lying across the glass stage, as shown in the dotted outline. The silk cord, H, is used to hold the animal in its place. A glass cover is now laid on the tail. The tadpole should not be left in more than three hours at a time. The circulation is apt to flag during the first ten minutes; it then revives. By this plan the circulation of the blood is well shown, also the changes in the inflamed parts, &c." See also "Circulation," Chapter 5.

37. *Glasses, &c., for Aquaria* (Fig. 40).—No microscopist should be without at least one large confectioner's jar, or a propagating glass (see drawing) filled with pond water, in which to keep water-insects, desmids, diatoms, &c. The aquarium should not be

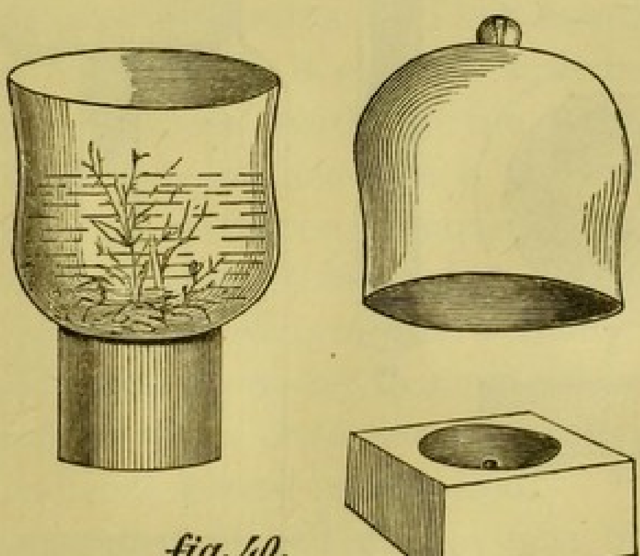


fig. 40.

larger than two feet in diameter; that is, if it is used for keeping water-insects. When at the seaside, if it is desired to keep minute marine objects, a piece of seaweed growing on a limpet-shell or piece of rock should be placed in the sea-water for at least two days before any zoophytes, &c., are placed there. Rough stands for the bell glasses can always be made out of a block of wood, or an old white jar, &c. (see the drawings.) It is very interesting to grow species of desmids, &c., in separate jars.

38. *Collecting Bottle* (Fig. 41.)—These bottles are used for collecting small beetles and other insects. A small wide-mouth bottle being chosen, a cork is bored exactly in the centre with a cork-borer or rat-tail file; into this hole is cemented a piece of quill of about the length of *a* (Fig. 41.) Some small pieces of bruised

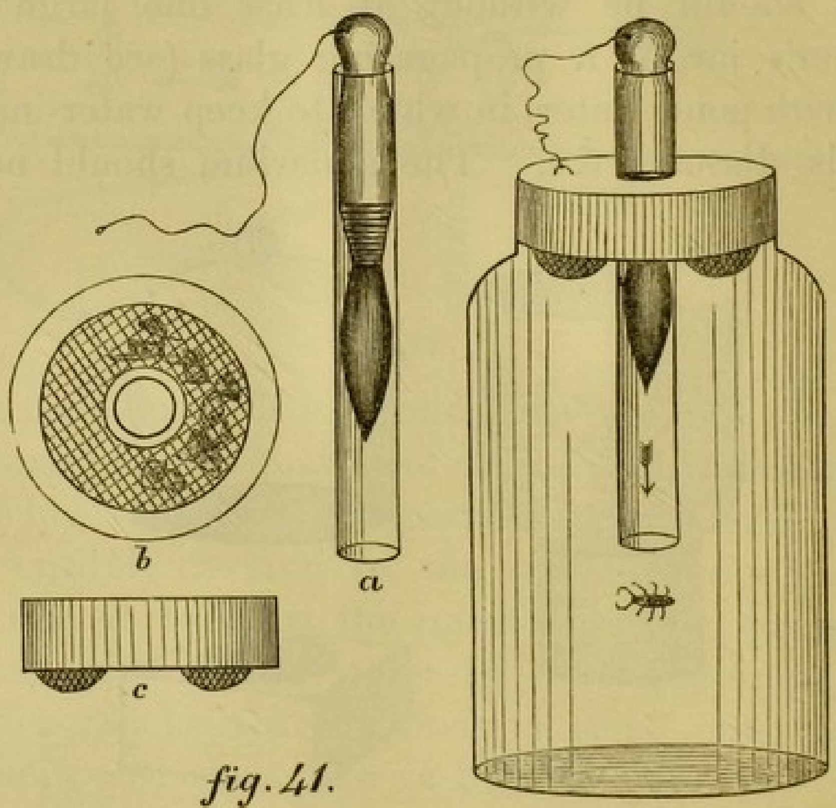


fig. 41.

laurel leaves are taken and kept in their place by the aid of a circular piece of fine muslin, see *b*: *c* shows the sectional view of the cork with the muslin pad. The muslin can be fastened to the cork with glue or the small pins used by drapers. A camel's hair brush in a short cedar handle is now fixed to the cork with a piece of fine string (see drawing); this brush must be kept constantly damp. Glycerine will be found useful for this purpose. The cork may now be placed in the bottle, rather tightly, for it does not require to be taken out until sufficient insects have been collected. The drawing illustrates an insect falling into the bottle after being caught with the aid of the brush. A small piece of silk or muslin must be kept in the bottle, for the beetles, &c., to cling to; this prevents their being crushed.

39. When exhibiting any series of objects either to fellow-students or friends, it will be found a good plan to have a moveable board so fitted as to carry a microscope, one lamp, and sufficient space left for all other necessary apparatus. This board should be triangular, one side of it covered with baize, and the other with American leather; the baize side to be used on a smooth surface like a polished table, and the leather side on a rough surface like on a table already covered with a table-cloth. This plan will be found a great advantage where many objects are shown, as it is not necessary to move either the lamp or the microscope when once fixed in right position, the board only being moved as required.

40. Propagating or bell glasses may be obtained of Messrs. Claudet and Houghton, High Holborn.

41. Test tubes and chemicals I always get from Mottershead and Co., Manchester, the price of the tubes being only about 3s. per hundred.

42. Scalpels, razors, Valentine's knife, scissors, &c., may be obtained of any optician or instrument maker.

43. *Crucibles.*—I find the best place to get these is from the Plumbago Crucible Company, Battersea, London.

44. *Reagents* (see Chapter 7).

45. The large tins in which the Australian meat is sold will be found very useful for many purposes.

46. The microscopist, especially if he is fond of chemistry as well, should not be without a small dialysing drum, which may be made as follows:—Over one side of a lamp-glass chimney tie or fix with cement a piece of sheet india-rubber or bladder, great care being taken that it is tightly fixed. It is now ready for use, for the method of which see Recipe 9, and it will be found very useful in separating salts, especially from glycerine, &c.

47. When a moderate heat only is required for slides whilst in process of mounting, a good plan is to use an ordinary basin filled with boiling water, over which invert a plate. The best plan is to get a tinman to make a square tin box about seven inches square and four inches high, a small hole only being left open in one corner, through which the boiling water must be poured in; a cork being used to stop the hole.

48. *Lamp.*—An ordinary paraffin lamp will do for most purposes of illumination; but if a better is required I prefer Fiddian's lamp, though many others are sold by Mr. How and other opticians, which are nearly as good.

49. The student must not forget to obtain or make a small soldering-rod, like those used by gas-fitters, only much smaller.

50. A good blowpipe will also be found useful, especially in fusing borax, beads, &c., for microscopical examination.

51. Very good and useful spring clips can be obtained of Mr. Baker, High Holborn.

CHAPTER II.

THE DRY METHOD OF PREPARATION OF VARIOUS MICROSCOPICAL STRUCTURES.

52. THE dry method of mounting may be considered the easiest of all the plans that are used for preparing microscopic inorganic and organic substances. It may be considered as divided into two large divisions: viz., the dry transparent, and the dry opaque modes of preparation.

53. But before we begin it is as well to inform the student that if possible a separate room, however small, should be at his disposal; and it is preferable to have the floor of this room or workshop covered with floorcloth, as the woollen fibres from carpets and druggets generally float in the air of the room, and however careful the manipulator may be, fine fibres will often rest on a careful dissection or preparation and not be noticed until the thin glass is applied,—when, if delicate, to remount the object would most likely injure, if not spoil it. Therefore, it is advisable to examine the dust of the room with his microscope, and if fibres are found, to trace them to their source and remove it. If only dust proper or inorganic dust chiefly remains, the room may then be considered ready for future work; and we wish our readers success.

54. *Dry Transparent Method.*—For this mode of mounting the student may have ready to hand on his mounting-table or bench the following articles:

Two dozen glass slips: viz., one dozen rough edge crown slips, and one dozen patent plate ground edge slips. Six of the ground edge and six of the rough edge are to be used for the transparent method of mounting, and the same number for the opaque.

Eighteen thin glass circles, this number to allow for breakage; the sizes are to be two of the $\frac{3}{8}$ inch, eight of $\frac{1}{2}$ inch, five of $\frac{5}{8}$ inch, and three of the $\frac{7}{8}$ inch.

Eighteen thin glass squares, the sizes to be three $1\frac{1}{2}$ by $\frac{3}{4}$ inch, five of the $\frac{7}{8}$ inch, six of the $\frac{3}{4}$ inch, and four of the $\frac{1}{2}$ inch.

These sizes will be found the best for the mounting of the objects that I shall describe:

Apparatus with wire clips; the section cutter; the holding screw; both of the drying apparatuses; the bell glasses and the broken wine-glasses; two of the test tubes and holder; forceps, one pair; one scalpel; both pairs of scissors; the spirit-lamp; a few of the watch-glasses; a small camel's hair brush; Matthews' turn-table; the small soldering-rod; the writing diamond; file, saw, copper-wire, &c.; caoutchouc cement; gold size; Berlin black; and the gum-bottle and cases necessary for covering twelve slides, as the other twelve will be on the ground edge slips.

We will take the following twenty-four objects, twelve transparent and twelve opaque, and I have chosen them on account of their being easily obtained; and if the reader will follow the process of mounting he will gain a fair amount of experience in the dry process, they being to a certain degree typical slides taken from Chapter 5 :

1. Wing of cabbage butterfly, properly called the small garden white (*Pieris rapæ*), R.E.*

2. Eye of house-fly (*Musca domestica*), R.E.

3. Scale of roach (*Leuciscus rútilus*), R.E.

4. Diatoms (*Diatoma vulgare*), G.E.

5. Section of human, or other bone, R.E.

6. Pollen of bird's foot trefoil (*Lótus corniculátus*), G.E. ; pollen of fumitory (*Fumaria officinális*) ; or pollen of hyacinth (*Hyacinthus orientalis*).

7. Spores of an equisetum (*Equisetum telmatéia*), G.E.

8. Transverse section of rush (*Juncus communis*), G.E.

9. Transverse section of oak (*Quércus róbur*), R.E. ; dog rose (*Rosa canina*) ; or any wood which shows exogenous structure.

10. Cuticle of ivy (*Hedera helix*), with the stellate hairs attached to it, G.E.

11. Monopetalous corolla of pimpernel (*Anagállis arvensis*), R.E.

12. Sulphate of lime (SO_2Cao''), G.E.

The other twelve objects are named and described in the next division, under the head of Dry Opaque Mounting.

We will take the objects in the same order as they are numbered.

Slide 1. *Wing of cabbage butterfly* (*Pieris rapæ*).—It is easy to catch one of these insects, as they are very common. After it is caught kill it by piercing the thorax, and if necessary apply one drop nitric acid with the needle; one wing must then be cut

* R.E. signifies rough edge slip ; G.E. signifies ground edge slip.

off and placed under one of the wine-glasses to protect it from dust, and also the chance of being blown away. Then take one of the rough edge slips and thoroughly clean and polish it; and if there is any difficulty in removing the dirt, use a strong solution of caustic soda or potass, but if either of these are used the glass must be well washed in cold water to remove all traces of them. Then polish with an old silk handkerchief or wash-leather, I prefer the silk; then take one of the pieces of thin glass, $1\frac{1}{2}$ inch by $\frac{3}{4}$ inch, clean with the silk handkerchief, with less pressure of the fingers, as the glass is very brittle; if any great difficulty is found in cleaning this glass without breaking it, use rubbers made thus: take two pill boxes, and cement wash-leather to the bottom of each, fill the boxes with plaster of Paris to give them weight, then put the lids on, and give them a coating of sealing-wax varnish to make them look neat; when dry and ready for use place the piece of thin glass between the wash-leather sides, and gently rub them together. By this plan it will be thoroughly cleaned without the risk of breakage. When perfectly clean draw a thin layer of gold size all round the piece of thin glass, on which place four narrow slips of paper. Let these dry; then place another thin layer of gold size over the paper slips, and whilst this is drying measure the width of the wing of the butterfly; if too wide cut a small piece from each side, so as to make it about $\frac{1}{4}$th of an inch less in width than the piece of thin glass; then place it in the centre of the glass slip, but previously rub a few of the scales off, so as to make it semi-transparent. This is necessary to show the arrangement of the scales. The exact centre of glass slips is best taken as follows: Draw lines on a piece of thick cardboard the exact size of a glass slip, viz., 3 inches by 1 inch; then from each corner rule a line to the opposite corner, so that both lines may cross in the centre—this will give an exact centre for all slips. Always centre a quantity of slips at one time, by placing them over this guide, and with a pen depositing one small drop of ink in the exact centre.

Now we will take the thin glass and place it over the wing, and taking the soldering-rod, which has been previously made hot, either by a fire, spirit-lamp, or gas, gently touch the edge of the thin glass all round, which will cause the gold size to flow; and if well done, make an hermetically sealed cell. When thoroughly dry, which will be in about two or three days, another slight coat of varnish must be put all round the edge of the cover; but this time it is better to use the sealing-wax varnish. The slide must then be put aside for a day before it is covered with the ornamental paper covers—if these are used—if not, another thin layer of sealing-wax varnish, or what is much better, Berlin black, may be applied, and the name and date written on a small paper label, or the glass itself may be written upon with the writing diamond. It is always well to put the date of the day when mounted, as this is often a great guide in fluid and other preparations as to the properties and quality of the various cements, fluids, &c., used in their preservation.

Slide 2. *Eye of House-fly* (*Musca domestica*).—Catch and kill one of these insects. Cut off the head as in A, Fig. 1, Plate 5; then separate one eye from the head, as seen in A, Fig. 2; soak it in a solution of potass until it becomes soft and all the extraneous matter is separated from it, which process assist by gently brushing it with a soft hog's-hair brush until it is clean; let it lay in the potass at least two hours before using the brush; wash well in warm water and then in cold; slightly dry by placing it on a piece of blotting-paper and remove to a small piece of cardboard, which place in the object holder of the drying apparatus (see Fig. 27) until dry, which, as the object is small and of thin texture, will soon occur. Remove it to a glass slip which has been duly centred; but care should be taken that it is not placed on the drop of ink, but immediately opposite to it on the other and clean side; trim the edges with a scalpel, then proceed in the same manner as described for mounting the wing of a butterfly; press the thin glass slightly after applying the soldering rod, so as to make perfect adhesion between the glasses and the gold size, and it is as well to see that all cements are perfectly dry before covering with paper—that is if covers are used—which I do not recommend if the objects are to be mounted for study, for though they make the slides look better they greatly interfere with any alterations and observations which the student may desire to make. But as some persons may prefer to cover their objects, I give a slight sketch of the way to proceed. At Plate 1, Fig. 42, is a representation of a slide in the same stage of progress as the eye of the house fly, a description of the process of mounting which we have just given; it also roughly represents the same object. A piece of paper $3\frac{1}{2}$ inches by $1\frac{1}{2}$ inch is cut from a sheet coloured red on one side and gummed on the other; this paper is sold at most stationers' (or the pieces already cut in packets of 100 may be bought of most opticians); a hole is then punched in the exact centre (see Fig. 43); a wet brush is then passed over the gummed surface, and the slide laid upon it, so that the hole may come exactly in the centre of the thin glass, only on the opposite side; then, with a sharp pair of scissors, cut the paper as represented in the dotted line, Fig. 43; the gummed surface must then be moistened, and the edges folded over the glass slip very tightly, as shown in Fig. 44; after all the four edges are brought over, the ornamental cover must have its gummed surface moistened with the brush, and laid so that its hole, which has been previously punched out, shall be exactly in the centre of the slide, and also if possible of the thin glass square or cover; round or oval labels of white gummed paper must then be placed at the top and bottom of the slide, and the name and date written thereon (see Fig. 45).

Slide 3. *Scale of Roach* (*Leuciscus rutilus*).—Take a few scales from this or any other common fish, place them in a weak solution of potass for a few hours, so as to loosen the remaining pieces of membrane and pigment cells; then put them into one of the small white porcelain saucers, and with the hog's hair brush gently brush the remaining matter from them; put them in a basin of warm water for half an hour and wash, then transfer them to a glass slip, cover with another, put the slips between an American paper clip and leave until dry. As the object is rather thick and requires a cell, cut a piece of cardboard seven-

Plate 1.

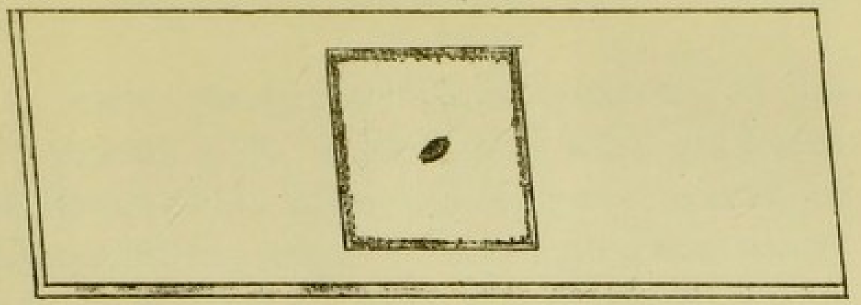


Fig. 42.

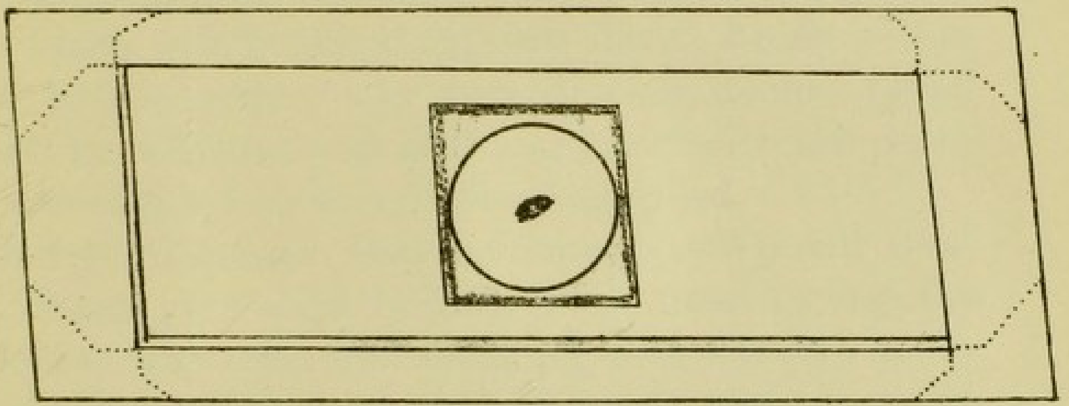


Fig. 43.

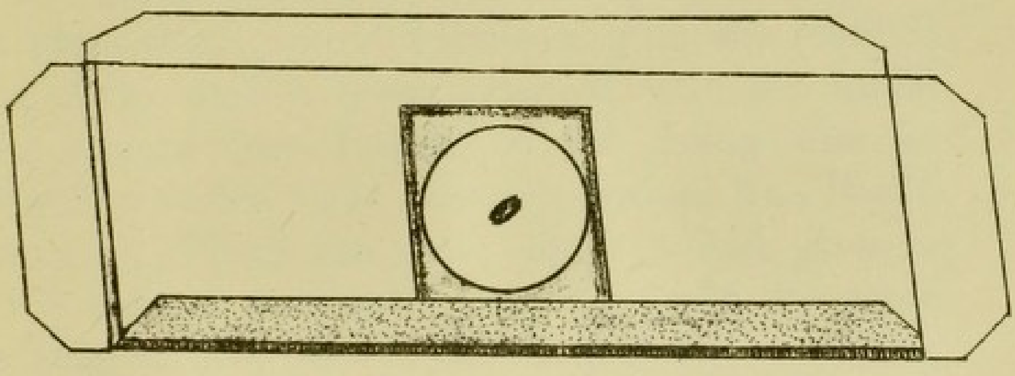


Fig. 44.

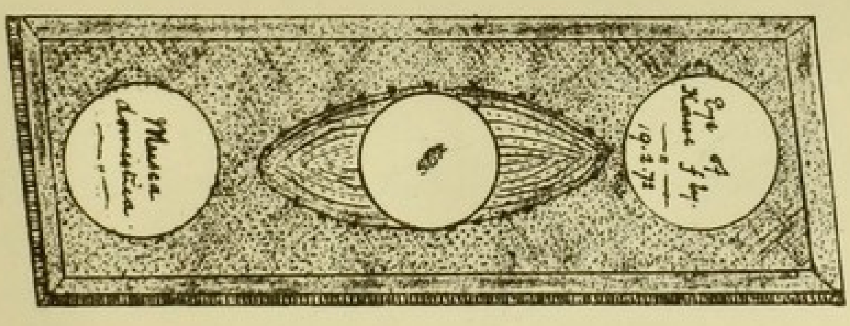


Fig. 45.

eighths of an inch square, punch a hole exactly in the centre, and cement it to a glass slip with gold size cement (see Recipe 64); place the object in centre of this cell, and round the edges of the thin glass cover, which should be $\frac{3}{4}$ths of an inch square, draw a thin line of the same cement; then place this cover on to the cardboard cell and let it remain until thoroughly dry, which will be in about two days; brush a thin layer of the sealing-wax varnish (see Recipe 7) all round the edges of the cell, and cover with the paper and ornamented cover as before described.

Slide 4. *Diatoms* (*Diatoma vulgare*).—We will treat this object in a slightly different manner, giving the process of mounting and finishing with the turn table. This object may be obtained in nearly every wayside pond and pool, and for the method of collecting it, and also other species of diatoms, see Chapter VI. On a glass slip, ground edge (see Fig. 46, plate 2), turn a circle with a brush charged with the india-rubber cement (see Recipe 5); in doing this use Dr. Matthews' turn table (see description, &c., Fig. 5, Chapter I.) Place the slide under a bell glass, so that the cement may get nearly dry. In the mean-while take a drop of the distilled water containing the diatoms (see Chapter V.), and evaporate it on one of the small glass circles. Use size three-eighths or four-eighths of an inch, place this with the diatoms inside, on the ring of cement, which should be nearly dry (see Fig. 47, Plate 2); then with a small camel's hair brush, charged with a very small quantity of the india-rubber cement, paint round the edge of the thin glass circle a thin layer of the cement, and let the whole remain until quite dry, say one or two days. When dry lay another thin layer over the last —only use the turn table this time—dry, and repeat the process until a nice even ring of cement is formed, then finish with one coating of Berlin black varnish, or use gold size mixed with lampblack. I find that a good body is made by putting a small quantity of gum damar varnish to the Berlin or Brunswick black; it dries well, and takes off the brittle properties of the Brunswick black, which is very liable to fly when dry. It may now be labelled, the name and date written, &c. (see Fig. 48, Plate 2).

Slide 5. *Section of Human Bone.*—Place a piece of this or any other bone between the plate and the screw of the holding screw (see Fig. 6); then with the fine saw (Fig. 22) cut as thin a section as possible. Take this section and cement it to one end of a glass slip with Canada balsam cement (see Recipe 65), then place the slip in the holding screw, and with a coarse file file it until it is moderately thin, then use a finer toothed file for a short time, then warm the balsam and remove the section, which again cement to the glass slip on the side that has been ground; when fixed, repeat the process on the other side until it is thin enough to show the structure of the bone when placed under the microscope. Soak in ether or benzole for ten or fifteen minutes to remove all grease from the section; polish on a small marble slab with Tripoli powder and water; when sufficiently polished well wash in warm water, and place between two slips until thoroughly dry, after which it must be removed to a square cardboard cell in which a hole has been punched out (see Figs. 49 and 50). The thin glass cover may then be cemented to the cell, in the same

Plate 2.

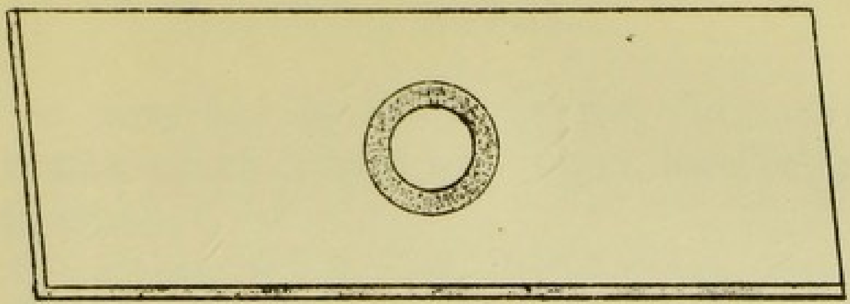


Fig. 46.

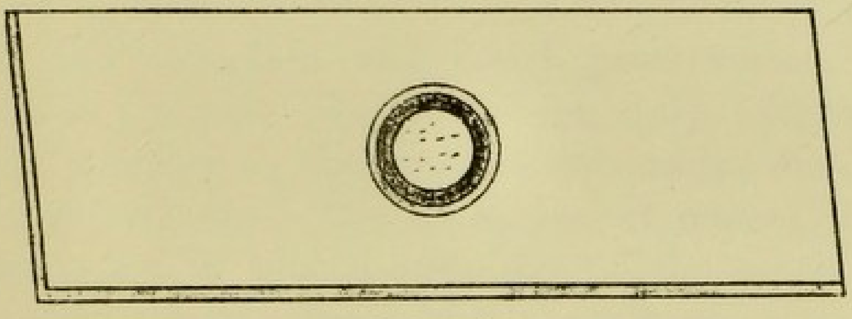


Fig. 47.

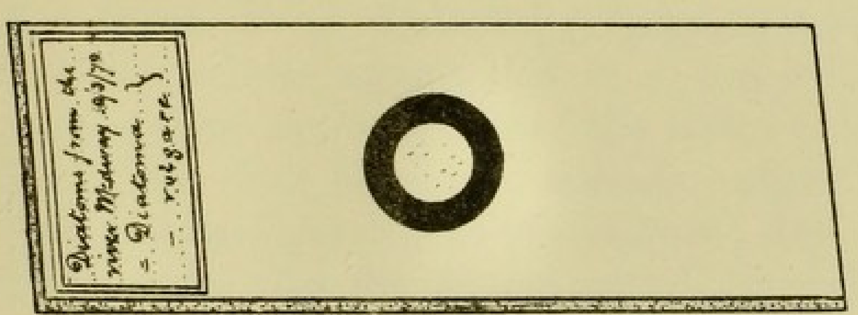


Fig. 48.

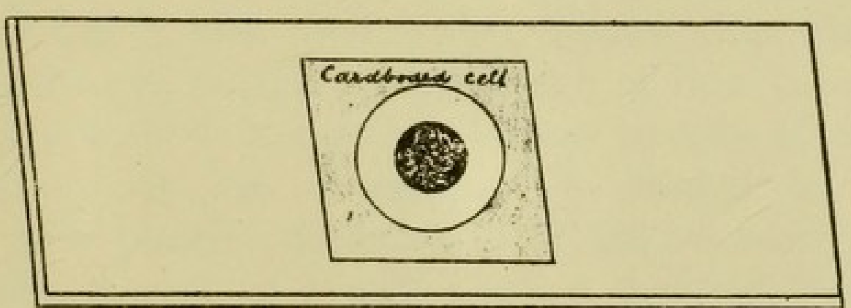


Fig. 49.

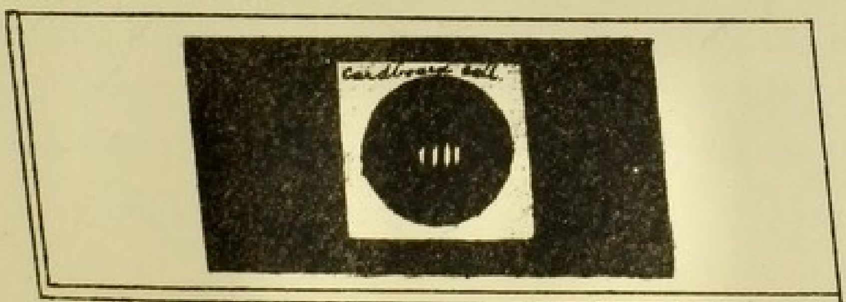


Fig 50

manner as described in mounting the wing of the butterfly, after which it must be covered, labelled, and named as usual.

Slide 6. *Pollen Bird's Foot Trefoil* (*Lotus corniculatus*).—The process of preparation for mounting this object is quite easy, the only care to be taken is that the object is thoroughly dry, which it will be if the rules for the collection and rough preservation, as described in Chapter VI., have been duly followed. It may be mounted in the same manner as the diatom (*Diatoma vulgare*), with the exception, of course, that the pollen must be placed quite dry on the centre of the thin glass circle, after which the process may be followed exactly.

Slide 7. *Spores of an Equisetum* (*Equisetum telmatéia*).—It is as well to mount this in a temporary manner, as the chief characteristic of the spores is the contraction of the four elaters or threads under the influence of even a slight degree of moisture; and as this moisture evaporates the elaters uncurl, generally with some degree of force, so as to cause the spores to spring about in a remarkably life-like manner. A cardboard cell is best used with a square thin glass cover fitted to it, having a small hinge of thin paper. When it is desired to observe the movements of the spores the thin glass cover may be turned back, and the slide placed on the stage of the microscope. If a slight current of breath is then directed upon the open cell, the spores may be seen to move as if endowed with life. When finished with, the thin glass cover may be kept in its place with a small elastic band passed over the slide, after which a label may be attached at one end of the slide, bearing on it the name and date. It may then be placed in the cabinet or rack box with the other objects.

Slide 8. *Transverse Section of Rush* (*Juncus communis*).—A piece of the stem of this rush, about $1\frac{1}{2}$ in. in length, must be placed in melted wax until it is well saturated with it. In doing this one of the small white porcelain saucers must be used, and the wax kept at the melting point with the aid of the hot-water bath described in Chapter I., page 44. When the piece of rush is well saturated with the wax it must be taken out; and, when cold and well set, thin sections may be cut from it with a sharp scalpel. To separate the wax from these sections they must be soaked in benzole or ether until it is thoroughly dissolved. To be quite certain of this the section had better be put into some fresh benzole, even after it appears to be quite freed from the wax; then dry in the apparatus for drying objects (Fig. 27), after which it may be mounted in the same manner as the diatoms (*Diatoma vulgare*), only great care must be taken that the varnish cell is deep enough for the section; care also must be taken in placing the first thin layer of cement, so that it may not run into the cell. A thread passed round, just under the cover, will be found useful to prevent this. Finish as usual. The method of preparation used for this section must be followed in nearly all sections that are taken from cellular or porous parts of plants, especially where they do not contain much water, as in elder and other piths, &c. In section of fruits, vegetables, &c., and where the substance is soft and succulent, the support of the wax is not required, the cells being so closely together that they support each other.

Slide 9. *Transverse Section of Oak* (*Quércus róbur*).—For the exact method of cutting sections of woods, see Chapter V., also page 6. After the section is cut it must be mounted in a paper or cardboard cell, in the same manner as described for mounting the wing of the butterfly.

Slide 10. *Cuticle of Ivy* (*Hedera helix*).—For the methods of separating this and other cuticles of leaves, see Chapter V. It may be mounted as follows:—After the cuticle has been separated from the leaf float it in a white saucer, then place one end of a ground edge slip under the cuticle whilst it is floating in the water, then gently guide it up the glass slip with a camel's hair brush until it is quite in the centre of the cell (see Fig. 46, Plate 2). All the water may then be drained from it; then place it to dry under a small bell glass. In some cases it will be found to curl up from the glass when dry. When this is the case it is as well to mix a small quantity of gum water with the water that is used for floating the cuticle—this will make it adhere. If the glass is at all dirty round the edges of the cuticle clean it with a damp camel's hair brush, then finish the slide in the same manner as described for mounting the diatom (Slide 4).

Slide 11. *Monopetalous Corolla of Pimpernel* (*Anagallis arvensis*).—Dry this monopetalous corolla in the same manner as described for drying petals in Chapter V.; after which it must be mounted and finished in the same way as Slides 1 and 2 (see Plate 1, Figs. 42, 43, 44, 45).

Slide 12. *Sulphate of Lime* (So_2Cao'').—A solution of this salt is taken at its full strength, which is the exception to the general rule, as crystals form in greater beauty and regularity if a lesser strength than a saturated solution is used. A drop from this is placed with the pipette, in the centre of a cell like Fig. 46; it must then be allowed to evaporate naturally. When needle-like crystals of the sulphate of lime are formed, the slide may then be finished in the same manner as Slide 4. For future information in regard to forming various crystals, see Chapter V.

In mounting objects by this method great care should be taken that the object is perfectly dry before it is mounted. Such as leaves, petals, &c., may be dried as described in Chapter VI.; others, such as pollen, are best dried naturally, except when they are mounted with the anther and stamens, when the use of the drying apparatus (Fig. 27) is the best mode of treatment. If the student has sufficient of the material that he is about to mount, it is as well to put a small quantity into one of the small test tubes, or into one of the test bottles—these must be previously quite clean and dry—then place it on the hot plate, when if any moisture occurs on the inside of the bottle or tube, of course it is not dry. And even such a small amount of moisture will nearly always cause fungoid growths on the object, or at least on the inside of the cell in which they are mounted. It is always the best plan with transparent objects, when mounted dry, to keep them in the centre of the cell by the pressure of the thin glass cover alone, but occasionally this is almost impossible, in which case gum water—made from the very best white gum Arabic, and well filtered through blotting paper—is the substance generally used. The plan is this: A small drop, less in size than the object, is placed in the centre of the cell; it must then be allowed to dry, after which one of the smallest camel's hair pencils or brushes must be dipped in water, and the surface of the drop of gum moistened sufficiently to hold the object which is placed on it. Care must be taken that it is thoroughly dry and well fixed; it may then be finished as usual. In mounting objects dry, care must be taken that both the glass slip and the thin glass cover are perfectly dry and clean. Many objects, such as diatoms, scales of insects, many pollens, &c., do not require to be fixed to the glass in any way, as they possess great holding power in themselves. When varnish or cement cells are made it is always the best plan to do a large quantity at one time, say five or six dozen, for—as well as its being a saving of time—by the time one or two dozen have been turned, the hand acquires greater skill and nicety; and again, by the time six dozen are done, if required, the first may be taken, and the cell made deeper by the application of another layer of cement or varnish. The cells that I find the best for dry mounting are cement and varnish for shallow cells, with a slight ring of paper placed on them when nearly dry. I find this prevents the varnish running in after the thin glass cover is applied; I also often use a small piece of thread for the same purpose. For thicker cells use cardboard, if paper covers are to be used; if not, the ebonite, glass, metal, or india-rubber rings form the best cells. Gutta-percha I do not recommend for use in the form of cells. Especial care should be taken that all cells should be well fixed to the glass slip.

55. *Dry Opaque Mounting.*—We will now take the

remainder of the glass slips and thin glass covers; clean them well and proceed with the twelve opaque objects as follows :—

Slide 13. Foraminifera from sea-sand. R.E.

Slide 14. Spines of a brittle star-fish (*Ophiocoma rosula*). R.E.

Slide 15. Spore cases of a fern (*Polypodium vulgare*). Wooden slip.

Slide 16. Stamens and pollen of the mallow (*Malva sylvestris*). G.E.

Slide 17. Seeds of red campion or lychnis (*Lychnis dioica*). G.E.

Slide 18. Eggs of a butterfly — common garden white (*Pieris rapæ*). G. or R.E.

Slide 19. Palate periwinkle (*Litorina litorea*). R.E.

Slide 20. Pollen of convolvulus (*Calystégia sépium*). R.E.

Slide 21. Peristomes and capsules of a moss (*Hypnum rutabulum*). G.E.

Slide 22. A British weevil, often called the British diamond beetle (*Polydrosus pterygonialis*). R.E.

Slide 23. A lichen (*Parmelia parietina*). G.E.

Slide 24. Crystals of silver. R.E.

Slide 13. *Foraminifera, from Sea-sand.*—The process of cleaning foraminifera is described in Chapter V. The best method of dry mounting when an opaque view is required is to mount them as shown at Fig. 49, Plate 2. This plan allows for their being seen with the parabolic reflector and Lieberkuhn combined. The method is as follows :—Take a rough edge slip, centre it in the Matthews' turn table (Fig. 5); then, with Berlin black varnish, Recipe 66, or any other good black varnish, Recipe 11,

&c., turn a disc of the varnish exactly in the centre of the slip (see Fig. 49); allow this to dry; then, with the gold size cement, Recipe 64, fasten a cardboard cell, so that the disc of varnish may be exactly in the centre of this cell; allow this to dry, and with a fine camel's hair brush gently lay a thin layer of the cement, Recipe 3; allow this to dry slightly (it never gets thoroughly hard); then place the foraminifera in the exact position that you require, let the slide stand under glass for about twenty-four hours to dry; cement the thin glass cover on with the gold size cement previously mentioned; cover and finish as usual.

Slide 14. *Spines of a Brittle Star-fish* (*Ophiocoma rosula*).—After the spines have been well cleaned and dried (see the process for cleaning spines and spiculæ, Chapter V.), they may be mounted in the following manner: Cut a slip of black paper $1\frac{3}{4}$th of an inch long by $\frac{7}{8}$th of an inch wide; it is as well to cut a few dozen this size; slightly touch each end of the black side with gum and damp the centre, then lay it on the ground edge slip in the manner shown in Fig. 50; place this under slight pressure, so as to keep the paper smooth whilst drying; when dry, cement to the other side of the glass slip a cardboard cell (Fig. 50). In doing this use the gold size cement; when dry place in the centre of the cell a small quantity of cement (see Recipe 2), which has been previously coloured to a sandy tint; slightly touch the cement with the soldering rod, and fix the spines immediately, or the gum cement (Recipe 3) may be used instead; fix the thin glass cover on, and finish as usual.

Slide 15. *Spore Cases of a Fern* (*Polypodium vulgare*).—Many persons prefer mounting their dry opaque objects on wooden slides, which are now made and sold in large quantities. Fig. 51, Plate 3, shows this object as it appears when mounted in one of these slides. For objects that do not require much care this method is one of the best. The piece of fern, after it has been thoroughly dried by pressure in the usual manner, has only to be fixed to the bottom of the cell, the thin glass circular cover applied, a slight coating or ring of the gold size cement (Recipe 64) painted round it, and the paper ring cemented with gum, so as to hide the edge of the thin glass cover; it only then requires to be labelled and named. From these remarks the student will see that the process is extremely easy.

Slide 16. *Stamens and Pollen of Mallow* (*Malva sylvestris*).—After this object has been thoroughly dried in the object-holder of the drying apparatus (see Fig. 27, also Chapter V.), it may be mounted as follows:—Take a ground edge slip, centre it in the Matthews' turn-table (Fig. 5), and with a brush, charged with the Berlin black varnish, turn a disc about four-eighths of an inch in diameter; allow this to dry, then cement one of the ebonite cells to the glass slip with the india-rubber cement (Recipe 5), so that the varnish disc may form the opaque bottom of the cell (see Fig. 52). When dry, place in the centre of this cell a small piece of a cement, previously coloured in purple and pink shading to resemble the petal of the flower (see Recipe 2); but the cement need not show if care is taken to use a small quantity only. Place the stamens on this

Plate 3.

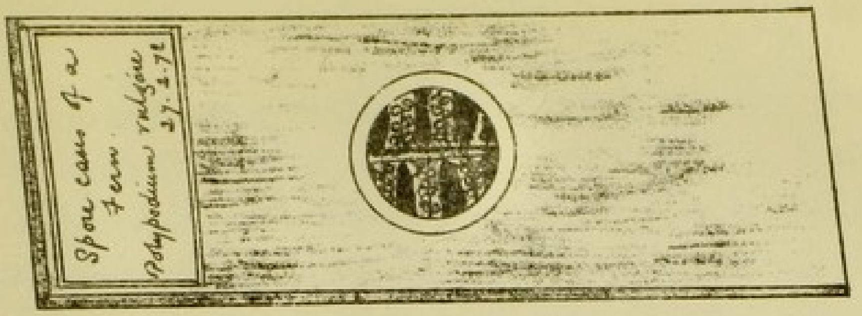


Fig 51

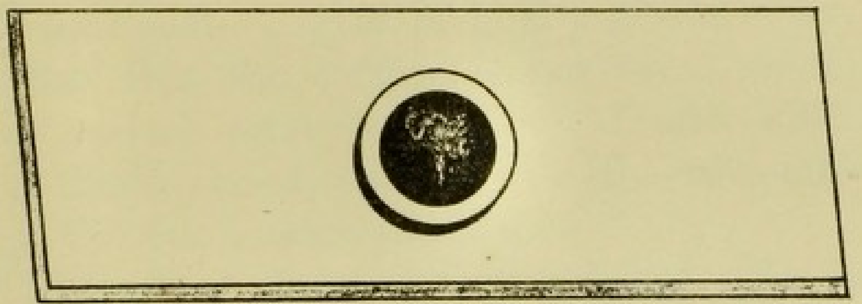


Fig 52

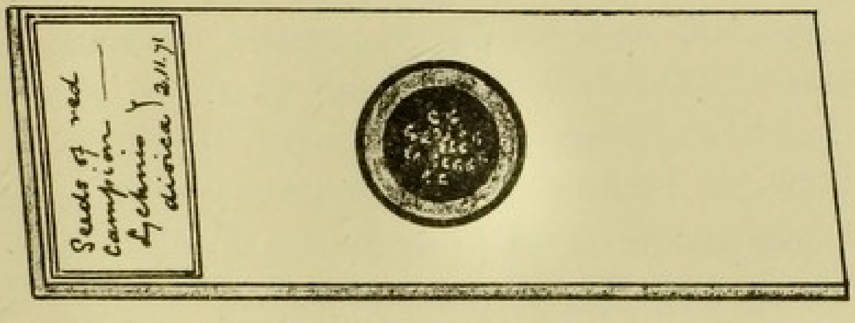


Fig 53

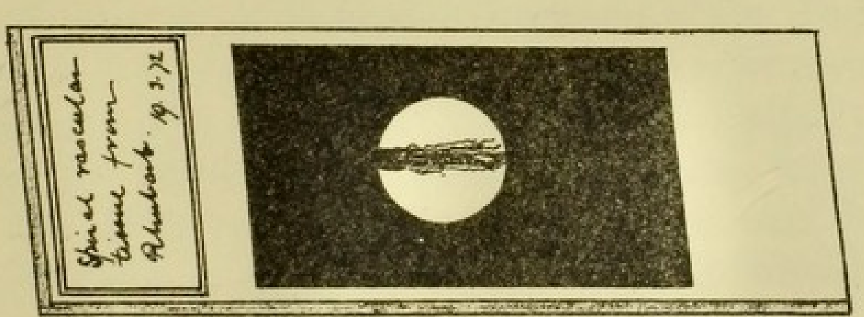


Fig 54

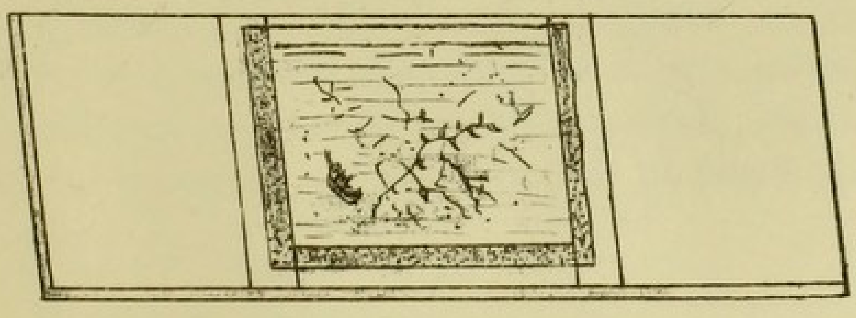


Fig 55

drop of coloured cement, touch the edge of the thin glass cover with gold size and let it nearly dry, then place it on the cell, and when thoroughly dry—which will be in about twenty-four hours if the gold size is good—paint round the edge a very thin layer of gum and whiting (Recipe 67). Let this dry; with the turn-table turn another layer of gold size—let it dry; and if, after this, the surface is not even, another coating of varnish must be applied. Finish with a coating of Berlin black, put on with the turn-table. When dry, label and name as usual.

Slide 17. *Seeds of Red Campion or Lychnis* (*Lychnis dioica*).—This object may be mounted in one of the wooden slides, as described for Slide 15, or in a cell like the preceding object; in which case, perhaps, it is advisable to make, in the centre of the cell, a small cup-like body out of the cement (Recipe 2), which has been previously coloured a whitish green; or, if the manipulator prefers it, all these opaque objects may be fixed with the gum and glycerine (Recipe 3); the slide may then be finished as described for Slide 16.

Slide 18. *Eggs of a Butterfly, Common Garden White* (*Pieris rapæ*).—Eggs of moths and butterflies, as mentioned in Chapter V., show best when mounted opaquely, especially the large ones, after the larva has forced its way out of the shell. The smaller ones may be killed by the action of hydrochloric acid (if previously pricked, whilst in the egg state), but the former method I find to be the best. A small drop of cement (Recipe 2), coloured black, should be placed in the centre of the cell, and the eggs fixed to it by a minute drop of gold size thickened with lampblack; or the eggs may be mounted on a small disc of cardboard

$\frac{1}{16}$th of an inch in diameter, previously fixed to the centre of the cell, and coloured a dull black with Indian ink. The eggs may then be mounted on this with gum water, using an extremely fine camel's hair brush. Finish in the same manner as Slide 16.

Slide 19. *Palate Periwinkle* (*Litorina litorea*).—After this palate has been dissected from the mollusc, as described in Chapter V., and after it has been well washed, it must be mounted as follows: Take a rough edge slip, which already has a piece of black paper fixed on one side (see description, Slide 14), place the palate on the other and clean side, stretch it exactly across the middle of the glass slip parallel to its length; at each end of the palate, and before it is dry, put a drop of the india-rubber cement (Recipe 5). Let it dry thoroughly; then take a thin glass cover, $1\frac{1}{2}$ inch by $\frac{3}{4}$ inch, to each corner of this, cement a small piece of cardboard with the gold size cement (Recipe 64); when thoroughly dry cement this cover over the palate by touching the cardboard with the cement and immediately fixing it to the glass slip, so that the palate may come exactly in the centre of the cover, parallel with its length. The sides that are left open must then be closed with the cement (Recipe 5 or 6), using the solder rod in doing this. Make the edge of this cement neat and smooth, after which the slide may be covered in the same manner as Slide 14.

Slide 20. *Pollen of Convolvulus* (*Calystégia sépium*).—This object, after it has been thoroughly dried, as described in Chapter V., may be mounted in precisely the same manner as Slide 14, only care must be taken when the cement is laid upon the black varnish disc that an extremely thin layer only is put on, for if this is not attended to, the pollen will absorb the cement and be spoilt. Another and perhaps better plan is to use a black paper disc, cement this to the centre of the cell, and cover with a very thin layer of gum; when nearly dry scatter the pollen over it; when quite dry cement the thin glass cover over all, and finish as usual.

Slide 21. *Capsules and Peristomes of a Moss* (*Hypnum rutabulum*).—These objects show best when mounted on the cement (Recipe 2), which has been previously coloured an olive green. Place a small quantity of this in the centre of a cell, in the same manner as described for Slide 16 (see Fig. 52), using the soldering rod to slightly melt the surface of the cement, after which the capsules must be fixed to it immediately. It may then be finished in the same manner as Slide 16.

Slide 22. *A British Weevil, often called the British Diamond Beetle* (*Polydrosus pterygonialis*).—This specimen ought to have been previously fixed, with its legs and antennæ placed in their proper position, on a gummed slip of card (see Chapter VI). If this has been properly done the gum may be moistened with a fine camel's hair brush and the insect transferred to the centre of a cardboard cell, to the bottom of which a disc of white gummed paper has been added (use *gum tragacanth*). When quite dry the thin glass cover must be cemented on, and the slide finished as usual.

Slide 23. *A Lichen* (*Parmelia parietina*).—This object does not require any previous preparation; simply dry it in its natural position. Cement it to the centre of an opaque cell with the cement (Recipe 2), then follow the same process as described for Slide 16. After which place name and date on the label as usual.

Slide 24. *Crystals of Silver.*—This object is one of the most beautiful of all the opaque objects. The best method of making the crystals is by using the galvanic battery, a full description of the process of which is given in Chapter VII. An easier method is to take a piece of copper foil, place it on a glass slip, make a slight wall of wax round it, and into this cell pour a small quantity of nitrate of silver. When the crystals are properly formed float them on the surface of a basin of water, then take a clean glass slip and gently place it under the crystals; raise one end of the slip gradually, so as to let the water run off, or the silver film may be washed on the slip. When dry mount in a cell, in the same manner as described for Slide 19, after which finish and label as usual.

57. The following objects show well when mounted by the dry process. The letters D.T. signify Dry Transparent method, and D.O. Dry Opaque :—

Human bone, D.T.; elephant's bone (*Elephas Indicus*), D.T.; horse (*Equus caballus*), D.T.; ox (*Bos domesticus*), D.T.; monkey, D.T.; saw fish (*Pristis*), D.T.; rat (*Mus decumanus*), D.T.; ostrich (*Struthio camelus*), D.T.; toad (*Bufo vulgaris*), D.T., &c.

The following sections of teeth are good and typical. Make vertical and transverse sections :—

Beaver (*Castor fiber*), D.T.; human, D.T.; horse (*Equus caballus*), D.T.; eagle ray (*Myliobates*), D.T.; ox (*Bos domesticus*), D.T.; rabbit (*Lepus cuniculus*), D.T.; saw fish (*Pristis*), D.T.; tiger (*Felis tigris*), D.T.; crocodile (*Crocodilus*), D.T.; kangaroo (*Macropus Parryi*), D.T.; seal (*Phoca vitulina*), D.T.; porcupine (*Hystrix cristata*), D.T.; pike (*Esox lucius*), D.T.; lemur (*Lemur ruber*), D.T.; bat (*Vespertilio pipistrelius*), D.T.; Hedgehog (*Erinaceous Europæus*), D.T.; mole (*Talpa Europæa*), D.T.; black bear (*Ursus Americanus*), D.T., &c.

Ctenoid scale of sole (*Solea vulgaris*), D.T.; cycloid scale of eel (*Anguilla acutirostris*), D.T.; ganoid scales of sturgeon (*Acipenser sturio*), D.T.; placoid scale of shark (*Scymnus bovealis*), D.T.; spiculæ of various species of gorgonia, D.O.; spiculæ of geodia barreta and many other species of sponges, D.T. and D.O.; spines of spatangus, various species of echinus, brittle and other star fishes, D.O.; diatoms, many species, D.T.; scales of butterflies, D.T.; scales of butterflies and moths, *in situ*, on the wing, D.O.; foraminifera, chiefly D.O., in some few cases where very transparent, D.T.; Polycystina, D.O.; sections of granites, marbles, limestones, &c., chiefly D.T.; weevils, beetles, and other insects having brilliant scales and markings on the elytra or wing-cases and other parts of the body, chiefly D.O.; heads of butterflies, moths, &c., D.O.; eyes of butterflies, flies, bees, &c., if before dissection, D.O., after dissection generally D.T.; gizzard of crickets, and also beetles, D.O.; legs and feet of beetles, D.O.; nests of small spiders, D.O.; galls (minute) and tracts of leaf-mining insects, &c., D.O.; a few spiracles, D.O.; elytra of beetles, such as diamond beetle, &c., D.O.; Diatomaceæ on seaweed, and other algæ, D.O.; shell of orbitolite, D.O.; feathers of humming-bird, peacock, and other birds, D.O.; Flustra foliacea, and a few other zoophytes, D.O.; palates of periwinkle, whelk, trochus, limpet, &c., D.O.; peacock and ruby copper ore, D.O.;

gold dust and small nuggets, D.O.; calyx of deutzia, with siliceous hairs, D.O.; pollens, mallow, convolvulus, D.O.; also all large pollens, and smaller kinds if transparent, D.T.—see Chapter V.; some Raphides, D.O.; capsules and peristomes of hypnum, tortula, and many other species of moss, D.O.; skeleton leaves, D.O.; section of clematis and other stems, D.O.; seeds—antirrhinum, digitalis, verbascum, portulacca, and many others, D.O.; seeds of orchis maculata, D.O. and D.T.; a few algæ, marine and fresh-water, D.T.; spores of equisetum, and also ferns, D.O.; spores of equisetum, D.T.; spores of fungi, D.T.; moulds, brands, rusts, cluster cups, &c., both D.O. and D.T.; sections of spine hedgehog, D.T.; and other spines, bone of cuttle-fish, D.O.; embryo oysters, D.O.; scales of fish, both D.O. and D.T.; also *in situ*, in the skin; starches, D.T.; cuticle of many leaves and petals, best D.T.; spiral vascular tissue from rhubarb, D.T.; scales eleagnus, D.O.; sting of nettle, D.O.; frond Tunbridge film fern (*Hymenophyllum Tunbridgense*); sections of woods, many sections are best dry, D.T.; others in balsam, &c. See Chapter V. Hairs of plants, generally D.T.; lichens, generally D.O.; some acari, D.T., but generally in glycerine, &c.—see Chapter V.; sections of rice-paper and other forms of pith, D.T.; section of rush, D.T.; a few crystals, D.T., &c. This short list will give an idea of the sort of objects that require to be mounted dry. It would be an impossibility to name all the objects separately, but for a general guide in the examination of an object—with respect to the best method of mounting it—it is as well to look at it first as a transparent object; if too thick, then look at it as an opaque object; if not well defined and distinct, try fluid mounting; if this fails to render it transparent, try balsam or dammar varnish. But the student must bear in mind that each object generally requires a separate treatment according to its nature; which knowledge is, of course, best gained by practice. In placing any object into its position in which it is required to mount it, always use the forceps; never, in any case, handle objects, as they are mostly so delicate that they will not bear handling.

When objects are mounted by the opaque process, thin sheets of variously coloured gutta-percha will be found useful, especially for insect preparations (Recipe 62). Occasionally slight fungoid growths arise from using these sheets of gutta-percha, but if corrosive sublimate ($HgCl_2$) is added whilst mixing the colour, this will be prevented.

58. Many objects, such as the scales of fish, &c., require to be dried under pressure. The American paper clips give sufficient pressure for most objects; but when the specimen is very thick, and greater pressure is required, the holding-screw (Fig. 6) will be found useful. When the object is only required to be kept in its place whilst drying, as for example a cuticle, a thin glass cover should be applied, and a moderately strong india-rubber band brought over the slide so as to confine the thin glass cover in its place.

59. *Hairs.*—Scales, &c., of plants are often mounted dry; but to show them well, it is best to mount them in their natural position on the cuticle of the leaf; to do so they should be mounted D.O.; they should also be mounted D.T., and in fluid and balsam; see Chapter III., Chapter IV., and Chapter V.

60. When zoophytes and seaweeds are mounted dry, care should be taken that they are thoroughly freed from sea-salt; to do this, wash well in water and in weak acetic acid, and lastly in warm water to free them from the acid.

61. Many opaque objects show well when mounted in a dry transparent cell, and the diaphragm brought under it so as to form a dark background, especially if the object is semi-opaque. This method of mounting will be found the best, as it can then be seen both by transmitted and reflected light, and by this means the structure will be more fully investigated. Another way to mount opaque objects dry is to grind a hollow cell in the centre of a thick, rough-edge slip. Fix the specimen to the bottom of this cell with a cement, either Recipe 1 or 2, page 61; when fixed, cover with a thin glass square or circle, and allow a very small drop of the Canada balsam and chloroform to run in between the glasses by capillary attraction; but care should be taken that too much is not put, or it will run into the cell and spoil the object. When quite dry, the slide may be covered as usual; by this plan all moisture is kept from the object, and fungoid growths prevented.

62. A good plan for labelling dry and other objects when they are mounted on ground-edge slips (Figs. 46, 47, &c.), is to punch some circles out of very thin talc; cover the edge of the glass slip with a thin layer of gilder's whiting and gum-water; when dry, write on this with common ink; let it dry, put a very small drop of Canada balsam on to it; cover with a circle of thin talc, and allow all to dry; then clean the edges with benzole and water mixed. This

plan will be found a good one—legible and lasting—being superior to writing on ordinary white labels, as these often peel off or get dirty. This kind of label can of course only be used when the rest of the glass is exposed, as in the case of mounting with ground-edge slips.

CHAPTER III.

THE PREPARATION BY THE CANADA BALSAM AND DAMMAR PROCESSES.

63. THERE are many objects, such as insect dissections and polarising crystals, &c., that cannot be mounted in any medium but Canada balsam, though when the dammar varnish comes to be better known, I believe for many of them it will supersede the balsam; but, no doubt, Canada balsam will never be entirely replaced by any medium, for it has certain properties which will always recommend it—not but what the dammar is best for general use, it dries better than the balsam, which alone will make it the most favourable medium for the microscopist.

64. As we followed the plan of taking a series of common typical objects in the process of dry mounting, it will be as well to follow the same course in the method of mounting by the Canada balsam and dammar processes. It is much better to keep both the balsam and the dammar in the collapsible tubes mentioned in Chapter I., Fig. 58, Plate 4, for as well as being the cleanest plan, the balsam keeps much better than in a corked bottle, Fig. 59, Plate 4; the required quantity is also much easier obtained. Take twelve clean slips, rough edge, and the following are

the twelve objects, the process of mounting in Canada balsam taking nine of them, the other three being by the dammar process.

Slide 25. Human flea (*Pulex irritans*).

Slide 26. Palate of whelk (*Buccinum undatum*).

Slide 27. Crystals of chlorate of potass (ClO_2Ko).

Slide 28. Raphides in onion (*Allium cepa*).

Slide 29. Potato starch (*Solanum tuberosum*).

Slide 30. Siliceous cuticle of equisetum (*Equisetum hyemale*).

Slide 31. Fibres of wool (*Ovis aries*).

Slide 32. Fibres of cotton (*Gossypium herbaceum*).

Slide 33. Spiracle of water-beetle (*Dytiscus marginalis*).

Slide 34. Bramble brand (*Aregma bulbosum*).

Slide 35. Spores and sporanges of brake fern (*Pteris aquilina*).

Slide 36. Foraminifera from chalk.

Slide 25. *Human flea* (*Pulex irritans*).—This slide illustrates the method of mounting most of the small insects. The flea must be placed in the liquor potass, and left in it for a few days; when tolerably soft, place it between two glass slips and gradually squeeze out the contents of the abdomen, &c.; use very slight pressure at first, and if it feels at all hard, it must be replaced in the potass until soft, but if it is found that the body gives way to the pressure, it may be increased until all the matter is ejected; then place it in warm water for a quarter of an hour, after which repeat the process until the insect is perfectly clean: it may then be washed in warm water, or, what is much better, silicic acid (for method of making which see Recipe 9); this acid has an affinity for potash, turning it into silicate of potass ($SiKo_4$), which substance is very soluble in water; then well wash in water, place it between glass slips to dry, taking care that the slips have been previously slightly greased, as this will prevent the insect sticking to the slips when dry, which otherwise it sometimes does, and some of its legs are lost in consequence; when quite dry, which will be in two or three days if in a warm room, place it in a small porcelain saucer full of turpentine, cover it with a broken wine-glass, allow it to soak until quite transparent, but do not let it be in the turpentine long enough to lose its colour, transfer it to the centre of a rough-edge slip, and, from the tube containing the balsam (Fig. 58), drop one large drop on to it, then cover with a square, thin glass cover (Fig. 56, Plate 4), and place the slide in the pressure apparatus (Fig. 29) for a short time, so that most of the air bubbles are forced out; then put it in the drying apparatus, or on the warm plate, as described in Chapter I., page 10. When the balsam is quite set and hard, it may be cleaned off with an old knife made slightly hot. When all the superfluous balsam has thus been cleared from the slide—this is best done under water—it may be made quite clean with the aid of benzole or turpentine, used with a rag kept for the purpose; the slide may then be covered and finished as described for Slide 2, Chapter II., page 51, and Figs. 42, 43, 44, 45. If the student does not care to use the silicic acid, washing in warm water will do nearly as well, but I prefer the acid. And again, after being well washed in water, many manipulators prefer to transfer it to spirit (methylated will do), and then take it out, slightly drain it on paper, and transfer it

Plate 4.

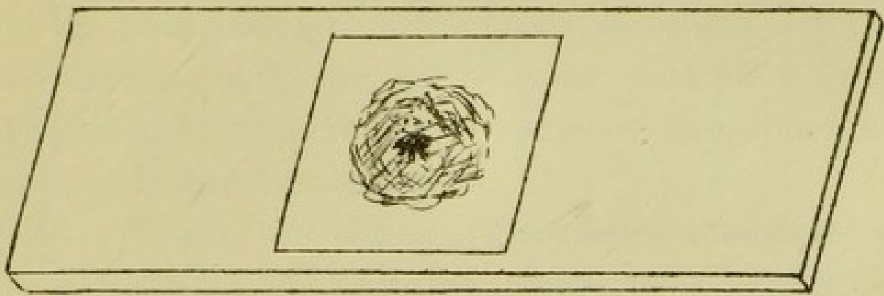


Fig. 56.

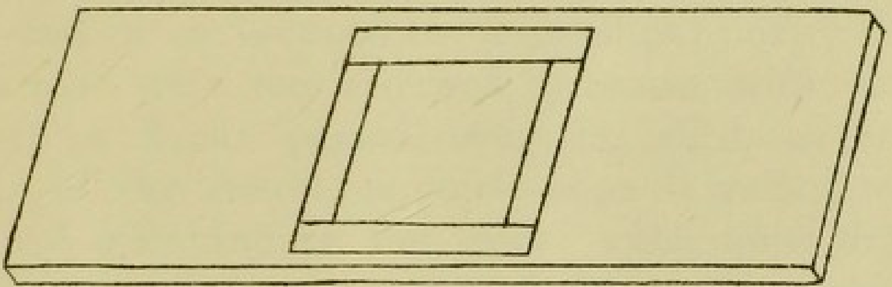


Fig. 57.

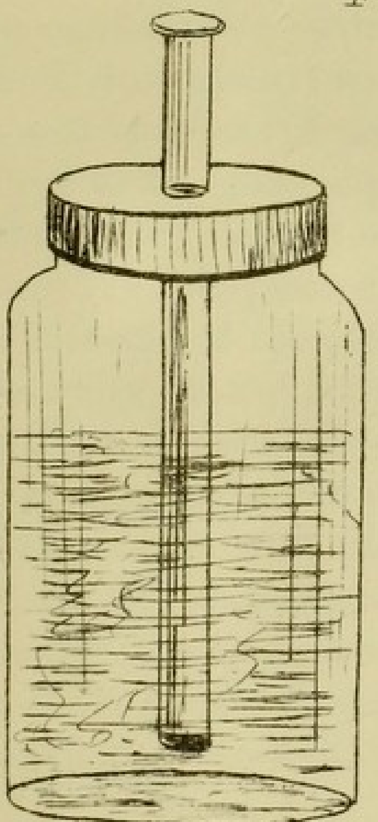


Fig. 59.

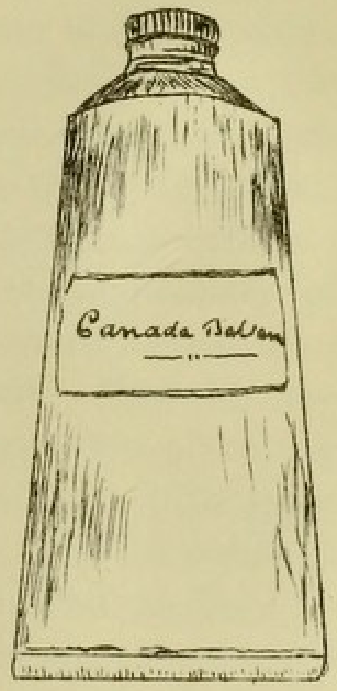


Fig. 58.

to benzole, from thence to the turpentine, and lastly balsam; by this process the object is never dry; it answers tolerably well in many cases, but very great care is required to free it from traces of the spirit by well washing in the turpentine.

Slide 26. *Palate of Whelk* (*Buccinum undatum*).—For the dissection of palates, refer to Chapter V. The palate must then be put into a test-tube with a small quantity of potass, and boiled until clean, which will take about ten or fifteen minutes; then well wash in warm water to free it from the potass, and place between two glass slips to dry; but in this case, give the required pressure with two india-rubber bands passed over the slips, as the pressure of the American paper clips is rather too great, and often injures the teeth; when quite dry, soak in turpentine, using one of the small porcelain saucers; when transparent, transfer to the centre of a cell made as follows:—with a writing diamond cut four slips of thin glass, two $\frac{7}{8}$ths of an inch long and $\frac{1}{8}$th wide, and two $\frac{5}{8}$ths of an inch long and $\frac{1}{8}$th wide; cement these to the glass slip with marine glue, or the cement, Recipe 68, so as to make a cell $\frac{7}{8}$ths of an inch square (see Fig. 57, plate 4); when quite dry, clean off from the inside of the cell any superfluous cement; after it is quite clean, pour in a small quantity of turpentine, but do not allow it to remain longer than two or three minutes, then pour out. Now fill the cell with Canada balsam, and in the centre place the palate of whelk; moisten one side of a thin glass cover, exactly $\frac{7}{8}$ths of an inch square, with turpentine, and drop it on to the balsam, so that all air-bubbles may be excluded from the cell; this is easily done if sufficient balsam has been put into the cell. Place the slide in the drying apparatus (Chapter I., page 9) until dry, then clean and cover as usual.

Slide 27. *Crystals of Chlorate of Potass* (ClO_2Ko).—This is a very beautiful object for the polariscope when well mounted: place a small quantity in the test-tube, enough to occupy one part of a tube graduated into six equal parts; then pour in water two parts, boil until the chlorate is dissolved, then pour over glass slips; allow them to crystallize gradually, and without the aid of artificial heat; when quite dry, pick out the best of them, and again the best one from these, then drop one drop of Canada balsam on to the mass of crystals, and place the thin glass cover on; press gently, so as to squeeze the superfluous balsam out, after which the balsam must be allowed to dry gradually, for if forced with heat the crystals would be spoilt; when quite dry, which will be in a few weeks if only *just sufficient* balsam has been used, for the thinner the layer under the thin glass cover, of course the quicker it dries, then cover and label as usual. Some crystals require different treatment and mounting (see Chapter V.)

Slide 28. *Raphides in Onion* (*Allium cepa*).—These raphides, like most of those that are contained in the sepals, cuticles, &c., of plants, only require to be dried under pressure, and the piece of cuticle or sepal soaked in turpentine, and mounted in balsam. If the raphides require to be tested with the reagents, to ascertain whether they are sulphate, oxalate, &c. of lime, they must previously be moistened with water, or glycerine (if glycerine reagents are used), so as to allow the reagent to pass into the tissues of the leaf, otherwise a slight difficulty in its passage would occur; but for further information in regard to the testing of these bodies, see Chapter VII. Occasionally, where the raphides are not required for the polariscope, they may be mounted in fluids (see Chapter V.); but if mounted in balsam, the slides may be dried in the drying apparatus (Figs. 7, 8), and cleaned and covered in the usual manner.

Slide 29. *Potato Starch* (*Solanum tuberosum*).—I have chosen this starch as it is the largest of all the common starches, for though *Tous-les-mois* is larger, it is not so easily obtained. This potato starch, on account of its size, is therefore much easier to examine. To obtain it pure from the tubers (see Chapter V.) take a small quantity of the dry starch on the tip of a scalpel, and place it in the centre of the centred slips; then drop one drop of turpentine on to it—allow it nearly to evaporate; then drop some Canada balsam on to a thin glass cover, which place on the small lump of starch, but which has been previously spread evenly over the centre of the slip with a dissecting needle, press the thin glass cover gently, and if it is found that the starch lies too thickly in the centre, move the thin glass cover round with a circular motion; this will distribute the granules of starch better than any other plan. The balsam answers very well for these objects, but dammar is much better. If any air bubbles have got into the balsam or dammar they need not worry the student, for if the slide is placed in a warm place—say on a window-shelf, south aspect, or on the mantel over the fireplace—it will be found that they disappear entirely after a few days. It does not matter whether the starch is mounted in balsam or dammar, it must not be dried by the aid of artificial heat, or the granules of starch will be spoilt; but if good dammar or the Canada balsam and chloroform, Recipe 13, is used, it will not take very long to dry. When dry the slide may be cleaned from the superfluous balsam, and finished as usual. Some starches are mounted dry, others in fluid, &c., see Chapter V. For the tests for starch, see Chapter VII.

Slide 30. *Siliceous Cuticle of Equisetum* (*Equisetum hyemale*).—After this cuticle has been separated with nitric acid (NO_2Ho)—see Chapter V.—it must be well washed in warm water. A clean glass slip must then be taken, and the centre, where the piece of cuticle will come, a very thin layer of mucilage, formed from gum tragacanth, must be evenly spread, so that the cuticle will fit on to it as nearly as possible. On this place the cuticle exactly in the position that is required, as it will not be moved again; over this place another glass slip, which has been previously slightly greased to prevent it sticking; then place the slips between an American paper clip. When the cuticle is quite dry take the top slip of glass off, and allow the cuticle to be well soaked with turpentine. At the same time the edges of the piece of cuticle can be cleaned and trimmed with a sharp scalpel. Drain the superfluous turpentine off, and drop a small quantity of balsam on to the cuticle, then cover with a thin glass cover, and press the cover. Place the slide to dry in the drying apparatus, Chapter I., page 9; and, when dry, clean and cover as usual. The cuticle may be mounted without the aid of the gum tragacanth, but on drying it is very liable to curl up and separate from the slip: the gum is used to prevent this. The cuticle may also be mounted in a cell with glycerine, &c., see cuticles, Chapter V. This is a magnificent object for the polariscope.

Slide 31. *Fibres of Wool, Sheep* (*Ovis aries*).—I have taken this object, not on account of its beauty or remarkable appearance, but from its structural characteristics. Its felting power, as has lately been noticed, no doubt proceeds from its sinuous nature, and not from its but slightly imbricated surface, which is much less than the hairs of either mouse, or common bat, and other animals. Wool may generally be distinguished from cotton, &c., by its structural peculiarities, see Fig. 89, Plate 10, and also by chemical tests, &c., see Chapter VII. After being well washed in warm water and dried, it may be further washed in benzole, to free it from any grease, and soaked in turpentine, and mounted in Canada balsam or dammar; dry in the drying apparatus, but use a gentle heat. When quite dry clean with benzole, and cover as usual. For further information in regard to wool, see Chapter V.

Slide 32. *Fibres of Cotton* (*Gossypium herbaceum*).—Vegetable fibres are generally distinguished from animal by potass having little action upon them; whereas, in the animal fibres, they are dissolved by the potass, especially if a slight degree of heat is used, see Chapter V. and Chapter VII. Cotton may be mounted in the same way as the wool, that is, if it is required for the polariscope, with this exception that it does not want to be washed in benzole, being a vegetable fibre, and in its pure state it contains no grease. Like the wool it must be dried with a gentle but continuous heat. Finish and cover in the same manner, care being of course taken that the exact kind of cotton, with the date of mounting, &c., be correctly stated.

Slide 33. *Spiracle of Water Beetle* (*Dytiscus marginalis*).—For the proper method of dissection of this and other spiracles, I must refer the student to Chapter V.; and now take the opportunity to mention that this is done to save undue repetition, as well as the matter being placed in its proper position. After the spiracle, therefore, has been dissected and well washed, and in this case it is as well to pin the piece containing the spiracle or spiracles to a piece of loaded cork, which place in a saucer, and direct a fine stream of water from the wash-bottle—Fig. 13, Chapter I., page 16—on to it, so as to wash it thoroughly. This is not immediately necessary, but if any dust or dirt of any kind remain amongst the fine hairs surrounding the orifice of the spiracle, by this process it will be removed. When washed, dry between two slips of glass, which have been previously slightly greased to prevent the skin and spiracle from sticking to them. For pressure in drying use an American paper clip. When dry soak in turpentine until transparent, and transfer to the centre of a clean ground-edge slip, drop a drop of balsam or dammar on to it, cover with square thin glass cover, press it gently, then place it in the drying apparatus, Chapter I., page 9. When dry finish as usual.

Slide 34. *Bramble Brand* (*Aregma bulbosum*).—The best method of mounting this brand, so as to show the spores well, is to take a fine section, by cutting through the centre of a cluster of this brand, and also right through the bramble leaf; as thin a section as possible must be cut; soak in turpentine until the spores are quite transparent, which will be in two or three days; the section may then be transferred to a clean slip, and mounted in balsam or dammar. Dammar is much the best for this object. The chief difference in mounting, when using this varnish, is to place the thin glass cover over the object, and allow the dammar to flow in by capillary attraction. This method has many advantages, especially when the object is small and requires to be in the centre of the slide; for in mounting with balsam, however much care the learner takes, he will often find a great difficulty in keeping his object in the right place; but by using the dammar this difficulty is avoided. Dry the slide in the drying apparatus, Chapter I., page 9. Use moderate heat. When quite dry, clean with the knife and benzole, and finish as usual.

Slide 35. *Spores and Sporanges of Brake Fern* (*Pteris aquilina*).—The method of collecting these spores is described in Chapter V. Take a small quantity of the spores and spore-cases on the tip of a scalpel, place them in the centre of a clean glass slip, drop one drop of turpentine on to them, cover with a thin glass cover, and let the dammar flow in by capillary attraction; place the slide in the drying apparatus to dry; use moderate heat; when dry, finish as usual. Most of these objects, if preferred, may be mounted on ground edge slips, but if so, the circular thin covers must be used, and when the balsam or dammar is dry, clean with an old knife and benzole, and finish the slide by turning a neat ring of Berlin black varnish with the Matthews turn-table, so that the slide, when finished, will look like Fig. 48, Plate 2.

Slide 36. *Foraminifera from Chalk.*—Boil a small lump of chalk in a test-tube with potass until it separates in powder; put this into an 8-ounce phial bottle and fill with water; fresh water must be added as long as it comes away of a milky tint; the deposit will then consist chiefly of minute foraminifera, &c.; take a small quantity of this powder, place it in the centre of a clean glass slip, then dry it over the spirit-lamp; when quite dry, drop a drop of turpentine on to it; drain the superfluous turpentine off; place a thin glass cover over the foraminifera, and allow the dammar to flow in by capillary action; dry in the drying apparatus; when quite dry, clean with an old knife and benzole; finish and cover as usual.

65. In mounting with Canada balsam or dammar, it is always best to use the collapsible tubes mentioned in Chapter I., for, as well as keeping cleaner than in the stoppered glass bottles, as generally recommended, the balsam also keeps in a much better condition. Thin balsam is generally the best for mounting purposes, as it dries quicker than when old and thick. If, after it is bought, it is found to be too thick, it may be diluted with benzole, turpentine, or chloroform; and if any cloudiness remains after mixing, it will go off in a short time (see also recipe 13). Before mounting any object in balsam, great care must be taken that the object is thoroughly dry. To make quite sure of this, the object, even after being dried in the object-drier (Fig. 27), may be tested in a tube (see Chapter II., page 58). Dampness is known by a cloudiness in the balsam round the object. If this

occurs whilst drying the slide, extreme heat will sometimes clear it; but it is best, if the specimen is valuable, to soak the slide in turpentine and remount the object.

66. Air-bubbles, as I mentioned before, need not trouble the student so much as they generally do, for they will often disperse of their own accord; but if any difficulty is found, the slide must be placed in the air-pump (Fig. 30), and the air exhausted, by which means the bubbles are gradually brought to the surface and dispersed (see also Chapter I., page 29). Foraminifera, and other objects which will stand heat, may be cleared of air-bubbles by boiling in turpentine. But although much mention is made of turpentine as a useful and important medium in which to soak most objects previous to their being mounted in balsam, great care must be taken that the objects are not kept too long in it, for if they are, the colour will be nearly taken away, and the object rendered too transparent either for beauty of structure or definition of form.

67. Objects, when thick, are best mounted in a cell, which may be made of cardboard, thin glass (see Fig. 57, plate 4), and also thicker glass drilled to form cells (see Fig. 36). If cardboard is used, after it is cut it must be well soaked in turpentine before being used; and in mounting objects in a glass cell, always take care to thoroughly saturate the cell with turpentine to get rid of all the air and air-bubbles, after which it must be well cleared from the turpentine by draining. It is best to use the balsam cold in most cases; but if the object does not contain much air, and it is desirable to mount quickly, hot balsam may be used with advantage.

68. For many minute objects the use of the chloroform and balsam will be found the best, as most small objects have a great tendency to flow towards the edge of the cover when mounted in the ordinary way, and the cover applied and pressed down. To check this, touch the centre of the glass slip with a small drop of turpentine; place the object or objects in this, cover with the thin glass, and, whilst slightly pressing the cover, apply at the edges a tube filled with balsam and chloroform (Fig. 58, plate 4), so that the fluid may run under the cover and flow towards and over the object by its own capillary action.

69. I have not tried it myself, but many persons prefer using resin dissolved in benzole and strained so as to clear it from impurities. It is said that it dries much quicker than balsam; and if the resin could be obtained quite pure, it seems to me to be a good medium for general objects. If the object is to be mounted in this medium, care should be taken that it has been previously soaked in pure benzole; the slides may be dried in the same way as Canada balsam.

70. Paper varnish is also often used for mounting many objects: objects mounted in this simply require a previous soaking for a few days in a large quantity of the varnish; a drop of fresh varnish is then placed in the centre of the slip and the object placed in this, and the cover applied as usual. Nearly the same amount of heat may be used in drying the slide as when balsam is used.

71. In all these methods of mounting, the object requires a slight pressure to be applied to the thin glass cover. This can be obtained in many ways; for ordinary use I find fine copper wire twisted round

the slide the best; this will give an even and moderate amount of pressure. Thread may also be used, but the wire is preferable. Again, it is recommended by some manipulators to coat the edge of the thin glass cover with thick gum water. As this dries, the superfluous balsam is squeezed out; and, lastly, an apparatus (see Fig. 29) is used for the same purpose, different degrees of pressure being applied by using elastic bands of different sizes and strength, a full description of which is given in Chapter I., page 28.

CHAPTER IV.

THE PREPARATION OF OBJECTS BY THE FLUID AND SEMI-FLUID MEDIUMS.

72. THE fluid method of mounting had, until lately, greatly gone down in the estimation of microscopists as vehicles in which to mount their various specimens; but glycerine, and the more recently used, if not so useful substance silicate of potass, which appears to be a favourable semi-fluid for certain vegetable objects, when mixed with a small percentage of water, have again caused them to be used. There are many fluids in use, but we will first treat of glycerine, it being the most generally useful, and at the same time the most difficult of all the fluids to mount with, for the various kinds of mediums may generally be sealed with the india-rubber cement; but glycerine being of a viscid nature and having the property of never drying, makes it very difficult to confine it to a cell without its leaking at the edge. The following twelve objects will show the method of mounting with this and also various other fluids:

Slide 37. Section of human bone.
Slide 38. Lung of frog (*Rana temporaria.*)
Slide 39. Gizzard of house cricket (*Acheta domestica.*)
Slide 40. Tongue of snail (*Helix aspersa.*)
Slide 41. Wheat starch (*Triticum vulgare.*)
Slide 42. A zoophyte (*Laomedea gelatinosa.*)

Slide 43. A desmid (*Micrasterias denticulata.*)

Slide 44. Conferva glomerata—a common species of conferva.

Slide 45. Section of a green capsule of a moss (*Bryum hornum*), showing the columella, &c.

Slide 46. Cuticle of a fern (*Polypodium vulgare.*)

Slide 47. Proboscis of house fly (*Musca domestica.*)

Slide 48. Crystals of oxalate of ammonia—

$$C_2 O_2 Amo''_2.$$

Slide 37. *Section of Human Bone.*—After the section of bone has been cut and prepared as described in Chapter V., it may be mounted if desired in glycerine, or what is still better, in glycerine and acetic acid (Recipe 70), a suitable cell having been made for its reception as follows: With a camel's hair brush charged with either gum dammar solution, white cement (Recipe 74), or india-rubber cement (Recipe 5), turn a cell of a diameter suitable for the size of the section of bone. In doing this use the Matthews turn-table (Fig. 5, Chapter I., page 7); and at the same time turn at least one dozen various-size cells for future use. When the cell is quite dry it may be filled with the glycerine fluid, and the section of bone placed in it. The section may have been previously tinted with nitrate of silver (see Chapter V.) if desired; but in any case it must have been previously placed for a short time in glycerine and alcohol. A thin glass cover must then be allowed to fall gradually, so as to cause a wave of fluid to flow onwards (see Fig. 60). The superfluous glycerine must then be removed with the aid of a damp camel's hair brush, washing this and freeing it from the glycerine until all is removed from the edge of the cell. A very thin layer of dammar varnish must then be painted round the edge of the cover, care being taken that a fresh brush is used, and that the varnish is laid evenly and thinly round the edge, but sufficient being put to embrace both the edge of the thin glass cover and the cell previously made. When quite dry it must again be washed with a damp camel's hair brush, and the brush constantly freed from glycerine. When all traces of glycerine have been removed, another thin layer of cement must be applied and allowed to dry; after which, to make quite sure that all the glycerine has been removed, it must be washed once more. When quite dry after this washing, a layer of gold size must be applied. In this case the Matthews turn-table (Fig. 5) must be used to cover all the inequalities of the surface made by the previous layers of cement. When dry it may be finished by applying a thin layer of Berlin black varnish, using the turn-table; after which the slide may be finished and labelled as usual.

Slide 38. *Lung of Frog* (*Rana temporaria*).—If injected with the carmine fluid, it may be mounted in glycerine in the same manner as described for the previous object. Most injections show well when mounted in glycerine, or glycerine and acetic acid, though chloride of zinc will be found useful in many cases.

Slide 39. *Gizzard of House Cricket* (*Acheta domestica*).—This object when mounted in glycerine shows well; but for the sake of an illustration of the process we will mount it in silicate of potass. This, when procured at the shops, is too thick for use; it must therefore be diluted with distilled water until it flows freely, which will be when about $\frac{1}{4}$th of water is added to $\frac{3}{4}$ths of the silicate. A cell having been made of cement, as in Slide 37, the gizzard of cricket, which has been previously dissected, opened, and cleaned, (see Chapter V.), must then be placed in the centre of the cell and sufficient silicate of potass to fill the cell added; a thin glass circular cover must then be gradually lowered over the object, (as in Fig. 60); when this cover has been placed in position, if any air-bubbles occur, the slide must be transferred to the air-pump, Fig. 30, and the bubbles got rid of in the usual manner. Air-bubbles will be found the chief fault in this medium. When the air-bubbles are all gone, the silicate of potass must be allowed to dry

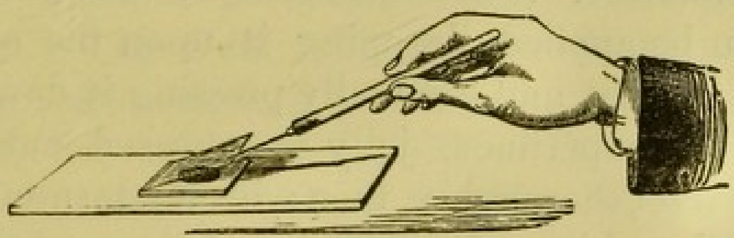


FIG. 60.

gradually; if, in drying, any space is left between the thin glass cover and the slide, it must be filled up by the addition of more silicate. When quite dry it may be cleaned with water and camel's-hair brush, and finished by turning a ring of gold size, dry, and repeat with Berlin black, in both cases using the turn-table; it may then be finished as usual. This object also shows well in balsam, glycerine-jelly, &c.

Slide 40. *Tongue of Snail* (*Helix aspersa*).—After the tongue has been dissected from the snail and cleaned (see dissections, Chapter V.), it may be mounted in glycerine, Deane's compound, glycerine-jelly, &c. I prefer the glycerine-jelly which is as follows: After the tongue has been well washed it must be drained of all superfluous water, but not allowed to dry. The glycerine-jelly having been rendered liquid by placing the bottle in hot water (Recipe 60), a large drop of it is placed in the centre of a suitable size cell made of cement (see Slide 37); this drop must be examined to see that it has no air-bubbles in it: if it has it must be placed under the air-pump, Fig. 30, and the bubbles got rid of in the usual manner, or if the student has not obtained an air-pump, a fresh drop of jelly must be taken. When quite free from air-bubbles, the tongue, which must be still moist, should be gently placed in the centre of the drop of jelly, care being taken to avoid making any fresh air-bubbles. A *moistened* circular thin glass cover must then be applied, dropping it upon the centre of the drop of jelly, and gradually pressing it downwards until all the superfluous jelly is squeezed out at the edge; let it set thoroughly, then with the turn-table turn a ring of the white cement (Recipe 74) round the edge of the glass cover so as to hide the edge; when dry, finish with one or two coats of Berlin black applied with a camel's-hair brush in the same manner. Finish as usual.

Slide 41. *Wheat Starch* (*Triticum vulgare*).—After the starch has been separated from the gluten by the usual process of washing (see Starch, Chapter V.), a small quantity may be taken and mounted in a suitable fluid (Recipe 52) in a shallow cell, proceeding in the same manner as Slide 37; only in this case the superfluous fluid may be entirely soaked up by using small strips of blotting-paper; when quite dry at the edge it is best to use the india-rubber cement

(Recipe 5) for sealing the cell; after which a layer of the white cement (Recipe 74) must be put on by using the turn-table: finish with Berlin black as usual.

Slide 42. *A Zoophyte* (*Laomedea gelatinosa*).—This, together with other species of zoophytes, should be killed quickly, so that the tentacles are extended (see Chapter VI.) They may be mounted in many ways, in Deane's compound, glycerine-jelly, chloride of calcium, and in fluids (Recipes 44, 52, 54, 72, &c.); but I prefer a fluid of nearly the same density as that in which they live, which I make, by adding to 6 ozs. of fresh sea-water a $\frac{1}{4}$ oz. of proof-spirit, in which six drops of creosote have been dissolved; in this fluid I always keep a small lump of camphor constantly floating; a small percentage only dissolves in the sea-water. This fluid will also be found useful in mounting marine algæ, &c. The process of mounting the zoophytes varies but little from the method used for other objects in fluid; a suitable cell, both in size and depth, being chosen. In some cases where the zoophyte is large, a glass cell like those at Fig. 36 will be required, in which case great care must be taken that all air-bubbles are excluded. All the branches or polypidoms must be neatly placed, and the tentacles of all the polypes being extended where it is possible; in doing this use one of the smallest camel's-hair brushes fixed in a suitable cedar-handle; the cover may then be applied and sealed with any of the proper cements as used for Slides 40, 41, &c., it may then be finished and labelled as usual.

Slide 43. *A Desmid* (*Micrasterias denticulata*).—The process of collecting desmids is described in Chapter VI., and the method of separating them from the mud, &c., at Chapter V. Many fluids have been recommended in which to mount these delicate organisms, the best of which will be found in Recipes 75, 72, 54, 52, 12, &c., but I prefer glycerine alone, which is added in a gradual manner so as to prevent the rupture of the primordial utricle: a description of the process is given at Slide 45; in all other respects the desmids may be mounted in a shallow cell and sealed with the same cement as described for Slide 37, page 87, the size and depth of the cell being of course much less. Finish as usual.

Slide 44. *Conferva Glomerata—a Common Species of Conferva.*—A few threads of this conferva must be taken and mounted in a shallow cell in precisely the same manner as described for the following object in Slide 45—but if desired it may be mounted in a suitable fluid, Recipe 72.

Slide 45. *Section of a Green Capsule of a Moss* (*Bryum hornum*), *showing the Columella, &c.*—A cell having been made by the aid of the turn-table, Fig. 5, of a depth equal to the thickness of the section of the capsule, which section must be made in the manner as described in Chapter V., page 126, the capsule having been previously embedded in the wax, it must then be taken and put in a solution as follows: Mix 4 parts alcohol, 3 parts water, 1 part glycerine; place this fluid in a bottle or jar having a wide open mouth; in this place the object or objects (for it is as well to do more than one, as it saves time and trouble); place the jar or bottle in a warm place, so as to allow the alcohol and water to evaporate, leaving the object in the glycerine, which does not evaporate. It is better to keep the jar under a large bell glass whilst the fluids are evaporating, as it keeps them from dust; but this is not absolutely necessary if the room is not very dusty. The above plan prevents rupture of the primordial utricle from the action of osmosis, &c. The section of capsule, desmids, &c., may then be transferred to pure glycerine, and mounted in a shallow cell like any other object that is preserved in glycerine.

Slide 46. *Cuticle of a Fern* (*Polypodium vulgare*). For the method of separating the cuticles of leaves, &c., (see Chapter V.) Cuticles, when thin and filmy, as in this case, show best when mounted in a fluid, Recipes 72, 54, 52; but if thick and leathery are best when mounted in glycerine or balsam, &c.; if the cuticle is siliceous, it is mounted in balsam or dammar for the polariscope. Both the filmy and leathery cuticles are mounted in a shallow cell, and sealed in the same manner as Slide 37, &c.

Slide 47. *Proboscis of House Fly* (*Musca domestica*). —For the method of dissection of the proboscis, (see Chapter V.) This object shows well when mounted in glycerine, but previously to this it should be subjected to the same treatment as the section of the capsule of moss, Slide 45—after which it may be mounted in a cement cell of the right depth, glycerine or glycerine-jelly being used. Seal the cell with the dammar varnish, and finish as usual.

Slide 48. *Crystals of Oxalate of Ammonia.* ($C_2O_2Amo''_2$). —Castor oil will be found the best medium in which to mount these crystals, and also nearly all forms that are at all deliquescent. Glycerine also answers for some, but it is not to be equally depended upon, for after a short time it often attacks the form of the crystal. The method of mounting in castor oil is as follows:

After the true form of the crystal has been obtained (see Chapter V.), it must be surrounded with a layer of dammar varnish put on with a brush. This ring or layer of varnish may be of an oval, square, or circular form, but in any case it must be made exactly in the centre of the glass slip, that is if neatness is any object. When the dammar varnish is nearly dry, sufficient castor oil should be dropped into this shallow cell, and the thin glass cover, which should be of the same shape as the cell, applied as shown at Fig. 60. All the superfluous oil should then be cleaned off with either turpentine, benzole, or ether, using a brush in the same manner as described for clearing a cell from superfluous glycerine (see Slide 37): repeated coats or layers of the india-rubber cement, Recipe 5, or of the dammar varnish, must then be applied; each layer to be allowed to dry some time before the next is applied. It must then be finished and labelled as usual.

73. I have described all these objects as mounted on ground-edge slips, for if any leakage occurs it will be much easier to remedy it than if the object had been mounted in a cell the edges of which had been covered with the usual paper cover (see Fig. 45, plate 1).

74. Many plans have been recommended for closing cells filled with glycerine. Mr. Suffolk uses a coating of common liquid glue, and when dry he washes it well to free it from all traces of the glycerine. When the water used in washing dries off, another thin layer of the glue is applied, and washed, and so on for three separate layers. Gold size is then applied with a brush, using the turn-table. It is then finished with a circle of black varnish.

75. Glycerine dissolves in water, alcohol, &c. It is also a solvent for many substances, and in testing Dr. Lionel Beale recommends it strongly for dissolving the various salts used as re-agents. I prefer pure distilled water in this case. It should never be used in mounting any objects that contain carbonate of lime, as it dissolves that substance. Like fixed oils, it never evaporates or dries up, which property makes it very useful for nearly all purposes requiring only temporary observation, care, of course, being taken that it is not used for algæ, &c., without due precaution (see page 92), or it will rupture the cell-wall. When used for any object that is under temporary observation it is not necessary to seal the cell (see Chapter VII.)

76. Glycerine will be found a very useful medium in which to dissect all objects where the tissues are at all delicate, as it bathes them, and at the same time affords more support, the fluid being of a much greater specific gravity than water.

When specimens are mounted in glycerine it is sometimes troublesome to seal the cell in which they are contained; but if great care is used in washing this is got over.

Objects mounted in glycerine generally improve by keeping.

77. If objects are soaked in the preservative fluid (see Recipe 76) previous to their being mounted in glycerine, they will be rendered very transparent.

All objects mounted in Deane's compound, glycerine-jelly, glycerine, Ralph's liquid, and other semi-fluids and fluids, require a great deal of soaking in a large quantity of the liquid that they are to be mounted in.

When they are to be mounted in jelly and other semi-fluids, glycerine is generally the best to use. The object of this continued soaking is to rid the object of air-bubbles, and even then the air-pump (Fig. 30) is often required before they can be entirely got rid of.

78. When the cell that is used for mounting has been over-filled with the fluid, (and, of the two, to over-fill is better than not to use enough), blotting-paper is used to remove the superfluous fluid.

79. Lamp-black, moist colour, in tube, as sold by artists' colourmen, will be found useful for finishing slides when slightly diluted with water. When dry it may be varnished over with gold size.

80. In any case never lay varnish on thickly when it is used for sealing and finishing cells, &c.

81. A saturated solution of common salt (chloride of sodium $NaCl$) forms a good preservative fluid for many of the entomostraca, palates, &c. Sea-water, if camphor has been dissolved in it, will also be found useful for preserving delicate marine plants, zoophytes, &c., as it prevents osmosis (see Slide 42), and with care they may often be transferred to glycerine if required.

82. A solution of arsenious acid in camphor water is often used for the preservation of specimens, especially animal; but it is very poisonous, and other solutions do as well (see Recipe 53.)

83. Syrups will be found useful for preserving tissues, especially vegetable. The remains of seeds, cuticles, &c., taken from jams and preserved and crystallized fruits, will be found in a good condition for examination, and will often be found worthy of preservation.

84. Castor oil is useful in mounting crystals; also acari, parasitic and other small insects.

85. Solutions of borax and boracic acid have been found to retard the contractile power of muscle, and will also, no doubt, be found to be suitable fluids for the preservation of the muscular parts of insects, &c. It is worthy of further trial.

86. All the preservative fluids may be kept in the collapsible tubes (see Fig. 58, Plate 4); but where the fluid contains any corrosive salt, as in the case of Recipes 54, 55, 72, &c., the inside of the tube must be coated with bees'-wax to protect it from the action of the fluid. It may be coated in the following manner: Pour melted bees'-wax into it until full, and immediately empty it again; then place the tube upright on a plate, which put in a hot oven or before the fire to allow the superfluous wax to drain from the tube; then place it in a cool spot. When quite dry, the preservative fluid may be poured into it, and the edge turned up, and closed in the usual manner.

87. Pollens show best when mounted in an essential oil, such as lemon. In sealing the cell the india-rubber cement (Recipe 5) must be used.

CHAPTER V.

A GENERAL SUMMARY OF THE VARIOUS METHODS OF MOUNTING, WITH MANY ADDITIONAL NOTES.

88. In Chapters II., III., and IV. I have treated of the various methods of mounting microscopic objects, but in this Chapter I shall mention the various methods of preparation to render them ready for mounting in any of the before-mentioned mediums. Suffice it to say that all objects should be well examined—both dry, balsam, and in fluid.

89. *Acarea or Mites.*—An example of this class of objects is the cheese mite (*Acarus domesticus*). The parts of the mouth, &c., sufficient to distinguish the species, are generally made out from crushing the insect between a glass slip and piece of thin glass, but if it is required to mount permanently, greater care must be taken in crushing them, and all extraneous matter separated by solution of potass. Afterwards wash with acetic acid, and mount in glycerine (see Recipe 70), or dry, and mount in balsam or gum dammar. They do not require a cell if mounted in this manner.

90. *Acheta domestica* (House cricket).—From this insect many interesting objects can be obtained (see "Gizzards, Elytra," &c.)

91. *Adulterations* (see Chapter VII.).

92. *Algæ.*—After having been well washed in fresh water, or if marine in sea water and then fresh water, they may be mounted in Deane's compound (Recipe 71) or in glycerine-jelly (Recipe 60), or they may be mounted in a cell with a suitable fluid (such as Recipe 54 or Receipe 72); if mounted in glycerine care should be taken to place the algæ in fresh distilled water, and gradually add the glycerine. This is best done by putting the specimen in a watch glass, and adding about every hour two or three drops of pure glycerine, until the proper consistency is gained, or do as recommended, page 92. By these plans all rupture of the cell-walls will be prevented. For the method of mounting in glycerine, see Chapter IV., page 87.

93. *Anguillula.*—Anguillula glutinis is one of the most common species of this genus. They have been popularly called "eels in paste;" and as it is interesting to observe their movements, I give the method of obtaining them. Make a moderately thick paste with flour and water, stir and beat up daily with a spoon to prevent any growth of moulds, when, if the weather is moderately warm, the young entozoa will be found, sometimes in large quantites. To observe them, place a small piece of paste containing them in a drop of water in an ordinary animalcule box, or between the two cells of the gas-cell (Figs. 9 and 10, Chapter I., page 13). These animals may be kept for years if a little fresh paste is added occasionally.

94. *Anoplura.*—An order of insects, parasitic, upon birds and animals, generally known as lice. These insects may be treated in a similar manner to the acari or mites, especially if they are of a small species; if

larger, as in the case of the parasite on the pig, human, &c., it is better to treat them with potass as described for small insects (see Chapter III., page 73), and mount in balsam or dammar, or they may be washed in acetic acid, and mounted in glycerine.

95. *Antennæ of Insects.*—These organs require but little dissection. It generally is sufficient to cut them off from the head of the insect with a pair of sharp-pointed scissors, and if thick remove them, to be softened in the potass, washed, pressed, dry, and mounted in balsam in the ordinary manner; if not thick enough to require this, they must be soaked for a short time in turpentine, which will render them transparent enough to be observed, or in some cases they may be mounted dry transparent, as, for instance, the antennæ of the common gnat. Some of the antennæ of the larger beetles only show well when mounted in a dry opaque cell. Many of the small antennæ show well when put up in a cell in a suitable fluid (Recipes 3, 12, 52, 55, &c.).

96. *Anther.*—This part of the stamen of flowers contains the pollen. The case or anther often has a very beautiful epidermis, which may be separated from the other tissues by the action of dilute nitric acid, as mentioned in the treatment for cuticles; but the epidermis being very delicate, greater care must be taken than with any ordinary cuticle. The following flowers contain the most beautiful forms:—Poets' Narcissus (*Narcissus poeticus*); white poplar (*Populus alba*); thorn apple (*Datura stramonium*); wall-flower (*Cheiranthus cheiri*); Henbane (*Hyoscyamus orientalis*); *Iris florentina;* rocket (*Bunias orientalis*); London pride (*Saxifraga ambrosa*); yellow water lily (*Nuphar*

lutea); *Primula Sinensis*; bryony (*Bryonia dioica*); privet (*Ligustrum vulgare*), *Calceolaria*, *Anemone*, *Veronica perfoliata*, *Tropæolum majus*; forget-me-not (*Myosotis palustris*), *Adonis vernalis*, *Magnolia;* daisy (*Bellis perennis*); dandelion (*Leontodon*), &c.

97. *Antheridia.*—These interesting bodies, which answer to the anthers of the flowering plants, that is, they contain the reproductive bodies called spermatozoids, &c., which act in a similar matter to pollen, only much more active, are well worthy of study. Mosses and lichens being the best and easiest plants for this purpose, they are best mounted in fluid (see Recipes 52, 54, 72.)

98. *Antlia*, or as it is commonly called, the proboscis of moths and butterflies, is an interesting object when properly mounted. After it is divided from the head of the insect, it must be placed for one or two hours in a weak solution of potass; if kept in this fluid longer than two hours it will get too soft to mount properly; if a small and delicate one it must not be kept longer than one hour; press gently between two glass slips to flatten it; then well wash in acetic acid and then water, after which it may be mounted in glycerine or dried under pressure (use apparatus, Fig. 29), and mounted in balsam or dammar as usual.

99. *Aphidæ.*—These insects being of a very delicate structure, require but little preparation. I find the best method is to press them between glazed writing paper until nearly dry; then transfer them to water, after which they may be dried under pressure and mounted in balsam, or transferred from the water to a suitable fluid (see Recipes 52, 14, &c.), and mounted

in a shallow cement cell. It will be found that glycerine renders them too transparent.

100. *Arachnida.*—This class of animals contain the spiders, scorpions, &c., and many interesting objects can be obtained from it: the mandibles of spiders, spinning organs, toothed feet, and the poison bag or sac. The part of the head containing the mandibles requires but little preparation. Soak in potass for a short time to soften them; well wash, dry under pressure, and mount in balsam as usual. The spinning organs must be taken from the body of the spider; they will be known by appearing like three small cone-shaped bodies at the end of the abdomen; they must be cut away with a pair of sharp scissors, cleaned with potass and then warm water, dried under pressure, and mounted in balsam; or they may be mounted in glycerine in a shallow cell, so as to show them in their natural position. The feet of the spider only require soaking in the potass; put under pressure, then well wash and mount in glycerine; or dry and mount in balsam. To find and show the poison bag well, one of the mandibles must be placed in water, and allowed to remain for about a fortnight; it will then be found slightly decayed, and if one of the mandibles is separated at the second joint from the other parts, it will draw out with it the poison bag or sac, and if its course is traced it will be found to terminate in a minute orifice near the tip of the mandible. After being well cleaned it may be mounted in glycerine, glycerine-jelly, or dried and mounted in balsam or dammar.

101. *Apothecium.*—This name is given to the open cup-shaped bodies containing the spores, &c., of

lichens, a section of which must be taken to give a correct idea of their structure. These sections may be mounted in Deane's compound, glycerine-jelly, or in a suitable fluid (Recipes 52, 54, 72, &c.), or dried under pressure and mounted in balsam as usual. When the entire cup or apothecia is taken, it only requires to be mounted in a dry opaque cell. The sections must be made with a fine scalpel.

102. *Archegonium.*—This is the rudimentary organ representing the ovule of mosses, ferns, &c. They show best when mounted in Deane's compound, or a suitable fluid (Recipes 52, 54, &c.)

103. *Blight.*—The examination of the various species of this class of micro-fungi will be found interesting. Some of the best forms are: Hop blight (*Sphærotheca castagnei*); maple blight (*Uncinula bicornis*); guelder rose blight (*Microsphæria penicillata*); hazel blight (*Phyllactinia guttata*); rose blight (*Sphærotheca pannosa, &c.*) To show the conceptacles, the best plan is to mount a small piece of the leaf containing the blight in a dry opaque cell. The wooden slides (see Fig. 51, plate 3) answer well for this purpose; or a very small piece of the leaf may be mounted for the use of the parabolic reflector (see Fig. 49, plate 2; also description, Chapter II. page 60). The conceptacles and spores may also be mounted as transparent objects, either in Deane's compound or glycerine-jelly, in which case they must be previously soaked in a small drop of water placed in the exact centre of a glass slip; or they may be mounted in glycerine or balsam; but however mounted, a slight cell of india-rubber cement (Recipe 5) must be used to prevent the conceptacles being crushed.

104. *Blood.*—The best method of mounting so as to show the corpuscles of the blood (Fig. 61) well, is to take a drop of fresh blood and spread it evenly, and as thin a layer as possible, over the centre of a glass slip, and allow it to dry; then mount in the dry transparent method; or use the vapour of a two per cent. solution of osmic acid; then apply one drop of acetate of potass, and cover with thin glass as usual. This is recommended by Professor Mac Schultze. By this plan the corpuscles are but little altered. In spreading them thinly and evenly, it will be as well to use a small piece of thin glass moved over the centre of the slip with a circular motion. If it is only desired to observe the blood whilst fresh, a piece of thin glass must be placed on a glass slip, and a drop of fresh blood allowed to flow under it. By capillary action, the corpuscles will then be found to be evenly distributed, and their size, colour, and shape may be observed. If it is desired to obtain and observe the corpuscles after they have been long dried upon linen, cotton, or any other material; this should be soaked in a saturated solution of corrosive sublimate ($HgCl_2$, See Recipe 10). The shape of the corpuscles will then be nearly restored to their normal condition, and may be separated from the material with the aid of a small camel's-hair brush. (For Blood Crystals, see page 108.)

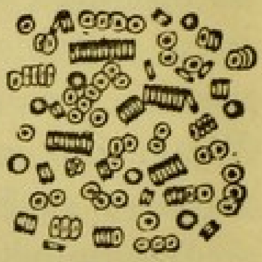


Fig. 61.

105. *Bone.*—To make sections of bone, the piece that is required to be cut must be placed in the holding-screw, Fig. 6, and tightly fixed by the aid of the screws, and a section cut with the small saw, Fig. 22.

This section must be cut as thin as possible with the saw; one side of the section must then be ground with various files of different degrees of fineness; then with water on an Arkansas stone and polished with putty-powder on a leather strop; this polished side must then be cemented to a piece of glass with Canada balsam (see Recipe 65), and the section ground until thin enough; finish and polish as with the first side; the section may then be removed from the glass, clean, and mount in a dry transparent cell. If it is required to mount the section in Canada balsam, it need not be ground on the stone nor polished. In fixing the section to the glass care must be taken before grinding that there are no air-bubbles between the section and the glass, for if so it will not grind evenly and flat. If the section is large enough, it is better to grind it between a piece of velvet-cork and the file, in preference to cementing it to the glass. The action of hydrochloric acid (HCl) and also the solution of potass on the sections of bone should be studied; the hydrochloric acid will dissolve the lime contained in the bone and leave the animal matter. The potass will do just the opposite—leave the lime and dissolve the animal substances. Sections of bone may be readily cut after they have been treated with the hydrochloric acid; these sections show well when mounted in balsam and examined under polarized light. Isinglass glue is sometimes recommended for fixing the sections to the glass before grinding, as it does not fill up the lacunæ so much as the balsam, and also requires no heat. Fossil bones are ground and finished in the same manner as ordinary bone, only greater amount of care must be taken in the grinding, as they are generally very brittle. If large, and sections are required to be cut and ground, this is generally done with the machine used for cutting and grinding rock sections (see Fig. 38).

106. *Brands.*— These form another large and interesting part of the micro-fungi; they may be mounted in the same manner as the blights, but to show the spores, &c. well, they must be soaked in turpentine and mounted in balsam or dammar. Some of the most interesting forms are: the rose brand (*Aregma mucronatum*); bramble brand (*Aregma bulbosum*); meadow sweet brand (*Triphragmium ulmariæ*); anemone brand (*Puccinia anemones*); compositæ brand (*Puccinia compositarum*); ground ivy brand (*Puccinia glechomatis*); willow herb brand (*Puccinia pulverulenta*); mint brand (*Puccinia menthæ*).

107. *Chalk. Carbonate of Lime* (CoCao″). — The best method of preparation to get the foraminifera clean is to take a small piece of chalk and scrape it fine, or, what is better, a small quantity of the natural powder found at the base of chalk cliffs; put this into an 8-oz. phial and fill with water, which remove with glass syphon. Keep on adding fresh water as long as it comes away of a milky tint; the deposit will then be found to consist of the foraminifera remains of sponge, spiculæ, &c. To mount the foraminifera, a small quantity should be soaked in turpentine for a short time, and then mounted in balsam as usual. If any air-bubbles occur, they will disappear in the course of a few days. Many persons prefer to reduce the chalk to a powder previous to washing, by rubbing it with a tooth-brush or any other moderately hard brush.

108. *Characeæ* are good plants to observe the circulation of the chlorophyll; young shoots are the best for this purpose, as they contain but little carbonate of lime, which often obscures the view.

109. *Chicory.*—This substance is much used for the adulteration of coffee (see Chapter VII.)

110. *Circulation.*—In studying the circulation in any animal, the first essential is that it should be kept on the stage of the microscope. This has generally been attempted by mechanical restraint, as in the case of the frog. "Sometimes chloroform is used, but the subcutaneous injection of the hydrate of chloral will be found to answer much better. A solution of four grains to the drachm is the best. As many minims should be injected into the frog as it is drachms in weight. The injection is made under the skin of the back with a morphia syringe. The web of the foot may then be stretched over the frog plate in the usual manner. When the tongue is used for observing the circulation, it is withdrawn from the mouth by means of horn forceps, and stretched over a large perforated cork. It is apt to become dry, when it must be moistened with water, or what is better—of water 100 parts, salt 1, and albumen from egg 10 parts." The circulation of blood is also well seen in young trout, wing and membrane of common bat, tadpoles, &c. The apparatus used for tadpoles is seen at Fig. 39.

111. *Coleoptera* (Beetles).—The most interesting parts of these insects are the gastric teeth and gizzards, and the eyes, elytra, &c. If small, the whole insect is often mounted in a dry opaque cell, as in the case of a small green weevil, so-called British diamond beetle (*Polydrosus pterygonialis*), Slide 22, Chapter II., page 65.

112. *Collomia Seed.*—The examination of the spiral fibres of this seed form an exceedingly interesting object under a low power. A very small slice must be cut from the testa or outer coat of the seed, and placed in a drop of water, when the fibres will gradually uncoil. It may then be mounted in a shallow cell in a suitable fluid (see Recipes 52, 72, &c.).

113. *Confervoideæ* are best mounted in a shallow cell with a suitable fluid (either Recipes 54, 72); or if mounted in glycerine it must be added to the water very gradually (see Algæ).

114. *Corallina.*—This genus of algæ are found nearly everywhere on the rocks between the high and low water marks. They must be well washed in fresh water, and then dried and mounted in a dry opaque cell; or, if their structure is desired to be observed, dissolve the carbonate of lime by the action of hydrochloric or acetic acid. They must then be washed and mounted in a cell with a suitable fluid (Recipes 12, 52, 54, &c.), or in glycerine (Recipe 70), or they may be dried and mounted in balsam; but fluid will be found the best to show the tetraspores.

115. *Corns.*—Sections of these excrescences show well, especially under the polariscope. To render the epidermic scales distinct, the sections must be treated with acetic acid or the solution of potass.

116. *Cork.*—Very thin sections show the cellular tissue well under a high power. Loaded corks are also used for dissections. A piece of velvet cork, about two inches square and half inch thick, is placed on a piece of sheet lead, three inches square, the sides of which are cut and folded over the cork; the edges

may be made smooth with a file. The insect is then fixed to the cork with pins, and is ready for dissection (see Dissections, and also Chapter I., page 23).

117. *Crystals.*—The plan recommended by M. Preyer for producing crystals from blood is as follows: The blood is received into a cup, allowed to coagulate, and placed in a cool room for twenty-four hours. The serum is then poured off, and a gentle current of cold distilled water passed over the finely divided clot placed upon a filter until the filtrate gives scarcely any precipitate with bichloride of mercury. A current of warm water (30°-40° Cent.) is now poured on the clot, and the filtrate received in a large cylinder standing in ice. A small quantity is taken, and alcohol added drop by drop till a precipitate falls. The mixture still kept in ice will, after the lapse of a few hours, deposit a rich crop of crystals. The forms of these crystals differ in various animals, but are all reducible to the rhombic and hexagonal forms. The best animals for experiment are the guinea-pig, cat, mole, dog, squirrel, sheep, horse, pig, ox, goose, sparrow, frog, bream, perch, pike, &c. The crystals are not generally soluble in water, alcohol, &c., but are perfectly so in alkalies. They may be mounted dry, or better in castor-oil or glycerine.

Most crystals form best when a less than saturated solution of a salt is used, the solution being allowed to evaporate spontaneously; but exceptions may be taken to this rule, especially in the case of deliquescent crystals, which must be obtained by the evaporation of their solutions by the aid of gentle heat, after which they are mounted in castor-oil.

A good plan for the formation of fine specimens of crystals, especially the salts of lime (calcium), is to mix a small quantity of each salt, which is to react upon each other, in about a teaspoonful of gum water, and then gradually mix the two fluids, when perfect crystals will be obtained. The reaction may thus be illustrated: Sulphate of zinc—about eighty drops of a saturated solution of this salt are mixed in a teaspoonful of gum water, and about eighty drops of chloride of calcium put into another teaspoonful of gum water; gradually mix the two, when in a short time fine needle-like and radiating clusters of sulphate of lime (see Fig. 97, plate 10) will be found, the lime having a greater chemical affinity for the sulpho-oxygen compound (SO_3) of the sulphate of zinc than the zinc itself has. The reaction is thus:

$$CaCl_2 + SO_2Zno'' = SO_2Cao'' + ZnCl_2.$$

Another and perhaps better plan is to place small quantities of the undissolved crystals used at a short distance from each other in the same vessel, or else separated by a membrane. The liquid used as the solvent can still be gum water, glycerine, albumen, solution of gelatine, or a mixture of these substances. Calcareous salts form best by this process. The following are a few of the best salts:

Chloride of Calcium,
Nitrate of Calcium,
Acetate of Calcium.
Chloride of Magnesium,
Sulphate of Magnesium,

and for the reactions—

Carbonate of Sodium,
Carbonate of Potassium,
Phosphate of Sodium,
Phosphate of Ammonia, &c.

A great resemblance to organic forms is often obtained when the solvent used is albumen, or albumen and gelatine mixed, and if carmine is used to colour the fluid, the crystals, &c., obtained are generally of a beautiful tint.* Other colouring matter may be used, especially if of an organic nature—such as logwood, saffron, &c. I also find, even in an ordinary way, that when a strong solution of gelatine is added to the solution of the salt that is to be evaporated, better and more perfect crystals are formed, especially if these are to be used for the polariscope. Gum water also answers well, especially for salicine, chlorate of potass, &c. When crystals of any of the salts are wanted for typical slides in micro-chemical analysis, water only should be used as the solvent. Then evaporate gradually.

Santonine, and many other salts, may be obtained from the evaporation of their solution in chloroform. Alcohol may also often be used.

The following salts are some of the most interesting: Salicine, pyro-gallic acid, citric acid, tartaric acid, chlorate of potass, sulphate of magnesium, sulphate of iron, sulphate of copper and magnesium, aloine, platino cyanide of magnesium, acetate of manganese, boracic acid, chloride of palladium, iodide of quinine, uric acid, urate of sodium, oxalate of soda, &c. (see also plate 10).

* See a paper on this subject by the author in the "Transactions of the Maidstone and Mid-Kent Natural History Society for 1870."

118. *Culex.*—The commonest insect of this genus is the common gnat (*Culex pipiens*). The proboscis of the female is the part generally mounted; it only requires to be dried between writing-paper, after which it may be mounted in balsam or dammar; it may also be mounted in a cell with glycerine without being previously dried.

119. *Cuticle of Plants.*—When well prepared, the various cuticles of plants will make an interesting and instructive series of slides. They may be obtained from the leaf by prolonged maceration in pure water; but the better plan is to separate them from the leaf by the aid of nitric acid and water, the acid being diluted more or less according to the texture of the leaf. If fleshy, more water; if thick and leathery, or siliceous, nearly or quite pure acid must be used. The leaves are boiled in a test-tube with the nitric acid and water until both the upper and under cuticle seem to separate; the piece of leaf is then transferred to a vessel of pure water—a white evaporating dish or one of Liebig's essence of meat pots is the best to use—well wash with water to free it from the acid; but if the cuticle is very delicate, it may be transferred to a glass slip at once. Let the cuticle lie on the slip with the inner side upwards, then with a camel's-hair brush and water wash away all extraneous matter, leaving the cuticle clean. Now place it in a watch-glass full of alcohol until ready to mount, which may be in fluid or balsam, according to the nature of the object. If siliceous, and for polarized light, in balsam or dammar (see page 78); if leathery, in glycerine (see page 93); if delicate, in a proper preservative fluid. When the cuticle is siliceous, after it has been separated by using

pure acid it must not be allowed to dry entirely, or it will cause great trouble to mount it well; it must therefore be quickly transferred, while still moist, to alcohol, then to benzole, and turpentine; finish by mounting in balsam or dammar (see page 78). A solution of chlorate of potass and nitric acid, equal parts,* is also often used for separating ordinary cuticles not being siliceous; they are boiled in the fluid in exactly the same manner. Cuticles of ferns make good slides, but, in fact, the student should examine all the leaves he meets with—he will find it good practice.

120. *Desmidiaceæ.*—Desmids, whilst fresh, are best cleaned from the surrounding matter by the aid of light. The gathering is put into a white saucer, with a small quantity of pond water. If the saucer is then placed in a strong light, say in a window sill, the desmids gradually collect on the side nearest the light, when they may be transferred to pure water by the aid of a camel's-hair brush. When they are thus obtained free from mud, &c., it is as well to transfer them to a suitable keeping fluid, as recommended at page 92. There are many other ways of cleaning them, but space will not permit of any but the best plan, either for these or other objects.

121. *Diatomaceæ.*—The first thing to notice when about to clean either a gathering of diatoms, or a sample of guano, is to test the average amount contained, and whether the species are common or not. This is best done by burning a small quantity of the matter containing them on a piece of platinum foil, using the triangle (Fig. 20). Burn until they are white, then

* N.B.—Use caution in mixing.

examine under the microscope, and if good and in sufficient quantity for the trouble, first noticing if the diatoms are delicate; if so, use nitric acid only; but if not, and most species will bear this treatment, proceed thus: Boil in sulphuric acid, using an open evaporating dish, until the organic matter turns a dark colour, which will be in about one minute, then gradually add, drop by drop, a saturated solution of chlorate of potass, taking great care only to drop it, or it will cause an explosion. The use of the chlorate is to bleach, and it may sometimes be left out; then throw the entire mass into about twenty or thirty times its own bulk of water, wash well, and decant the dirty water off, using a glass siphon. Then boil the deposit, which is left in nitric acid for a short time; well wash, and store in alcohol or distilled water. When a quantity is done, and there are many species of diatoms, then use the apparatus (Fig. 24); or advantage may be taken of their different specific gravity when sinking in a conical glass vessel, collect them as they sink with a pipette, from half a minute to nearly ten minutes, according to their gravity.

Many persons prefer to destroy the organic matter by burning them on the platinum foil, when the siliceous valve only is left. Then mount as usual.

They may be freed from algæ by using nitric acid 1 part, water 20; then strain through muslin.

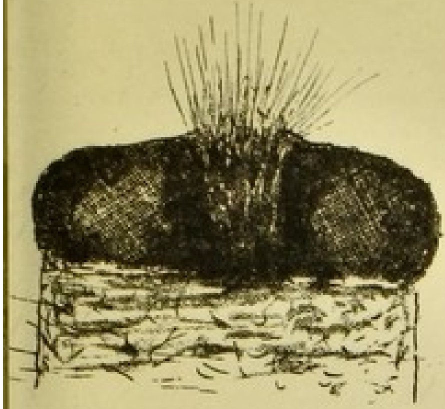
In mounting diatoms, always take care that the frustules do not overlap each other, so as to interfere with the view of them. Mount diatoms dry if small; if larger and coarser, then use balsam; and when the high powers of the microscope are to be used, fix them on the thin glass cover by the evaporation of the fluid containing them.

A very good plan, and perhaps the best if only one or two good slides are wanted, is to place a small drop of the deposit on a glass slip, and to pick out the diatoms one by one, using the thread of glass (see tools, page 2) until they are collected in sufficient quantity, then mount as usual; but when diatoms are suspended in a large quantity of water, use a glass tube covered at one end with filtering paper, and over this, muslin tied round the tube with thread. When sufficient quantity has collected on the paper, as the water passes through, cut the paper, and collect with a camel's-hair brush. Diatoms should show various positions to exhibit structure; this is best done by mounting in hard balsam, then grind the surface, slightly cover with fluid balsam, and mount with thin glass cover as usual.

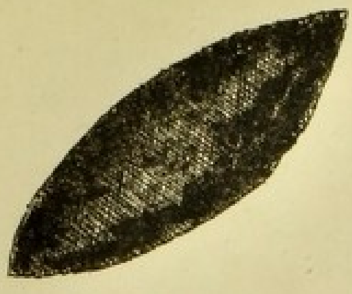
122. *Dissections.*—Of this subject also only a slight sketch, as space will not permit of more. Eyes of insects are extremely simple; they only require to be taken from the head in the manner shown at A (Fig. 2, Plate 5). Fig. 1 of the same plate represents the head of the house-fly (slightly magnified), with the eyes in their natural position. After being cut from the head they are soaked for a short time in liquor potass, which frees them from blood and extraneous matter. When mounted dry, the facets show well, as in A (Fig. 3). The proboscis or trunk of the house-fly may also be taken to exhibit the method of preparation of the various tongues. The insect is squeezed, when the proboscis will immediately protrude from the head; let it lie on a slip of glass, and let a thin

glass cover fall gently on to it (see B, Fig. 1, Plate 5). It must then be cut off, and allowed to dry in this position, both of the glasses having been previously slightly greased to prevent its sticking. Mount in balsam in the usual manner. C, Fig. 1, represents the tongue of house-cricket that has been so treated. Gizzards of beetles form an interesting class of objects. The dissection of the common house-cricket will explain the method of dissection (C, Fig. 2, Plate 5), house-cricket slightly over natural size. C, Fig. 3, the same insect having the third pair of legs cut off, and half of the second pair, the abdomen cut up, and the folds kept back with two dissecting pins (see drawing). The gizzard will then be found at the upper part of the abdomen (see same drawing). C, Fig. 4, represents the entire alimentary system—head, food-sac, and gizzard. The position of the gizzard varies but slightly in any of the beetles, always being below the larger food-sac. The gizzard is separated from the other parts and cut open with the fine-pointed scissors, soaked in the potass, which will soon free it from extraneous matter, then well wash, and mount as described at page 88. Spiracles of insects are generally seen on each side of the abdomen, and also on both sides of the larva of moths, butterflies, &c. D, Fig. 1, Plate 6, represents the magnified appearance of the spiracle of the greater water beetle (*Dytiscus marginalis*). D, Fig. 2, shows the spiracles as they appear when the elytra or wing-case is taken off, the letters S S pointing to them. D, Fig. 3, is the perfect insect. The spiracles are cut from the body with the fine-pointed scissors, washed with potass, then pure water, and mounted generally in balsam,

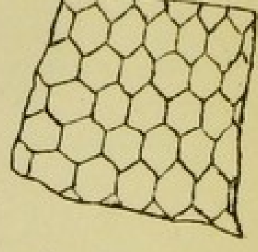
Plate 5.



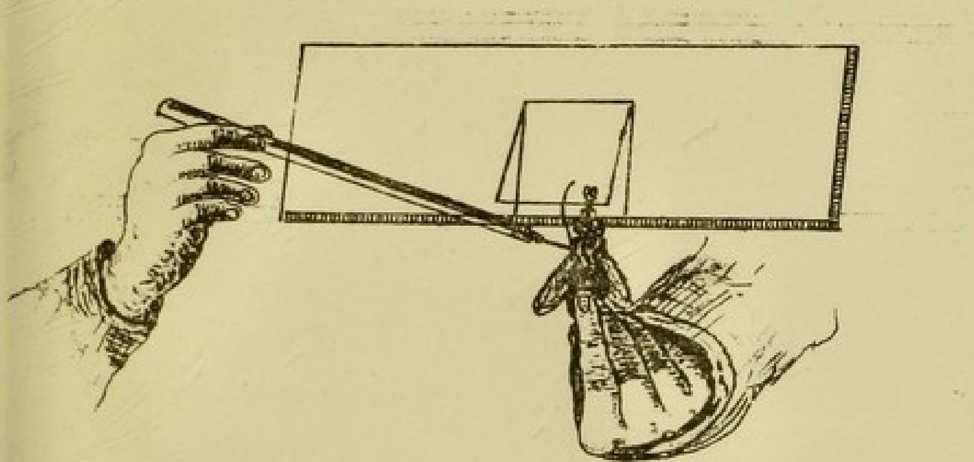
A. Fig. 1.



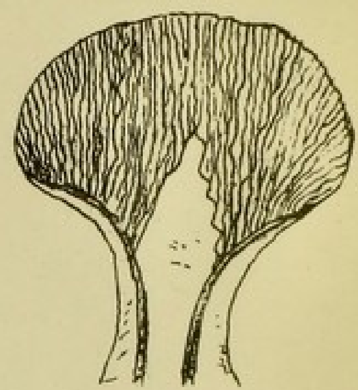
A. Fig. 2.



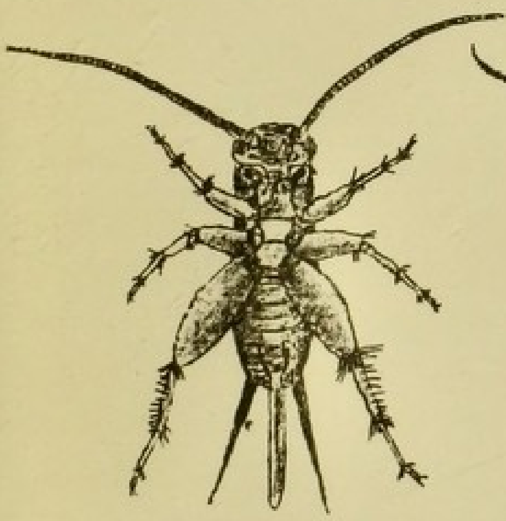
A. Fig. 3.



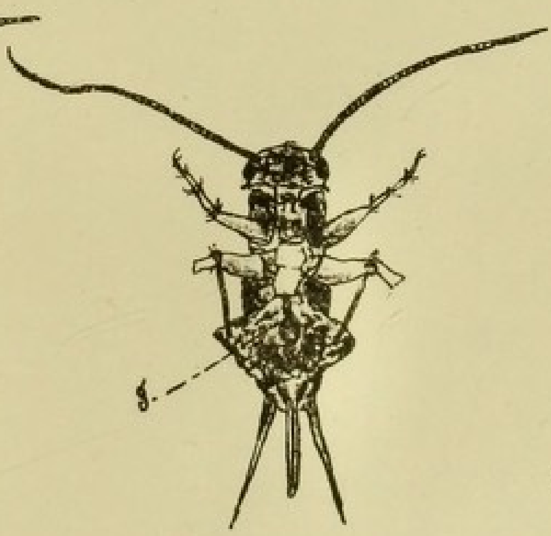
B. Fig. 1



C. Fig. 1.



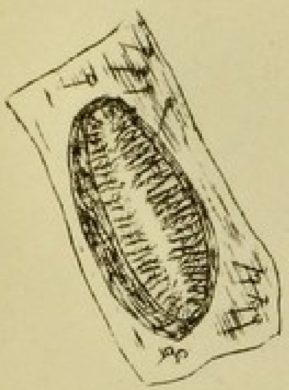
C. Fig. 2.



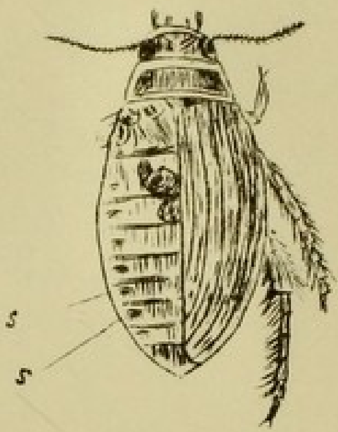
C. Fig. 3.

C. Fig. 4.

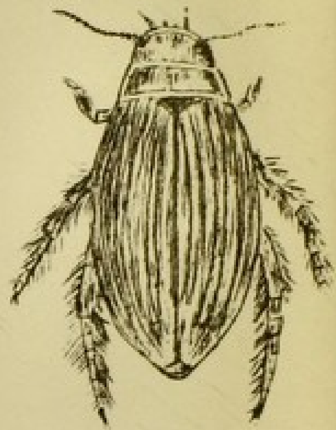
Plate 6.



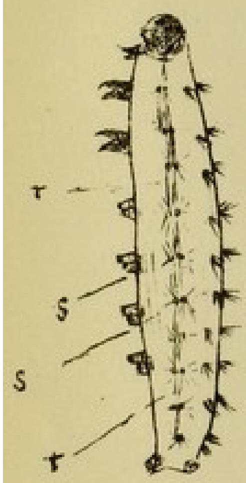
D. Fig. 1.



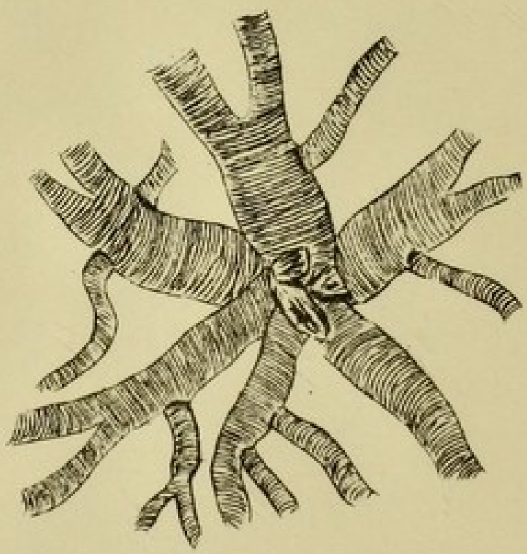
D. Fig. 2.



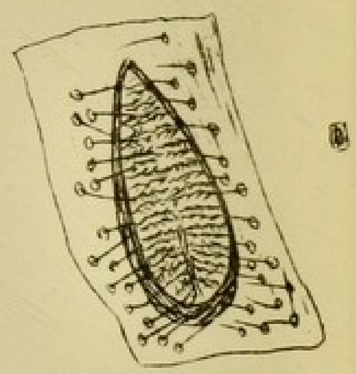
D. Fig. 3.



E. Fig. 1.



E. Fig. 2.



F. Fig. 1.

G. Fig. 1.

G. Fig. 2.

G. Fig. 3.

though sometimes in fluid—glycerine is good. The spiracles of flies are on either side of the thorax. E, Fig. 1, shows the larva of the red admiral butterfly (*Vanessa atalanta*) as mounted. To show the position of the tracheæ in relation to the spiracles, T T points to the tracheæ and S S to the spiracles. E, Fig. 2, are a mass of the air tubes or tracheæ which have just been taken from a spiracle; these are magnified 100 diameters. F, Fig. 1, is the spiracle of blowfly. The tracheæ are easily found and separated, when they must be well washed and then mounted in fluid. (Recipes 10 and 70 will be found useful.) When making dissections, it will be found useful to imbed the insect in wet plaster of Paris; let it set. Always make dissections under water. G, Fig. 1, Plate 6, is a rough sketch of periwinkle. G, Fig. 2, the mollusc, after being taken out of the shell; and at G, Fig. 3, the palate or tongue is shown proceeding from the top of the head in a spiral manner. It is so drawn to attract the notice of the student to its position, like a coiled spring pointed to by the letter T, in G, Fig. 2. The position of the tongue cannot be mistaken, it is just above the head, and the coil shows through the skin. Other palates are dissected differently, but the general method is the same; a good plan for the very small mollusca is to boil them in liquor potass when the bodies are entirely dissolved, leaving the palates intact—limpets, whelks, and garden snails, will be the best to begin with.

123. *Ducts.*—Scalariform tissue and most vegetable ducts are mounted in a suitable fluid, like Recipes 72, 54, &c.

124. *Dust* (see Fig. 62), when taken from most rooms will be found to consist of traces of carbon, soot, fibres such as wool and cotton, starch, &c. The dust of the work-room where the student is should be examined (see page 46).

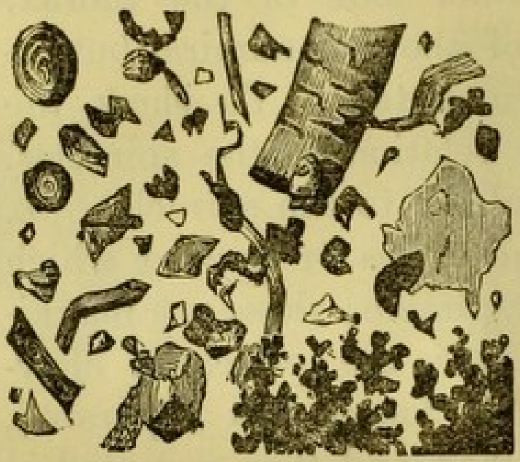


FIG. 62.

125. *Echinus Spines.*—Transverse sections of these are cut through and ground down in exactly the same manner as sections of bones and teeth (which see); only greater care must be taken in fixing them to the glass before grinding, and also care in the grinding itself, so as not to break them.

126. *Eggs of insects* are mounted both dry and in fluid. In the former case the young embryos must be killed by plunging them into acetic acid, and then allow them to dry; or the eggs may be kept in spirit, and when wanted allow them to dry for three or four days before mounting; they will then shrivel up, but may be restored to their original form by placing them under the air pump (Fig. 30) for a few hours, constantly exhausting the air. If in fluid try Recipes 10, 12, 52, 54, 70.

127. *Entozoa* are generally examined under the compressorium (see Fig. 37), and glycerine will answer well for their preservation.

128. *Feathers of birds* generally mounted in dry opaque cells, though for structure sometimes in balsam.

129. *Foraminifera.*—For separating foraminifera

from sand some persons recommend thoroughly drying, and then throw the sand into water, when the minute shells which contain air will swim, and the sand sink. Others recommend picking them out one by one, when the sand is placed on black paper, or use the finder (Fig. 25); but the best plan, and one that I believe is entirely my own, is to separate them by a chemical process as follows: Boil the sand in a test-tube containing only carbonate of potass or soda, which must be previously fused by the action of heat; throw the sand in, and boil until all the carbonic acid gas has passed off, leaving in the test-tube silicate of potass or soda, which must be dissolved in hot water; if any sand is still left, repeat the process. By this plan the foraminifera are freed from animal matter as well as the sand. When it is desired to separate the foraminifera from sea soundings, which often contain tallow, they must be cleaned by using benzole, care being taken not to bring it near a light, as it is inflammable. When the benzole comes away quite pure, which may be known by its not leaving any trace on a slip of glass after it has evaporated, the sand which contains the foraminifera may be freed from the benzole by using the liquor potass, and then warm water. Gatherings of foraminifera should be tested to see whether there are any diatoms, by dissolving the shells by the aid of hydrochloric acid, when, if there are any diatoms, they will be left nearly pure; if not quite so, finish by the sulphuric acid process (see page 114). Sections of foraminifera should always be mounted to show their structure, in the same way as for diatoms (see page 115).

130. *Hairs* (*Animal*) are best soaked in benzole, and

then transferred to turpentine, remaining in it for a week or two before mounting in balsam or dammar.

131. *Hairs* (*Vegetable*) are mounted dry, in fluid, and in balsam or dammar if for polariscope. As a general method I should recommend fluids like Recipes 12, 52, 72, &c., using a shallow cell (see Chapter 4); they are sometimes mounted in their natural position on the cuticle (see page 57). Interesting forms are from Antirrhinum (flower), Draba (leaf), Tradescantia (stamen), Verbascum (leaf), Deutzia (leaf), Digitalis (corolla), Viburnum (leaf), &c.

132. *Horn and Hoofs.*—Sections are made by placing them in hot water, which renders them soft. Cut sections with razor.

133. *Injection* is the method of filling the vessels of animals with a coloured fluid, which may be of an opaque, transparent fluid, or semi-fluid nature. It requires a special set of apparatus, consisting of a syringe (Fig. 63), pipes with stopcocks, &c. The

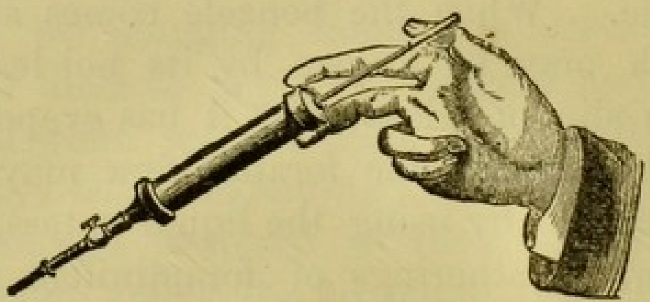


Fig. 63.

operation of injection is here shown, and at Fig. 64 the method of using the syringe, which has been filled with a suitable fluid (see Recipes 33, 35, 36, 38, &c.) Bullnose forceps are also much used to prevent the flow of the coloured fluid if it escapes. The operation of injection may be considered tolerably easy in action, but requiring much practice. Fill the syringe (Fig. 63) with the required coloured fluid, which must be kept warm if it contains gelatine; put the pipe into an artery or vein, tie waxed thread over the projecting arms and round the artery itself, so as to prevent its slipping off, then gently press the piston of the syringe, so as to force the fluid into the artery (see Figs. 63 and 64). This must be done very gently, or the fluid will escape either from the object injected, or force its way where the artery is tied to the mouth of the syringe. This, in a few words, as space does not permit of more, is the plan commonly pursued in injecting. I prefer another method, which, though it may be considered a primitive plan, I find useful. Take a small Woulff's bottle (Fig. 18), which fit up with fine metal tubes in the same manner as described for the wash-bottle (Fig. 13). On to the exit tube fit one of the ordinary injecting pipes. Do this with the aid of a bored velvet cork, or have the metal tube made to terminate in a long capillary tube, which run into the artery or vein that is to be injected, tie round with waxed thread, and also use, if necessary, the electrical cement (Recipe 6), to make all tight. Then blow gently into the bottle, when the injecting fluid, which has been previously placed in the bottle, will flow into the capillary tube and artery to be injected.

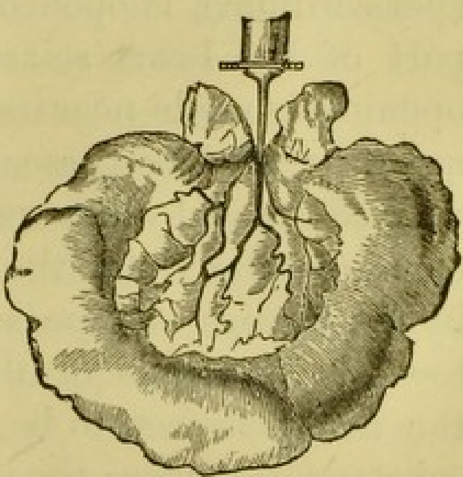


Fig. 64.

As a slight guide to the student, we will give the plan to be followed in injecting a frog. "An incision is made through the skin, and the sternum divided in the middle line with a pair of strong scissors; the two sides may easily be separated, and the heart is exposed. Next the sac, in which the heart is contained (pericardium), is opened with scissors, and the fleshy part of the heart seized with the forceps; a small opening is made near its lower part, and a considerable quantity of blood escapes from the wound: this is washed away by the wash-bottle (Fig. 13). Into the opening—the tip of the heart being still held firmly by the forceps—a pipe is inserted, and directed upwards towards the base of the heart, to the point where the artery is seen to be connected with the muscular substance. Before the pipe is introduced, however, a little of the injecting fluid is drawn up so as to fill it; for if this were not done, the air contained in the pipe would necessarily be forced into the vessels, and the injection would fail." The point of the tube can, with very little difficulty, be made to enter the artery. The artery is then tied firmly to the pipe (not too high up, or it will force its way through the artery), and the animal injected in the usual manner.

The systems of vessels are generally injected with different colours, like veins, white or blue; arteries, red; urinary tubes, yellow, &c. The organs or small animals, after being injected, may be kept in glycerine or alcohol. Sections of them are cut with the Valentine's knife (Fig. 15). If the coloured fluid in the Woulff's bottle contains gelatine, it should be kept warm by a hot-water plate during the process of injection. The best way to kill small animals when they are to be injected, is to let them fall from a height. The vessels will then be found in a fit state. Inject as soon as possible. It is as well to begin on the fresh kidney of a sheep or pig, a frog (as before described), mouse or rat, or a piece of an intestine (see Fig. 64) may also be tried.

134. *Insects* (mounted entire).—It much depends upon the order of insect how they are mounted. For instance, the coleoptera, or beetles, nearly always show best when mounted as opaque objects. Lepidoptera, or moths and butterflies, are rarely mounted whole; if so, only micro-lepidoptera, which are mounted in an opaque cell like the beetles. Diptera, or flies; hymenoptera, or bees, ants, &c.; aphaniptera, or fleas; neuroptera (especially the larva), and the anoplura, or lice, comprise the insects that are mounted as transparent objects, the method of treatment being again according to their size and the nature of their body. If delicate and small, like the anoplura, they are mounted as recommended at page 100; if firmer, like the small diptera, they must be placed in a weak solution of potass for a short time, to get rid of the extraneous matter in the abdomen and thorax; or if this solution is found to be too strong, get rid of the matter by pressure between blotting-paper. In any case they are well washed, dried under pressure, and mounted in balsam or dammar (see Chapter III.), or else mount in glycerine-jelly. If the insect is still larger and firmer in its tissues, as in the case of large flies, bees, &c., a very small hole may be made with a needle in the under part of the abdomen; then place the insect in a tolerably strong solution of potass, and allow it to remain until the contents of the abdomen, &c., come away; this process may be assisted by occasionally pressing it gently between

two glass slips; when quite free well wash, and mount in balsam as usual (see Chapter III.).

135. *Palates*, or tongues of the mollusca, after being dissected out as mentioned at page 117, require cleaning with the solution of potass; then well wash and mount in a cell with glycerine, or dry and mount in balsam for the polariscope.

136. *Petals of Flowers.*—Tear the cuticle of the petal off by using the forceps, or place the petal on a glass slip and gently scrape the tissues away until the under cuticle is left on the glass; or mount the entire petal in glycerine, using the fluid as recommended at page 92; but previous to this, place the petal in alcohol to get rid of some of the colouring matter contained in the cells; but soon after it has been placed in the glycerine solution, add a drop or two of sulphuric acid, which will restore the colour. Mount in glycerine or glycerine-jelly.

137. *Pollens* are best collected in the anthers of the flowers, choosing a dry day; they are then stored in pill-boxes. If rather small and transparent, mount them dry; if at all opaque, mount them in a shallow cell, using essential oil of lemon. A few good pollens are evening primrose, valerian, common mallow, geranium, convolvulus, chicory, musk, passion flower, &c. Glycerine may be tried for mounting some of them, if the fluid recommended at page 92 is previously used.

138. *Raphides* (or plant crystals).—These beautiful natural crystals consist of either oxalate, carbonate, phosphate, or sulphate of lime, and may be distinguished by the proper chemical tests (see Chapter VII.) The part of the plant containing them must be dried

under pressure, soaked in turpentine, and mounted in balsam. They then show well under the polariscope, though sometimes they may be mounted dry. The plants that contain them in largest quantity are orchids, lilies, hyacinths, cacti, spurges, nettles, geraniums, the umbelliferæ, &c.

139. *Rock Sections.*—A description of the general method of preparation of these sections is given in Chapter I., page 36. Many persons prefer using glass one and a-half or two inches square, both for the grinding and also the mounting of the sections, they being much less liable to fracture than the ordinary three inches by one slips. This size might be taken advantage of for other specimens, such as bone, teeth, &c.

140. *Scales of Plants.*—These bodies are generally taken from the leaves and stem, with the point of a fine scalpel; place in the centre of a glass slip, cover with a drop of turpentine, and mount as usual.

141. *Scales of Fish* are cleaned with a weak solution of potass, and mounted dry or in balsam. Use a fine hog's hair brush in cleaning them.

142. *Scales of Insects*, almost always mounted dry: rub the wing or insect on a slightly damped slip, when the scales will adhere. Mount in a shallow cell dry (see Chapter II.)

143. Seeds should generally be mounted "dry opaque," but sections should be taken, especially of the testa, so as to show the structure and form of the cells, which are often very peculiarly beautiful in form. These sections, if too thick for the "dry transparent," may be preserved by the "fluid" or the "Canada balsam process." If the testa is at all

oleaginous or oily, it is better to mount the section in a suitable fluid (see Recipes 14, 53, 54, &c.)

144. *Staining tissues.*—The section of tissue to be mounted is cut with a simple broad razor well covered with alcohol or water, the tissue being embedded in a mixture of wax and oil poured into a small paper tray if necessary. The section is then placed in a solution of carmine (see Recipe 43) till sufficiently stained, *i.e.*, three to twenty minutes. Then it is well washed under a stream of water from the wash-bottle (Fig. 13); then place it for half a minute in a watch glassful of water, with one drop of acetic acid added thereto, thence into absolute alcohol. After ten minutes in this, all the water being extracted, it is placed in oil of cloves, which completely clears it in a minute or two; it is then mounted in a solution of gum dammar in turpentine. Perfectly fresh tissues are placed in the solution of silver (Recipe 30), left in it for about ten minutes, washed and mounted in glycerine, and exposed to sunlight for half an hour or more; then finished as usual with fluid preparations; or they may be transferred to absolute alcohol, and mounted in the same way as the carmine section.

145. *Starches.*—The best plan to obtain starch is to grind or cut the root, stem, seed, or grain, into very small pieces, and finish in a mortar; then place this powder in a small flannel bag, cover with two thicknesses of muslin, and with the fingers press and agitate it in a glassful of water, using, if possible, a conical vessel like Fig. 79; the water will then assume a cloudy or milky appearance, which, as the vessel is allowed to stand some time, will settle as starch at the bottom of the vessel. The gluten and

other parts left in the bag must be thrown away, and the bag well washed and freed from starch, &c., before using for any other root, &c. Starches are mounted dry in fluid and in balsam (see Chapters III., IV.)

146. *Teeth.*—Sections are cut with the fine saw (Fig. 22), the teeth being placed in the holding-screw (Fig. 6); they are then ground down to the required thickness in the same way as sections of bone (page 105); but some kinds of teeth—for instance, elephants—are too hard for this treatment; they must then be cut and treated in the same way as rock sections (see pages 38, 39, &c.) Sections of teeth are generally mounted dry; but if the whole tooth has been placed in diluted hydrochloric acid, sections are cut with the razor, and may then be mounted in a suitable fluid, like Recipe 70, or else in balsam or dammar.

147. *Tracheæ of Insects* are tolerably easy to dissect, especially from larvæ, in which case the body is cut open and the contents washed out with a camel's-hair brush, using a weak solution of potass if any difficulty is found in removing the matter, but the larva must not be allowed to remain in the solution, or the tracheæ will be spoilt; when quite clean, wash well with water and mount in a cell with suitable fluid; or sometimes they are dried and mounted in balsam.

148. *Vallisneria*, *Chara*, and *Anacharis*, and a few other plants—all show the circulation of the protoplasm or cell contents. Fig. 65 illustrates a slice cut from the leaf of the vallisneria, exposing the cells ready for examination; occasionally the circulation cannot be

observed without a slight degree of warmth is obtained. The slice should be placed on a glass slip, covered with a drop of water and a piece of thin glass.

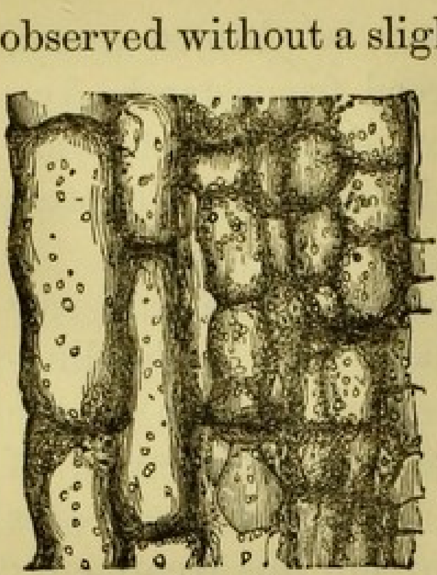


Fig. 65.

149. *Wood* (*Sections of*).—Although green wood is never used for cutting into sections, still it is always the best plan to place the wood that you are about to cut sections from in water for at least two or three days previously. Some persons prefer to place the wood in alcohol for a day or so before they soak it in water. If the sections curl up at all after being cut they must be placed in water, and then dried under pressure. Razors and other instruments are used in cutting the sections (see page 6).

150. To imbed objects in gum, place them in a funnel made out of blotting-paper, which must contain a concentrated solution of gum. Suspend the cone in absolute alcohol (methylated spirit will do well, and is cheap), when, in the course of a few days, the gum will acquire sufficient solidity to allow of its being cut together with the object; this is a good plan for many objects that require a support previously to sections being cut from them.

CHAPTER VI.

ON THE COLLECTION AND ROUGH PRESERVATION OF SPECIMENS, WITH NOTES ON THEIR HABITS, &c.

151. MANY objects are often lost which would not be the case if a slight knowledge of their rough preservation had been gained, and their beauty is often impaired by their being placed in an improper medium; as a general rule, very small insects keep well (when it is desired to store them) in acetic acid, to which 25 per cent. of alcohol has been added; but, of course, this rule is liable to certain exceptions, for instance, nearly all the small weevils directly they are caught require to be "set," as it is called, or the legs get so stiff that it is almost impossible to place them in their right position afterwards. The only way if this does occur from want of time, &c., is to relax the muscular parts by the use of laurel leaves. The weevils or other small beetles, &c., are placed in a bottle containing these leaves, which have been bruised in a mortar. The insects will then be found to be slightly relaxed; so much so that they may be "set" or mounted in their proper cell without any part being broken, if only moderate care is taken. These insects are generally fixed in rows on long strips of card-board, the legs being set in their proper position by the aid of a solution of gum tragacanth.

Fig. 41 represents a collecting bottle used for collecting these and other small insects.

We will now treat the subject of collection systematically under the following four heads, *i.e.*:

1. How to collect.
2. Where to find.
3. Rough preservation, with storing, labelling, and postage of specimens.
4. The classification of microscopic slides.

I. HOW TO COLLECT.

152. The following instruments which are absolutely necessary for collecting specimens, are drawn on stone at Plate 7: All the instruments with the exception of the forceps net, Fig. 69, have a hole turned in them, carrying a screw-thread of exactly the same size in each tool, so that the same rod (whether telescopic, and fitting into a walking-stick) or single, can be used. Fig. 66 represents a wide-mouth bottle fixed into a ring, but removable upon the slide (*a*), being slipped from off the elastic-like joint; this bottle is used for collecting small water insects, &c. Fig. 67 is a spoon fitted so that the rod can be removed at will, as before described; it is used for scooping up diatoms and desmids from the surface of mud, the rod being used when they are out of reach. Fig. 68 is a net used for catching butterflies, moths, and other winged insects. A stronger net must also be used for water insects. 69 represents a forceps net, very useful for catching beetles and small flies whilst in the act of resting on leaves. 70 is a kind of two-pronged rake; it is used for dragging water-weeds when out of reach of the collector. 71 is

Plate 7.

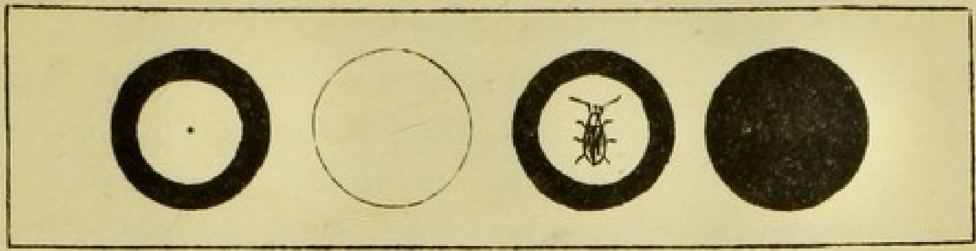
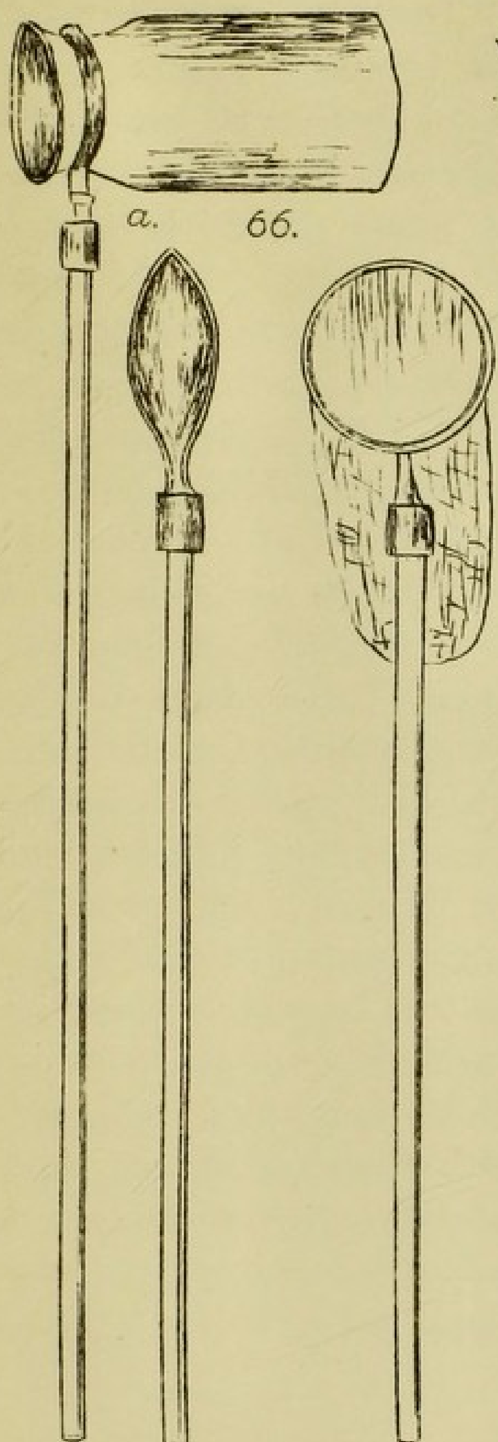


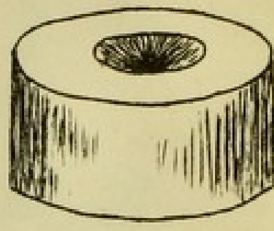
Fig. 76.



a. 66.

67. 68.

72.



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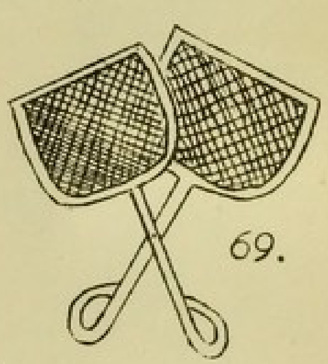

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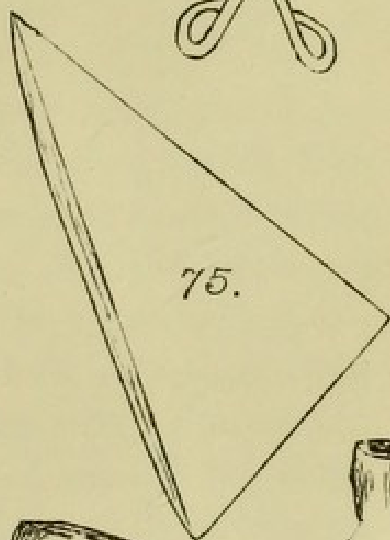

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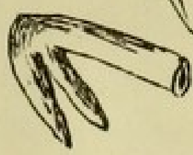


70.

71.

a useful tool used for cutting weeds, taking pieces off the bark of trees, and in all cases where a small lever and cutting instrument is required. 72 is a digging tool used for raising bulbs, roots, &c., and in searching for chrysalis. 73 is a pill-box filled with plaster of Paris, with a hole scooped out of the top (see page 143). Fig. 74 is a separate woodcut of a surface net, improved by Mr. Highley: this is made of bunting, stretched upon a cane hoop and supported by cords; the inner cone is much shorter, it is used to prevent objects being washed out again. At the bottom of the bag is fixed a glass bottle, and a bung is attached to it, with a cord to prevent its sinking too deep. This net is used in collecting marine objects, being towed at the end of a boat; the bottle must be emptied into others occasionally. In marine collecting, a dredge should also be used. Fig. 75 represents the corner of an envelope cut off to the required size: these will be found most useful for collecting all small specimens especially vegetable, like mosses, lichens, &c. Fig. 76 is one of the cell-holders which slide into the rack-box, Fig. 77; the left-hand circle represents one of the ebonite rings which are used for cells, and the right-hand black disc shows one of the circular holes into which they fit; the second circle from the left shows the back of one of the cells, and the next circle represents one of the cells having an insect mounted in it; for further description of these cells see page 145. Fig. 77, plate 8, shows the section of

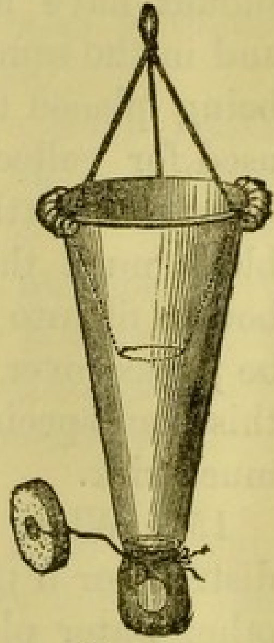


FIG. 74.

a rack-box containing six of the shelves or cell-holders, like the one at Fig. 76; a full description of these boxes, &c., is given at page 145. Fig. 78 also shows a square slab of wood as drilled with holes to receive bottles, &c., used in storing specimens, a full description of which is given at page 144. A modification of this arrangement will also answer well for the collection of objects; two blocks of wood, like Fig. 78, should have holes drilled in them of a suitable size, and in the same position in both blocks, so that upon being placed together the holes should meet; when used for collecting one block must be filled with the right-size bottles so as to fit rather tightly, the other block must then be placed so that the tops of the bottles fit into it; two stout india-rubber bands must be passed over the blocks to keep them together. By this plan specimens can be carried in bottles without much risk.

153. When much collecting is done in a marshy district, or if the collector cares more for the algæ and other water plants, &c., it is well to have the pockets of his coat lined with oiled silk; this plan will be found very convenient.

154. Fine muslin stretched tightly over a large ring about 1 foot in diameter, will also be found very useful, when fixed to the rod, for catching small water insects, &c., also for gathering desmids when floating in the water.

155. Tin boxes 4½ inches long by 3 inches wide, also sardine tins, &c., some of which must be lined with cork, will be found very convenient, and a tin sandwich box is also very useful for small plants, &c.

156. Before using the collecting bottle, Fig. 41, a

small piece of muslin must be put inside to allow foot-hold for the insects, otherwise the beauty of many of them might be impaired.

157. When beating bushes and low trees for beetles and other insects, always lay a white linen cloth about 4 feet square under the part that is about to be beaten for the insects to fall on ; it is as well always to carry this cloth in the coat pocket when out collecting. A small square of india-rubber cloth will also be found very useful when kneeling in damp places.

158. It is also advisable to carry two small books made of blotting-paper, one of them 5 inches square, the other 2 inches square, the largest to be used for small plants, flowers, petals, leaves, &c., and the other for small flies, mites, and other minute insects; both of these books will require to be kept well together by the aid of elastic bands after the specimens have been placed in them.

159. It is also a very good plan to keep a rough note-book in the pocket, in which to enter notes of the specimens collected, locality where found, &c., for if not done at the time it is forgotten, and often much valuable information lost.

160. In using the bottle, Fig. 66, for the surface of the water it must be held sideways, with the mouth partly below; but if it is desired to catch any insect beneath the surface of the water it must be carried under with the mouth downwards, so that it remains full of air when brought near to the insect or object it is desired to catch; it must be turned so that the mouth will point upwards ; the insect together with the water will then rush in, and may be brought to the surface, and the bottle emptied into another, or the

insect caught by pouring the water over the water-net, when it will be caught in the meshes.

161. *Blights*, brands, and other forms of micro-fungi, such as the well-known bramble leaf brand, &c., are best collected in corners of old envelopes. (See Fig. 75.)

162. *Desmids* are generally collected when in mud, where they are often found in large quantities, giving a greenish tint to the surface, by scooping the surface with the spoon (Fig. 67). The mud must then be put into cases made with oiled silk or sheet gutta-percha. They are cut out like a small envelope, and the flaps folded over and cemented there by the aid of the india-rubber cement (Recipe 5). When found in smaller quantities it is generally on conferva, water moss (*Fontinalis*), &c. The best way will be to wash the moss, &c., in a bottle of fresh water, letting the desmids and other matter fall to the bottom. Repeat this until a good gathering is obtained. The green scum on the top of ponds must also be examined. For this purpose a good Coddington lens is required. The collector should always carry one of these lens with him. Half-dried pools and puddles of water should always be examined, as they are often rich in desmids, diatoms, &c. It is desirable to preserve or mount, as soon as possible, all forms of algæ and conferva, more especially desmids, as they soon lose their colour, and begin to decay.

163. *Diatoms* are known from desmids by their being of a brown colour, often giving a rusty brown appearance to the surface of mud, whilst desmids are always green. They are collected with the spoon (Fig. 67), in the same manner as with desmids.

When found growing on masses of conferva and algæ they must be well rubbed, and then washed in a bottle of pure water, when the diatoms and other matter will sink to the bottom. In gathering the algæ, &c., for this purpose, when out of reach, use the rake (Fig. 70), which must be fitted into the rod. On new sponges, when washed in water, and the deposit at the bottom of the vessel collected, there will often be found good forms of marine diatoms. When at the sea-side always wash a large quantity of seaweed in fresh water, and collect the deposit; then bottle in spirit for future use. The alcohol will prevent any decay, and keep the diatoms until ready for the cleansing process (Chapter V., page 114).

164. To obtain amœba and other infusorial animalculæ, hay and other vegetable matter must be kept in a small quantity of water until it begins to decay. They will then be found in the water when subjected to examination under the microscope. A small piece of meat allowed to decay in water also produces good animalculæ. Amœba are almost certain to be found in the green frothy scum of puddles and pools of stagnant water.

165. Water fleas and other small water insects are caught by using the bottle (Fig. 66) or a small water net. If caught in a bottle, pour the water over a small piece of white linen rag, when they will be seen with the naked eye. Collect and store in small bottles, keeping each species separate if possible.

166. The best way to obtain many of the larger insects is to collect them, not in the perfect or imago state, but in the larva or pupa stage, and keep them until they emerge as a perfect insect. The advantage

of this plan is that, as well as the insect, the eggs may also be obtained. This is desirable, for as well as being rather a new field for investigation, these objects are often of great beauty. My plan, or rather one that Rev. J. G. Wood kindly suggested to me, is as follows: take a common white jam pot, fill it $\frac{2}{3}$rds full of water, then in the middle of a common saucer drill a hole about $\frac{3}{8}$ths of an inch in diameter. Through this hole I pass the spray of the plant that the larva feeds on, and over all (or some prefer only over the plant) place a lamp chimney or a common bell or propagating glass. The water in the pot, of course, keeps the spray of the plant green for a moderate time, but it is desirable to replenish it tolerably often. By this plan larva may be kept, and moths made to deposit their eggs upon the plant that is natural to them. Another plan is to place slips or cuttings of the plant that the larva or moths like, into a pot half full of earth; cover this with muslin, kept in its place with an elastic band passed over the rim of the pot.

167. *Gall Insects* (*Cynips*).—The best plan to obtain these insects is to keep the galls under a bell glass, or in a box having a glass lid, until they emerge. They are sometimes mounted whole, but generally the saw which is at the apex of the abdomen is the only part mounted.

168. *Poduræ* are small insects found generally in damp cellars, &c., well known for having minute scales, which are a favourite test-object to the microscopist, may be caught by placing over them a glass tube—a test tube will do as well. They jump into the tube. A finger must then be applied to the mouth, and a small quantity of tobacco smoke, fumes of

sulphur, &c., let into it; in a short time they will be killed.

169. *Mosses* may be collected in small pill boxes, each species being kept in a separate box.

170. To catch the greater water beetle (*Dytiscus marginalis*), and other water beetles, large larvæ, &c., the best plan is to tie a piece of thread tightly round the middle of a small worm, and let it into the pond, the other end of the thread being fixed to a long stick or the rod that is generally carried. Newts often take this bait also.

171. *Zoophytes.*—I find the best plan is to carry a moderately wide-mouth bottle filled with spirit—methylated spirit will do; wait until a wave passes over the zoophytes, or plunge them into sea water for a few minutes, then immediately drop them into the spirit. By this plan their tentacles will be found to be well extended.

172. In searching woods and fields for various micro-fungi, insects, &c , it must not be forgotten to sometimes collect seeds of wild flowers, small flowers, petals, leaves, stems, &c., which examine well after being brought home, or,

173. A good plan, if out for a long day's collecting excursion, is to forward your working microscope, with stock of thin glass slips, &c., to any cottage in the centre of the local district that you are about to explore, care of course being taken that the microscope is under lock and key, and no children about. From this cottage, as your local centre, radiate your short excursions of a mile, or half mile, bringing the specimens collected back to the cottage occasionally. By this plan much worry and fatigue of carrying

what you do not require at the exact time, and also the comfort of examining fresh specimens under cover and free from wind, &c., will be found a very great advantage.

174. When out for short excursions, it is as well to collect only one kind of thing—say, for instance, pollens. By this plan better work will be done than if you collected first pollens, then butterflies, then seeds, &c.

175. *Butterflies.*—When catching these beautiful insects, the best and less fatiguing plan is to allow them to settle on a plant, and then cast the net over them in the usual manner. Kill by a nip or pinch between the legs. This severs the nerves, and generally kills them.

176. *Moths* are caught chiefly at night time. The best plan is technically called "sugaring," as follows:

Take 1 pint of old ale.
1 pound coarse sugar.
1 pound treacle.

Mix and simmer together, but do not boil; when cold add a wine-glassful of rum—keep this in a large bottle. On any dark warm night from April to September, go into an orchard or wood, carrying a lantern with you; then paint a few trees with the mixture, using a common paint-brush. Return to the trees in about twenty minutes, when, if it is a successful night, various moths will be found sucking the liquid; they may then be beaten into the open butterfly net (Fig. 68), which must be held below them. Paint in patches of about seven or eight inches square;

do not use too much of the mixture for each patch; kill the moths in the same manner as butterflies; but if it is desired to keep them to lay eggs, place a small quantity of leaves in a tin box; put the moths in, and when arrived at home, give them a slip of the plant that is natural to them (see page 136).

177. *Foraminifera.*—When at the sea-side examine the sand well; also old whelk shells, &c., that have been driven in after a gale; but the best forms are always obtained by dredging the bottom some distance from the shore. Tenby, Weymouth, Isle of Wight, coast of Cornwall, and north-west coast of Devon, are about the best places to obtain good foraminifera, they being driven in-shore by the wash of the Atlantic.

178. When out collecting do not carry many things, as for a general rule the less apparatus taken the more specimens obtained; rough and ready means like old envelopes, pill-boxes, &c., will be found the best in the long run; and when apparatus must be used, care should be taken that it all fits into one common box or bag, the parts also fitting into one rod (see plate 7).

II. WHERE TO FIND.

179. The green weevil, often called the British diamond beetle, is found on the leaves of the common hazel (*Corylus Avellana*). The best time to collect most beetles is in the spring and autumn months, when masses of dead leaves, mushrooms, and other fungi, should be examined, also the hollow stems of cut wheat, &c.; and in the winter mosses and tufts

of grass will be found likely places. The common oil beetle (*Meloe proscarabæus*), which may be known from its peculiar blackish blue colour, has good gastric teeth, and will be found one of the best beetles on which to begin to dissect. The greater water-beetle (*Dytiscus marginalis*) is also good. This may be found on masses of weeds in the middle of ponds. All beetles should be examined for their gizzards and gastric teeth, especially the larger species.

180. *Butterflies* are often found in large numbers in clover fields, and also on chalk downs, such as those near Canterbury, &c.

181. *Fresh-water Shrimps* are found in nearly every stream, especially when it has a gravelly bottom. When small they are interesting objects, both alive and preserved.

182. *Water-fleas* are also found in nearly every fresh-water pond and pool, especially if covered with duckweed.

183. *Floscularia cornulata*, and other rotatoria, are found on fresh-water plants, particularly water-moss (*Fontinalis*).

184. I have a very good pocket microscope for observing these and other animalculæ, &c. It is sold by Mr. Wheeler, of Tollington-road, Holloway, London. The price, I think, was about a guinea.

185. Hastings and Torquay are both good places for zoophytes. Devonshire, Cornwall, south-west coast of Wales, are good for seaweeds. Occasionally a few good species may be found at Hastings. Collect at the very lowest spring and autumn tides, on the seaward side of rocks.

186. *Sphacellaria cirrhosa* is a very good seaweed for

showing the antherozoids or spores when the weed is mature; it is tolerably common, and parasitic upon larger algæ.

187. *Marine* diatoms are generally found on seaweed.

188. *Marshes* are good places to find diatoms, particularly salt marshes like Erith, Dartford, &c.

189. *Guano* — various samples — should be well searched for diatoms. Fossil earths, such as Oran, Toome Bridge, Bermuda, &c., are composed entirely of diatoms, but do not, as a rule, yield a great variety of species. Fresh diatoms are found nearly everywhere—in ponds, pools, puddles, round ponds, &c., either on water-plants, or on the surface of the mud round the edge of the pond.

190. *Desmids* may be looked for in ponds placed in exposed situations, like Hampstead heath, the ponds on Tunbridge Wells common, &c. Spring and autumn is the best time to collect these and other algæ.

191. *Mosses* are found on shady and damp banks, rocks, woods, &c., and some species, like *funaria hygrometrica*, on special places, as this species almost always grows on a place after a fire, especially if wood has been burnt, as in the case of encampments of gipsies, &c. A section of the capsule of this species shows the columella well. Some species are always common, like the common wall screw moss (*Tortula muralis*).

192. The bark of old trees, especially when covered with lichens, &c., often affords a living and hiding place for many minute insects, such as the larvæ of dermestes, and other small beetles, mites, &c. March, April, and May are the best months to search the bark of trees.

193. *Poduræ* are often caught in wine-cellars, and in many damp situations, such as under stones, flower-pots; also under large leaves like the dock. A stale cooked potato, an old meat bone, &c., form excellent baits when placed in a damp cellar, as they live upon decayed animal and vegetable substances.

194. The harvest bug (*Trombidium autumnale*) may be found in the hollow stems of the straw after the wheat has been cut, or by dragging a damp handkerchief through the stubble. They are minute red insects. Earth mites (*Tetranychus lapidum*) are found in the crevices of stones, bark, &c. Furze mites on gorse bushes, between a thorn and the main stem.

III. ROUGH PRESERVATION, LABELLING, AND POSTAGE OF SPECIMENS.

195. It is always well to keep sufficient of the material collected, for if not required for private use, they can be exchanged with friends. Beetles, butterflies, moths, vegetable hairs, pollens, stems of grasses, most seeds, sections of woods, feathers, bones, hoofs, horns, fish scales, teeth, tongues and palates of molluscs after rough dissection (see Chapter V., page 117, and also plate 6, G, Figs. 2 and 3). Sponges, spores of ferns, mosses, equisetaceæ, insect scales, mosses, diatomaceous earths, shells, foraminifera, &c., are best kept dry in small pill-boxes, suitable to the size of the specimen or specimens.

196. Flies, bees, wasps, crickets, and other large and fleshy insects, must be kept in alcohol.

197. Minute insects, such as parasites, acari, small

flies, &c., may be placed in the same fluid as recommended for algæ, &c. (see Chapter IV., page 92). The spirit and water must be allowed to evaporate, when glycerine will be left, if not sufficient fill up with pure glycerine; or they may be kept in acetic acid, to which 25 per cent of alcohol has been added, but this will render them much more opaque than the glycerine. If the parasites, &c., are to be mounted in balsam or dammar, it is best to put them immediately into turpentine, and not into either glycerine or alcohol. This, of course, depends upon whether they are full of blood, &c.; if so they must be treated with the solution of potass, as in Chapter III., page 73.

198. Algæ, especially the smaller kinds, such as the conferva, desmids, &c., require to be roughly preserved in the same medium as they are mounted in. Glycerine will be found the most generally useful substance, but care must be taken to add it gradually (see Chapter IV., page 92).

199. Zoophytes may be kept in the same bottle of alcohol in which they are killed.

200. A good plan, where only a very small quantity of desmids, small insects, &c., are desired to be preserved, is to fill pill-boxes with liquid plaster of Paris. Let it set and harden, then scoop out a conical hole in the plaster (see Fig. 73, plate 7). Place a small piece of wax in this cavity, which absorb into the plaster by the action of a moderate heat. The hole or cavity will then be found very useful for keeping small quantities of specimens, either dry or in glycerine, the lid of the pill-box forming a cover to keep dust out.

201. Where objects are stored in fluids, bottles, of

course, must be used. The small homœopathic bottles will be useful for small quantities; both these and larger bottles must be kept upright, by putting them into holes drilled of a suitable size in blocks of wood; a useful size for which is four inches square, and one and a half inch deep (see Fig. 78, plate 8). Both the pill-boxes and bottles must be kept in drawers of a suitable size, divided into compartments as below. It is as well to have three or more drawers labelled as follows:

DRAWER 1.—ANIMAL OBJECTS.

Roughly Preserved.

1. Vertebrata.
2. Mollusca.
3. Articulata.
4. Radiata.

DRAWER 2.—VEGETABLE OBJECTS.

1. Flowering plants.
2. Flowerless plants.

DRAWER 3.—MINERAL OBJECTS.

1. Metallic objects.
2. Rock sections, &c.
3. Crystals.

202. White paper labels, with the name and date, should be placed upon both boxes and bottles. Where the objects are foreign, yellow labels should be used, as it is a great guide in finding any object quickly.

203. The best plan for packing specimens of unmounted microscopic objects for postage, is to get a block of soft wood (deal is best) five inches long, one inch deep, one inch wide, drill five holes, more or less, and of different depths, according to objects. Fill what place is left, after the specimens have been placed in the holes, with cotton wool Use a flat cover the same size as the block, but only quarter inch thick.

Plate 8.

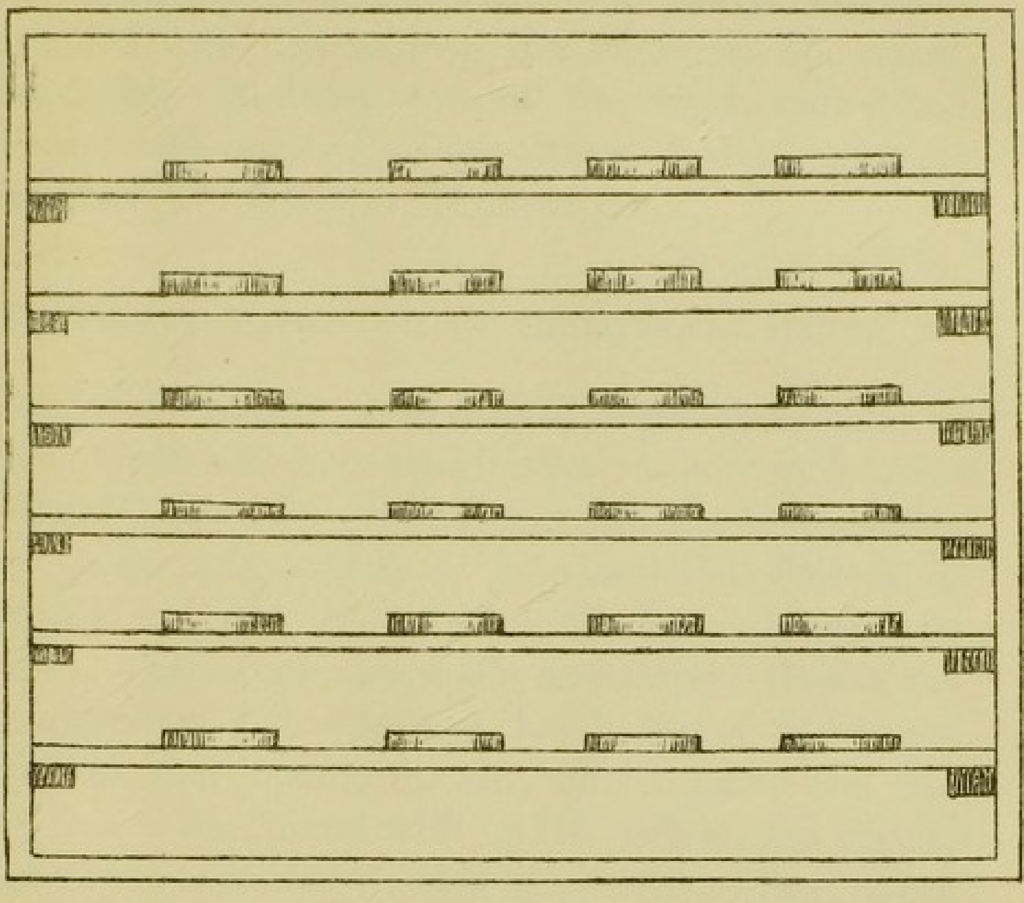


Fig. 77.

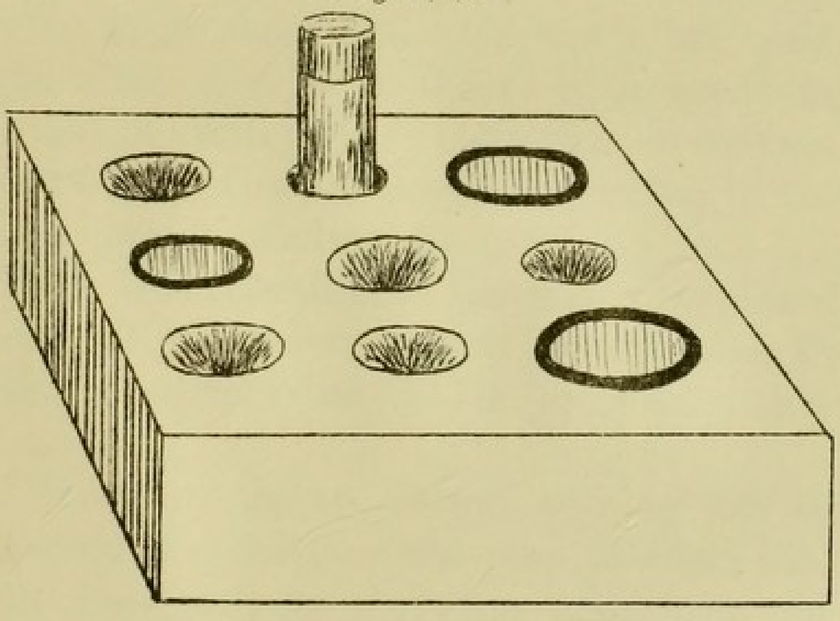


Fig. 78.

Screw this cover to the block with three screws, one in the centre, and one at each end. Over all place a gummed label containing the right stamp, name, address, &c. If slides are sent, the small rack-boxes made and sold especially for postage of slides, may be obtained of Mr. Wheeler, Holloway.

IV. THE CLASSIFICATION OF MICROSCOPIC SLIDES.

204. For rough observation, large quantities of opaque objects may be stored in the ordinary rack-boxes (see Fig. 77, plate 8). In this case they are temporarily mounted in cells, which fit into wooden shelves or plates, sliding into the grooves of the rack-box (see Fig. 77). These cells are made as follows: One of the vulcanite rings, $\frac{3}{4}$ in diameter, has a disc of cardboard exactly the same size as the ring cemented to one side of it; this is blackened with Indian ink on the inside. The object is mounted on this blackened surface, using either Recipe 1 or 2. The cell covered with a thin glass circle to keep dust out. On the other side, where a thin white disc of cardboard is exposed, the name of the object, with date of collection, is written. These cells are then dropped into holes drilled in the sliding plates, which shelves fit into the rack-box (Fig. 77). Four cells containing objects may be placed on each plate. Twenty-four objects can therefore be stored in the same rack-box which ordinarily only holds six.

205. But if money is no object, nothing can be better for storage of slides than the pine cabinets sold by most opticians, only each drawer must form one of a series which, combined, should be of so compre-

hensive a character that a slide may be absorbed into the whole without difficulty or disarrangement of the series.

The following is a plan which I should recommend:

A.

CABINET.—ANIMAL KINGDOM.

VERTEBRATA.

Drawer 1.—Bone system.
Drawer 2.—Muscular and fibrous systems.
Drawer 3.—Nervous system and organs of sense.
Drawer 4.—Integumentary system.
Drawer 5.—Nutritive system.
Drawer 6.—Miscellaneous.

B.

MOLLUSCA.

Drawer 7.—Classes, Polyzoa, Tunicata, Brachiopoda.
Drawer 8.—Classes, Lamellibranchiata, Gasteropoda, (tongues or palates), Pteropoda, Cephalopoda.

C.

ANNULOSA.

Class Insecta.

Drawer 9.—Orders, Coleoptera, Strepsiptera, Hymenoptera.
Drawer 10.—Orders, Lepidoptera, Diptera, Aphaniptera.
Drawer 11.—Orders, Hemiptera, Orthoptera, Neuroptera.
Drawer 12.—Orders, Thysanura, Mallophaga, Anoplura.

ARACHNIDA.

Drawer 13.—Classes, Arachnida, Myriapoda.

Drawer 14.—Classes, Crustacea, Chætognatha, Annelida, Gephyrea.

D.

ANNULOIDA.

Drawer 15.—Classes, Echinodermata, Scolecida.

E.

CŒLENTERATA.

Drawer 16.—Classes, Hydrozoa, Actinozoa.

F.

PROTOZOA.

Drawer 17.—Classes, Gregarinidæ, Rhizopoda, Infusoria.

CABINET.—VEGETABLE KINGDOM.

G.

FLOWERING PLANTS.

Drawers 18 and 19.—Reproductive system, including seeds, pollens, &c.

Drawers 20 and 21.—Epidermal tissues, including cuticles, hairs, scales, &c.

Drawers 22 and 23.—Cellular and vascular tissues, including sections of leaves, petals, &c.

Drawer 24.—Sections of woods.

Drawer 25.—Hard tissues.

Drawer 26.—Miscellaneous.

H.

ACOTYLEDONOUS, OR FLOWERLESS PLANTS.

Drawers 27 and 28.—Reproductive system, including capsules, apothecia, spores, &c.

Drawer 29.—Orders, Musci, Hepaticæ, Lichenen.

Drawer 30.—Fungi.

Drawers 31, 32, and 33.—Orders, Characeæ, Algæ.

Drawer 34.—Sections of stems and miscellaneous objects.

I.

MINERAL KINGDOM.

Drawers 35 and 36.—Sections of rocks, gems, &c.

Drawer 37.—Various crystallizations of salts.

Drawer 38.—Alkaloids.

Drawer 39.—Special micro-crystals, illustrating micro-chemistry.

Drawer 40.—Miscellaneous.

By the above plan any special part of the entire series can be enlarged or condensed without interfering with the whole. For instance, suppose the drawer containing sections of bones had overgrown its space, the only thing necessary is to add another drawer immediately below it, and label it, Drawer 1 b, signifying that is the second or extra drawer in the A series ; this would not clash or be confused with the B series, for that would be Drawer 7 c, which means the second or extra drawer of B series. If a smaller collection is required, two or three drawers can be reduced into one. It is as well to keep a book containing the names of the objects in the cabinet, each in its right position, with the number of duplicates for exchange, &c. Care being taken to make a note against the object when lent out to friends, &c.

CHAPTER VII.

METHODS OF EXAMINATION OF ORGANIC AND INORGANIC SUBSTANCES, WITH TESTS FOR ADULTERATIONS.

206. THE various processes of examination and investigation which are to be adopted with any object must, of course, depend greatly upon its nature. The examination of its outward form will also vary greatly, from the minute and more critical examination of its various fibres and tissues, if organic; and the determination of its chemical structures, if inorganic. Experience has told me that for any faithful and accurate investigations, it is advisable not to have many objects at the same time, but to rigidly exclude all but one, or, at the most, two specimens, bringing to bear on these subjects the full powers of the mind, with the use of the most accurate instruments, &c., at the disposal of the student.

207. The first point to notice in conducting an examination of any unknown substance is to test whether organic, inorganic, or combination of the two. This is done by the action of heat. It is best to use the spirit-lamp, as the deposit of carbon from the flame of gas greatly interferes with the examination. A piece of platinum foil is placed on the triangle (Fig. 20). The object is then placed on this, and held over the flame of the spirit-lamp, when, if the

substance is of an *entirely organic nature it turns black*, and if held long enough burns entirely away. If it is composed of inorganic and organic substances combined, as in a piece of wheat straw, it first becomes black, but in process of time a white ash is procured, which, however long the platinum is held over the spirit-lamp, still remains the same. This white ash is silica or flint, which has been deposited in the tissues of the plant whilst growing; *but if the substance had been entirely inorganic*, it would not have turned black or burnt away, but have remained the same, with the exception of crystals, which fuse and melt, but burn not away; and compounds of ammonia, which entirely sublime. As a type then of the three divisions—organic—organic and inorganic combined—and inorganic alone—we will take the following three substances: Shell-lac, wheat-straw, and bichromate of potass. Now, the wheat-straw, of course, shows to the unassisted eye its organic nature, but if the shell-lac has been previously tinted to the required tint, it would greatly resemble the bichromate of potass; but on subjecting it to the test of heat, or rather burning, the shell-lac will turn black, and burn entirely away, showing its organic nature; whilst the bichromate, with the exception of fusing, will remain nearly the same, which is a proof of its inorganic origin. For all the common chemical tests see page 153: it is quite necessary that the student should have, at least, a slight knowledge of them; for, with the microscope, the smallest quantity of any ordinary substance can be analysed if proper care is taken.

208. If the specimen under examination is proved to be of an organic nature, its further examination is

generally conducted with the microscope alone, few re-agents being used; but if of an inorganic nature, chemical tests as well as the microscope are brought to our aid. We will take, for example, wheat-flour and powdered chalk. Upon subjecting the flour to the heat test it will be found to *turn black*, and burn nearly away, proving its organic nature, and leaving only a small amount of silica, &c. We next roughly mount on a glass slip three small quantities of the flour—one dry, one in water, one in balsam—using for the purpose three $\frac{1}{2}$ thin glass circles. We then place that which is mounted in balsam, under the polariscope, using $\frac{1}{4}$ inch power. The well-known cross of starch granules will then appear, and as the analyser is turned, will rotate, proving that it is starch. To make quite sure, however, a small drop of the re-agent, solution of iodine (see Recipe 50, also page 157), is applied to the small quantity of the dry flour, allowed to remain one minute, add a small quantity of water; then place the slide under the $\frac{1}{4}$ inch power, when, immediately, the blue colour of the granules will be perceived, proving it to be starch. A better re-agent is iodide of potassium, to which add one drop of sulphuric acid: this liberates the iodine. The polariscope and analyser must be taken off previous to this observation. We have therefore proved the particles of matter to be starch. Their shape and size will generally prove of what kind. To observe their shape the granules that have been mounted in water must now be brought under examination, and by their globular character are proved to be wheat-starch (see Fig. 83, plate 10). On testing the powdered chalk with heat, its inorganic character is immediately discovered, for though consisting of minute shells, the remains of foraminifera (see Chapter V., page 106), these shells consist entirely of carbonate of lime, an inorganic compound. We proceed in testing as with the flour. Roughly mount three small quantities—one dry, one in water, one in balsam or dammar—using thin glass circles as before. Taking that which has been mounted in balsam, we place it under the polariscope, as in the case with flour, but, unlike that substance, it will be found to polarise scarcely at all, but we notice instead traces of various organisms; therefore, to get a clearer view of these, we observe it without the polariscope and analyser, and under the $\frac{1}{4}$ inch power many entire shells of foraminifera are seen, proving its former organic character. We next take the part that has been roughly mounted in water, to this we add one drop of sulphuric acid ($SO_2\ Ho_2$), using for this purpose one of the re-agent drop-bottles, Fig. 12. The action of this acid upon the shells must be observed, as it proves that they consist of carbonate of lime, the sulphuric acid disengaging the carbonic acid gas, which will be seen escaping in minute bubbles, and forming with the lime another compound, *i.e.* sulphate of lime (SO_2Cao''), the presence of which is proved by the needle-like crystals, see Fig. 97, plate 10. To make quite sure that it is a carbonate of lime, we add to the part that has been roughly mounted dry, one drop of hydrochloric acid (HCl), using the same kind of test-bottle, Fig. 12. Upon applying the acid, minute bubbles of carbonic acid gas will be seen escaping, causing much effervescence. When they have all escaped, what remains is a new compound—viz., chloride of calcium. This is formed from the chlorine of the hydrochloric acid having united with the lime after the carbonic gas had been set free. To prove the presence of lime, we drop one drop of oxalate of ammonia ($C_2O_2Amo_2''$) from one of the test-bottles on to the edge of the thin glass cover, allowing it to run into the fluid chloride of calcium, when, immediately, a white insoluble deposit of oxalate of lime is formed, again proving the existence of lime. This deposit may be examined under the microscope, and compared with Fig. 95, plate 10. From the above tests we may now safely conclude that the powder which we have been examining is carbonate of line in the form of chalk. The above will give an idea of the method of testing an inorganic compound.

209. For all the tests of the metallic and non-metallic elements, a good work on chemistry must be consulted, as space will not permit of our giving the entire series. But for the use of the student we will now give the characteristic chemical and micro-chemical tests of a few common metallic elements, and two non-metallic, viz.:

Potassium,	Gold,
Sodium,	Lead,
Calcium,	Silver,
Magnesium,	Mercury,
Iron,	Iodine, and
Copper,	Silicon.

210. *Potassium.*—When bichloride of platinum ($PtCl_4$) is added to a solution of any salt of potassium, to which a few drops of hydrochloric acid have been previously added, a yellow crystalline deposit is formed, which does not polarise light (see Fig. 100, plate 10); also

if a solution of tartaric acid is added to a solution of a potassium salt, a white crystalline deposit of cream of tartar (hydric-potassic tartrate) is formed.

211. *Sodium.*—If bichloride of platinum is added to a solution of a sodium salt, to which hydrochloric acid has been previously added, no precipitate or deposit occurs ; but if this solution is evaporated spontaneously it crystallizes in plates, &c., *which polarise light* (see Fig. 101, plate 10). By this test sodium may be distinguished from potassium. Another good test is to add carbazotic acid to a solution of soda, when crystals of carbazotate of soda are formed (see Fig. 99, plate 10). But the presence of sodium is best shown by the yellow band in the spectrum.

212. *Calcium.*—As mentioned before, when oxalate of ammonia ($C_2O_2Amo_2''$) is added to a solution of a calcium salt, an insoluble (in water) deposit of oxalate of lime is formed ; if the lime exists only in a nearly insoluble compound, as in the case of chalk, it must be dissolved by the action of an acid, and then tested with the oxalate of ammonia. The oxalate of lime may then be compared with Fig. 95, plate 10.

213. *Magnesium.*—If phosphate of soda ($POHoNao_2$), together with a small quantity of liquor ammonia is added to a solution of a magnesium salt, a white deposit of ammonic magnesic phosphate ($POMgo''Amo$) is formed, which compare with the drawing (Fig. 98, plate 10). If the magnesia is present as an oxide, carbonate, &c., it must be dissolved in an acid previous to testing.

214. *Iron.*—The best test is the formation of Turnbull's blue, or Prussian blue, according to whether the solution of a salt of iron (which should be rendered

acid by a drop or two of hydrochloric acid) is a negative or positive salt. The reaction is as follows: Negative salt of iron. Potassic ferricyanide causes a dark blue precipitate of ferrous ferricyanide ($Fe_3Fe_2Cy_{12}$), known as Turnbull's blue; it is decomposed by potassic hydrate (solution of potass). Positive salt of iron. Potassic ferrocyanide causes a dark blue precipitate, or deposit of ferric ferrocyanide ($Fe_2^{iv}(FeCy_6)^{iv}{}_2$), called Prussian blue; this is also decomposed by potassic hydrate. In testing for these and other precipitates, it is best to use my precipitating cell, shown at Fig. 102. If iron is thought to be present as an ore, or in small particles as a manufactured and prepared metal, it must be dissolved in hydrochloric acid (HCl) with a slight excess of acid.

215. *Copper.*—The colour of the solutions of salts of copper is blue or green. Liquor ammonia (ammonic hydrate) causes a blue precipitate; but when in excess it redissolves this, forming a beautiful dark blue solution, quite characteristic of copper. A piece of bright iron wire, when placed in a solution of a salt of copper, rendered slightly acid, becomes coated with red metallic copper. If copper is thought to be present either as an ore or metal, it must be dissolved by the action of sulphuric acid (SO_2Ho_2).

216. *Gold.*—When a solution of any salt of gold is acted upon by a solution of oxalic acid ($C_2O_2Ho_2$), gold is precipitated in the metallic state. A bar or small piece of tin also causes a precipitate of the so-called purple of cassius. A solution of protochloride of tin will also give a purple brown precipitate. If gold is thought to be present in the form of

gold dust, &c., it must be dissolved in aqua regia previous to using these tests.

217. *Lead.*—Iodide of potassium, when added to a solution of a lead salt, gives a bright yellow precipitate of iodide of lead (PbI_2), which dissolves in boiling water. Potassic chromate (CrO_2Ko_2) also causes a yellow precipitate of the yellow chromate of lead (CrO_2Pbo''). If lead is thought to be present as an ore or oxide, it must be dissolved in nitric acid (NO_2Ho) previous to using the above tests.

218. *Silver.*—Hydrochloric acid, when added to a solution of a salt of silver, precipitates the white curdy chloride of silver (AgCl) which is soluble in liquor ammonia (ammonic hydrate). If silver is thought to be present in the form of an ore, &c., it must be dissolved in nitric acid previous to using the above test.

219. *Mercury.*—If liquor potass (potassic hydrate) is added to a salt of mercury, to which nitric acid (NO_2Ho) has been added, a red precipitate of the red oxide of mercury (HgO) is obtained. If this is collected in a very small test-tube, and subjected to heat of spirit-lamp, the oxygen is driven off, and small globules of pure mercury will be formed in the upper part of the tube. Mercury may also be distinguished by placing a small piece of copper wire or foil in a solution of a salt of mercury, when it becomes coated with a white copper amalgam. The piece of wire must then be placed in a dry test-tube, and subjected to heat, when globules of pure mercury will be found in the tube. If mercury is supposed to be present in a powder, &c., it must be dissolved in nitric acid (NO_2Ho) previous to using the above tests.

220. *Iodine.*—The best test for free iodine is starch, which turns blue when brought into contact with it. If the iodine exists in the form of an iodide, it is best to liberate the iodine by the addition of a few drops of hydrochloric acid (HCl); it will then exhibit its characteristic reaction with the starch. It may also be known by its beautiful violet vapour which it gives off when heat is applied.

221. *Silicon* generally exists in the form of silica, which is not acted upon by acids, with the exception of hydrofluoric acid; but it dissolves when fused in carbonates of soda and potass, &c., which I have taken advantage of in separating foraminifera (see Chapter V., page 119). When testing, to be quite sure that silica has been dissolved in the carbonate of potass, hydrochloric acid must be added gradually until jelly-like flakes of silicic acid appear. In testing for this and small quantities of all other chemical compounds, &c., it will be found best to use a precipitating cell like Fig. 102.

These tests have only been added as a guide to the student, and not in any way to supplement reference to other works of a strictly chemical character.

222. *Carbonates.*—In testing for carbonates, if the substance is of an earthy nature, nitric acid (NO_2Ho) must be applied; when, if it consists of any carbonates (for instance, chalk, carbonate of lime), the lime will be dissolved, and bubbles of carbonic gas will be set free, which are easily seen escaping when the cell is placed under the microscope. If the carbonate to be tested is in the form of a solution of a salt like carbonate of soda, a small drop of chloride of calcium

($CaCl_2$) must be applied, when immediately carbonate of lime is formed (see Fig. 94, plate 10).

223. *Sulphates* are best distinguished by adding to their solution a small quantity of nitrate of barium, when a white deposit or precipitate of sulphate of barium is formed, proving the presence of a sulphate. This deposit is nearly insoluble in acids.

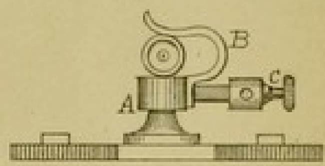
224. *Chlorides*, when in solution, are easily distinguished by adding a drop of nitrate of silver, when immediately a white curdy precipitate of chloride of silver (AgCl) is produced, insoluble in nitric acid, but soluble in liquor ammonia (ammonic hydrate).

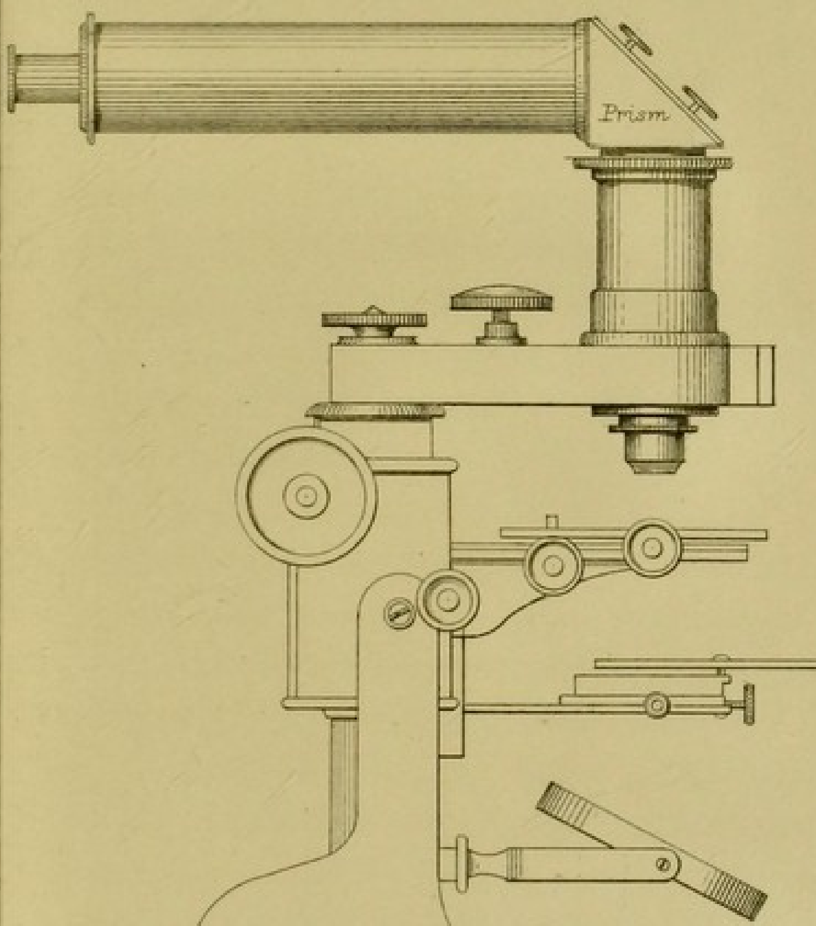
225. *Phosphates*, when in solution, may be distinguished by adding ammonia and then a few drops of a solution of sulphate of magnesia, when characteristic crystals of ammonic phosphate of magnesia will be formed (see Fig. 98, plate 10).

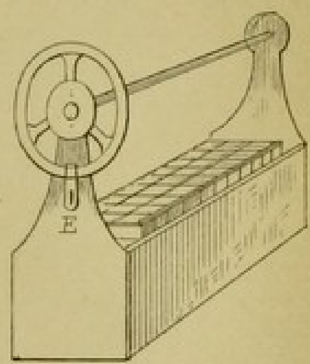
226. Having thus given a slight sketch of the methods of examination of inorganic substances, I cannot leave the subject without noticing the usefulness of electricity when applied to the microscope. By the kindness of Mr. Philip Braham, of Bath, and Mr. Hardwicke, I am enabled to give an extract from an article contributed by him to the "Microscopical Journal." "The instrument used I give a sketch of (see plate 9), and the electrical stage (a diminutive double discharger, which does excellently for spectrum analysis in connection with an induction coil), and galvanic battery, with fittings for varying the quantity and intensity of the electric current. The sketch of the discharger shows the manner in which it is fitted. The two short pillars, A, A, are of ivory, turned to a cup-shape

Discharger

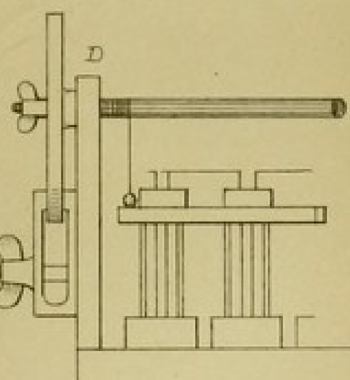
Spring Clip.







Battery.



Philip Braham del. W. West & Co. lith.

on the top to fit the balls; the springs, B B, keep the balls in their place, and are fastened to the side of the ivory pillars by the binding screws, C C, to which the wires from the poles of the battery are connected; the ends of the discharger rods are split to receive the short wires of the metal under electrolysis.

"The battery is similar in its construction to Smee's, but with carbon plates instead of platinized silver; and, excited with bichromate of potass and sulphuric acid, it has the advantage of not evolving fumes or acid spray. The wheel at the end, D, is provided with a break, E, to keep the plates at any required depth in the solution. The spring clip, G, connects any number in the series of six cells.

"When it is desired to examine the crystals of metal held in a solution of its neutral metallic salts, gold, silver, copper, lead, tin, and zinc, being the best, a drop must be placed on a glass slip and the ends of the wires fitted into the discharger rods dipped into it, and kept about a tenth of an inch apart (see plate 9, Discharger), lowering the battery into the solution, and carefully watching the terminal in connection with the zinc pole," practice will give the right degree. Quantity—*i.e.*, depth of plates in solution, and Intensity—*i.e.*, number of cells.

A rectangular prism is adapted to the body of the microscope to save fatigue in long-continued observations, and by turning on its optic centre enables many persons to see the same objects by turning the eyepiece towards them. The light must be entirely reflected by placing coloured glass in the place of the sub-stage diaphragm, and sending light through it. A clear outline is given to the metallic crystals, and the beauty of the effect enhanced. Chloride of barium, chloride of sodium, chloride of potassium, ferricyanide of potassium, bichromate of potass, &c., form well on the positive electrode.

227. The following re-agents are used in the examination of both organic and inorganic substances. All of them should be kept in the small test-bottles (see Fig. 12):

Sulphuric acid.
Nitric acid.
Hydrochloric acid.
Acetic acid.
Chromic acid.
Carbazotic acid.
Nitrate of barium.
Nitrate of silver.
Oxalate of ammonia.
Iodine (solutions of), see Recipe 50.
Ammonia (liquor).
Solution of potass.
Solution of soda.
Ether.
Alcohol.
Test-papers, &c.

228. *Sulphuric acid.*—The pure acid must be used. When it is added to the cells of plants previously dyed with iodine, it renders the cell-wall (cellulose) blue or purple. It causes epidermal tissues to swell up and also separates the cells; and as a test for lime, see page 152.

229. *Nitric acid*, when pure, dissolves all but cellulose and silica when vegetable substances are boiled in

it, also used for cleaning diatoms (see page 114). Colours albumen yellow, and then dissolves it. When 20 parts are diluted with 100 parts water, it coagulates albumen, and also renders muscular fibre cells better for examination.

230. *Hydrochloric acid* is chiefly used for dissolving out the inorganic compounds in bone, teeth, &c. It is also used for dissolving any substance suspected to be lime, previous to applying the proper tests (see page 154).

231. *Acetic acid* has the property of dissolving albuminous granular matter. It renders preparations that have been hardened in alcohol transparent, especially if boiled in it. It is also useful for testing phosphate and carbonate of lime, which it dissolves, whilst it does not in the least affect oxalate of lime. This is a useful test for raphides (see page 124).

232. *Chromic acid.*—This, when much diluted, is used for the hardening of tissues. For its preparation, &c. see Recipe 18.

233. *Carbazotic acid* is chiefly used for testing for soda (see page 154).

234. *Nitrate of barium* used for testing the presence of sulphates (see page 158).

235. *Nitrate of silver* used for testing for chlorides (see page 158). It is also used for staining tissues (see page 126), and it gives a yellow precipitate with phosphates.

236. *Oxalate of ammonia*, forming oxalate of lime, which dissolves in the strong mineral acids, such as sulphuric, but not in acetic acid, is used for testing for lime (see page 154).

237. *Iodine* (*solutions of*)—(see Recipe 50) is some

times used for dyeing transparent vegetable and animal tissues, so as to render them distinct; but it is chiefly used as a test for starch, which it colours blue (see page 151).

238. *Liquor ammonia* dissolves chloride of silver (see page 156); also much used for preparing the staining fluids, &c., extracting grease, &c. Ammonic oxide of copper dissolves delicate cellulose, but does not attack woody fibre, &c.

239. *Solution of potass* does not much affect vegetable structures, but it dissolves nearly all animal substances, with the exception of chitine. Its action is much stronger when heated; it separates many animal substances, such as bone, nails, &c., into their component cells, &c. It is also used in the preparation of insects.

240. *Solution of soda.*—This acts in nearly the same way as the potass, and some persons prefer it.

241. *Ether* is generally used as a re-agent for proving the presence of fatty or resinous matter, which it dissolves. It also dissolves animal and vegetable colouring matters. It may be known by its smell.

242. *Alcohol* is much used for its preservative properties. It dissolves resinous matter, and vegetable and animal colouring matters, &c.

243. *Test papers, &c.*—It is as well to keep both the red and the blue litmus paper. The red turns blue if there is any trace of alkali in the fluid under examination, and if any acid the blue paper turns red. The fluid is then subjected to further examination (see pages 154, 155, &c.)

244. I must now give a slight sketch of the method of examination of organic substances. If large, as in

the case of an insect, their correct name is, of course, gained by reference to suitable books; but if there remains only a small particle of matter it is much more difficult. The following is a general outline: Make a note of the form and colour. Note the effect of polarized, reflected, and transmitted light. In the case of shells or any rolling bodies, mount a very small quantity in hard balsam, and then grind the surface: this will go far to prove their exact form. If the object is soft examine it by pressure, using the compressorium, Fig. 37. If possible divide into ten or twelve parts, and note the action of the re-agents upon it; if very thick or hard, grind it until the section is transparent, taking a small piece from the whole for this purpose. If softer, cut sections with razor or scalpel, subjecting these sections to the action of the re-agents. If very minute, like dust, increase the power of the microscope until the shape of the object can clearly be made out, still noticing the action of the re-agents.

In examining deposits always use the pipette (see Fig. 79). When the re-agents are applied always use my cell (see Fig. 102). If the objects under examination are placed in fluid, the air-bubbles must not mislead the student (see Fig. 80), as they might do if he had not previously noticed the appearance of them when in water or oil; also note

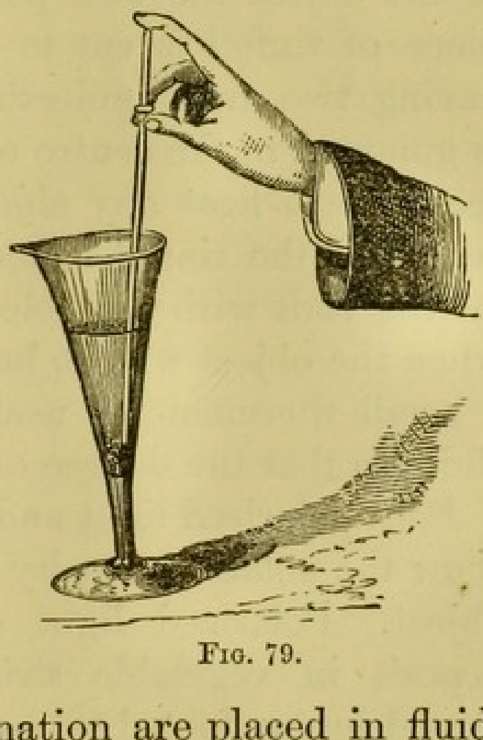


FIG. 79.

the difference of oil globules in water. If the object under examination is alive, and it is desired to keep it moist, a little apparatus, like Fig. 81, must be used; it consists of a small piece of glass tubing fixed with cement to a slide, a piece of thin glass nearly covers this little reservoir of water: a fine thread of cotton or wool is then placed between the object under examination and the reservoir; this serves to conduct the water to the object. Always make rough sketches of the object under examination, do this with the aid of the camera lucida, Fig. 34. When it is desired to apply heat to the object the best plan is one by H. Stricker: a piece of tinfoil is cut to the form of a picture-frame, having two arms projecting from opposite sides, this is gummed to the centre of a glass slip, and when it is required to heat any object it must be placed in the centre of the tinfoil frame, and connect the two projecting ends with the poles of a battery (see Plate 9), when the object will be heated. Some persons mount a small thermometer nearly the centre of the glass slide, so that the degree of heat may be regulated.

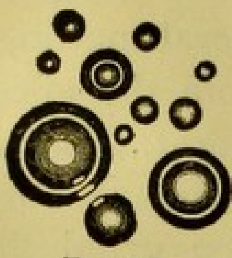


Fig. 80.

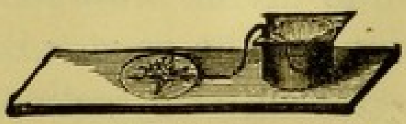


Fig. 81.

Both polarized light and the dark field illumination show the relative density or degrees of opacity in the object. Polarized light especially shows secondary deposit in vegetable structures. All investigations should be conducted if possible by daylight.

245. In noticing the adulterations of fabrics, special attention should be given to the action of the re-agents, as well as the general microscopical character of the

PLATE 10.

Fig. 82.
Potato Starch × 300.

Fig. 83.
Wheat Starch × 300.

Fig. 84.
Oat Starch × 300.

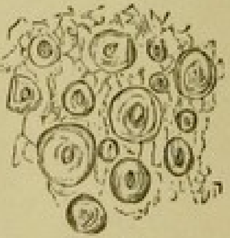


Fig. 85.
Sago Starch × 200.

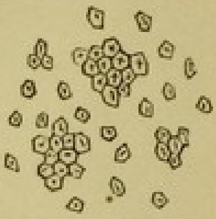


Fig. 86.
Rice Starch × 450.

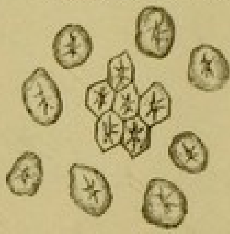


Fig. 87.
Maize Starch × 350.

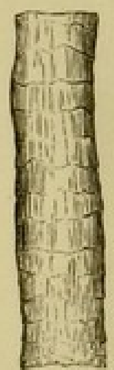


Fig. 88.
Human hair × 200.

Fig. 89.
Wool × 100.

Fig. 90.
Cotton × 200.

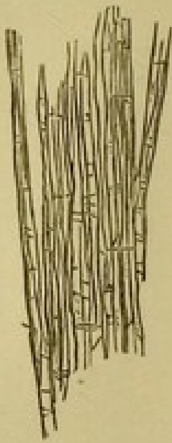


Fig. 91.
Hemp × 100.

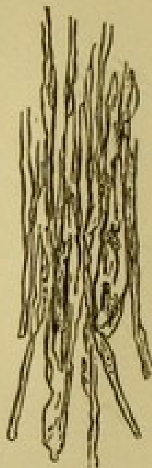


Fig. 92.
Flax × 100.

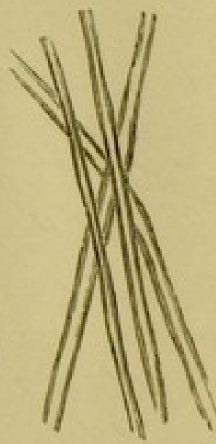


Fig. 93.
Silk × 150.

Fig. 94.
Carbonate of Lime × 100.

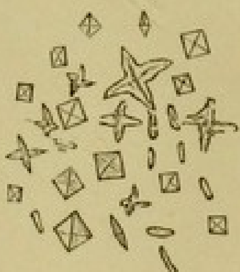


Fig. 95.
Oxalate of Lime × 400.

Fig. 96.
Phosphate of Lime × 100.

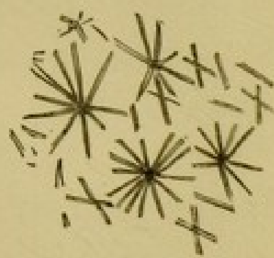


Fig. 97.
Sulphate of Lime × 100.

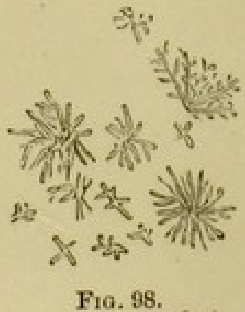


Fig. 98.
Ammonio-Phosphate of Magnesia × 100.

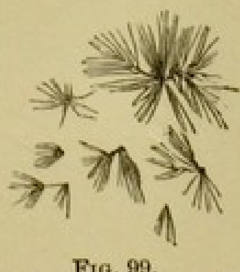


Fig. 99.
Carbazotate of Soda × 50.

Fig. 100.
Bichloride of Platinum and Potassium × 200.

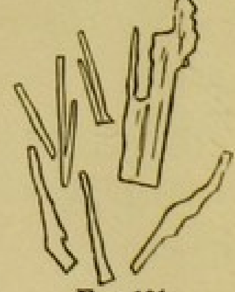


Fig. 101.
Bichloride of Platinum and Sodium × 50.

fibres; for instance, silk will dissolve in hydrochloric acid, but wool, cotton, hemp, &c., will be left intact, and both wool and silk dissolve in a strong solution of potass or soda, especially if used at boiling point, but cotton remains nearly entire. For the microscopical characters of the common fibres, I must refer the student to Figs. 89, 90, 91, 92, 93, Plate 10.

246. *Pepper* is often largely adulterated with starches, such as wheat, rice, pea, &c., for the microscopical characters of which see Plate 10. It is also adulterated with linseed-meal, ground mustard seeds, &c.; for the microscopical characters of which see Fig. 104, Plate 11, Fig. 103 being ground black pepper unadulterated.

247. *Cayenne* pepper is improperly so called, as it is made (or at least it ought to be) from a plant called *Capsicum annuum*, which belongs to quite a different natural order from the peppers; it is often largely adulterated with ground rice, deal saw-dust, salt, &c., also with red-lead, vermilion (protosulphide of mercury), venetian red, &c.. In testing for these inorganic compounds the cayenne pepper must be incinerated or burnt to an ash upon the platinum foil, using the triangle, Fig. 20: the ash may then be tested for lead, &c. (see page 156). Fig. 105 shows the unadulterated, and Fig. 106 the adulterated cayenne pepper.

248. *Mustard* is nearly, if not always, largely adulterated with wheat-flour, or starch, and turmeric. The wheat-starch may chiefly be distinguished by its microscopical characters (see Fig. 83, Plate 10), and the turmeric by the application of iodine, when the cells become a deep blue; or apply solution of potass,

when they are changed to a reddish colour. Fig. 107 represents the microscopical appearance of pure mustard, and Fig. 108 the adulterated.

249. *Coffee* is even now largely adulterated with chicory, roasted wheat, and potato starch, mangel-wurzel, acorns, &c. Fig. 109 shows a pure sample, and Fig. 110 an adulterated coffee (ground).

250. *Chicory* is also adulterated with roasted starches, mangelwurzel, saw-dust, &c. Fig. 111 is a drawing from the pure article, Fig. 112 the adulterated.

251. *Tea* is adulterated with other leaves, such as sycamore, elm, willow, horse-chestnut, beech, plum, &c., and also with Prussian blue (ferrocyanide of iron), plumbago, turmeric, chrome yellow (chromate of lead), &c. To test the leaves for their adulteration with any inorganic substance, the leaves must be burnt on the platinum in the same way as recommended for cayenne pepper. To obtain cuticles for comparison see page 112. Fig. 113 is pure tea, and Fig. 114 a sample of the adulterated article.

252. *Tobacco* is adulterated with dock, rhubarb, colts-foot, potato, and other leaves, especially British. It is also adulterated with sugar, salt, &c., to add to its weight. The tests will be chiefly performed with the microscope, as the adulterations are of an organic nature. Fig. 115 is a drawing of a pure sample of tobacco, and Fig. 116 the adulterated article.

253. *Cocoa* is adulterated with potato, arrowroot, wheat, maize, sago, and other starches, and with sugar, chicory; also with venetian red, red ochre, and other earths. To test for the inorganic compounds present (if any), it must be burnt to an ash on the platinum foil, as recommended for cayenne. Fig. 117 is

unadulterated cocoa, and Fig. 118 the adulterated article.

254. Before testing or examining an adulterated article, a slide of the pure substance should be mounted for constant reference; also slides of the articles used in its adulteration.

255. When an ash has been obtained by burning the substance upon platinum foil (or mica), it should be divided into ten or twelve parts, and each part examined separately, using the precipitating cell (Fig. 102), and noticing the action of the re-agents and tests.

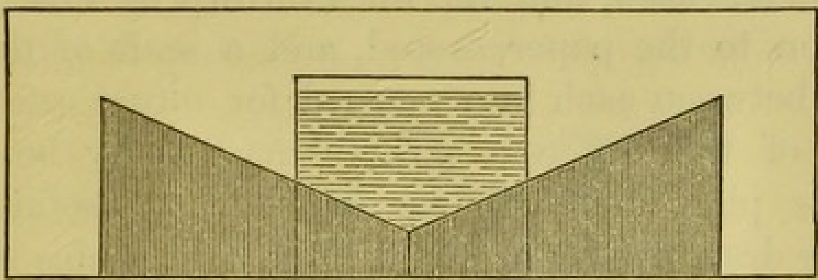


fig.102

256. *Drawing.*—As I mentioned before, it is quite necessary for the student to make sketches of all the objects that come under his observation. In doing this he should use a low power at first, and gradually increase it (if necessary) as his eyes and powers of observation become accustomed to the work. Hand-made drawing paper will be found better than machine-made, especially if the student tints his drawings with water-colours afterwards. If he desires to multiply his original sketches for the benefit of friends and others, a good way of doing so is by the electrical printing machine by Waterlow and Co., the chief fault against the process being that

the reproductions are in blue. The amateur student will also find the transfer lithographic paper, called the Autographic paper, sold by Maclure, Macdonald, and Co., very useful, that is if he desires to have his drawings printed. When making a sketch of the object under observation, the outline should be drawn with the aid of the camera lucida (see Fig. 34), and all the minuter details put in afterwards by a constant reference to the microscope. If possible, the objects should always be drawn to scale. To make this easier, the paper must always be exactly ten inches from the camera lucida (see Fig. 34), an eyepiece micrometer used, and the lines thrown by this instrument on to the paper, noted, and a scale of the distances between each line marked for future reference. Scales of the different powers may easily be made by this plan, and will be found very useful. In making drawings by artificial light, two lamps should always be used, one near the mirror to illuminate the object, and the other close to the paper upon which the student is making his sketch.

APPENDIX.

VARIOUS USEFUL RECIPES, &c.

Most of the following recipes are mentioned in the preceding chapters, but they are here given in full:

1. Chloroform 2 ounces.
   Gutta-percha $\frac{1}{2}$ ounce.
   Tallow 1 drachm.

Dissolve and mix. To be used for any purpose that requires a substance which never gets hard (see page 70).

2. Resin $1\frac{1}{2}$ ounces.
   Beeswax $\frac{1}{4}$ ounce.
   Tallow 1 drachm.
   Oil-colour any tint, colour, or shade.

Melt and mix. Keep in small salve boxes; or it may be kept in the small moist-colour pans used by artists. It is best to keep a stock of various tints, as it saves time when mounting many variously-coloured natural objects, such as lichens, seeds, mosses, &c. When wanted for use it must be dissolved by the action of heat. The heat from a water or sand-bath is best.

3. Solution of gum (thick), 1 ounce.
Glycerine, $\frac{1}{4}$ ounce.
Camphor, 4 or 5 grains.

It is as well to add 1 grain of arsenious acid.

Keep it in a corked, not stoppered bottle. This will be found very useful for many objects, more especially where quick mounting is required, as it does not require any heat. It is better adapted for minute insect than vegetable objects, as in the latter it often causes rupture of the primordial utricle or cell-wall.

4. Gutta percha, finely cut, $\frac{1}{4}$ ounce.
Turpentine, 4 ounces.

Dissolve with heat, and add shell-lac, $\frac{1}{4}$ ounce.

Dissolve with heat. The heat must be continued until a drop let fall upon a slip of glass becomes nearly hard when cool. Care must be taken in the preparation of this cement, on account of the inflammable nature of turpentine. This is cheap, and will meet all the requirements of a general cement for fixing many cells, &c.

5. Caoutchouc, cut small, $\frac{1}{2}$ ounce.
Mineral naphtha, 1 pint.

Dissolve with heat, and add shell-lac $\frac{1}{2}$ ounce. A smaller quantity of naphtha than this may be used, but using the larger quantity will be found the quickest. This cement is very useful, but it is chiefly used in making and sealing cells (see Chapters II., IV., &c.); if required it may be bought at most of the opticians, &c., under the name of caoutchouc cement. Use caution in making.

6. Resin, $2\frac{1}{2}$ ounces.
Beeswax, $\frac{1}{2}$ ounce.
Canada balsam, 1 drachm.

Dissolve with heat and mix. When wanted for use it must also be rendered mouldable by the action of heat. It is a strong cement, and may be used for fixing cells to glass, &c.

7. Powdered sealing wax.

Cover with methylated spirit and dissolve with a gentle heat. Often used for finishing circles, cells, &c.; but Berlin black is much better.

8. Gum arabic, 2 ounces.
Water, 2 ounces.

Dissolve gradually and add

Soaked gelatine, $\frac{1}{4}$ ounce.
Glycerine, 30 drops.
Lump of camphor.

Dissolve the gelatine in the gum water by the action of heat, and add the glycerine and camphor. Continue the action of the heat for a short time, and leave the lump of camphor constantly in the solution. This gum-water will be found the strongest and best for use, as it will not chip when placed on glass, &c. It may therefore be used for labels and other purposes where a strong gum is required.

9. Colloid silica, or silicic acid ($SiHo_4$) is made by adding

Silicate of potass, 1 drachm.
Water, 2 ounces.

Mix and pour into a glass vessel, and gradually add hydrochloric acid (HCl) in drops until flocculent films slightly appear; then pour into a dialysing drum, which place in a basin of pure water. The chloride of potass formed by the action of the hydrochloric acid on the potass will then pass into the water in the basin, leaving the silica in the form of colloid silica, or silicic acid ($SiHo_4$) in the dialysing drum. It is better if the water in the basin is renewed in the course of every three or four hours. To obtain the silica quite pure it is better to subject it to this process for at least three or four days. When various crystals, such as sulphate of copper, chlorate of potass, boracic acid, &c., are dissolved in this fluid and evaporated on a glass slide, most remarkable and interesting forms appear, and a large field of investigation is opened by its use. (See Chapter III.)

10. A saturated solution of bichloride of mercury ($HgCl_2$—corrosive sublimate) is very useful in rendering the bodies and cilia of the infusoria more distinct. It is also used for the same purpose with nearly all proteine compounds.

11. Lamp-black.
Gold size.

Mix well in a mortar. Makes a good black varnish for finishing slides and other purposes where a tough varnish is required.

12. Chloride of calcium ($CaCl_2$) is a good preservative fluid for many things (see Chapter IV.): it is often difficult to obtain at country chemists, but may be easily made by dissolving chalk in hydrochloric acid until the effervescence ceases, when the water may be driven off by evaporation, and the crystals that form may be taken out and put into a clean bottle

and sufficient distilled water added to make a saturated solution, which keep in stoppered bottle. A small quantity may also be kept in a drop-bottle to be used as a re-agent.

13. Canada balsam dried in a cool oven until it becomes of a pasty nature, and then dissolved in chloroform, benzole, ether, &c., is often much better to use than the balsam when undiluted. Camphor is also mixed with it when it has been brought to this pasty state, and by its action the balsam is again rendered fluid. Many persons prefer this plan to any other.

14. Boracic acid (BHo_3), made by adding hydrochloric acid (HCl) to a hot saturated solution of borax ($B_4O_5Nao_2$). As the liquid cools in the test-tube, crystals of boracic acid separate and fall to the bottom: they may be purified by re-crystallization from solution in hot water. It sometimes crystallizes in feathery forms, at other times in the form of minute discs, when they exhibit under the polariscope crosses and coloured rings, similar in appearance to those exhibited by oxalurate of ammonia. A solution of borax and also boracic acid might be tried with advantage in some preparations.

15. Sulphate of cadmium, made by dissolving the oxide of cadmium in sulphuric acid, when it is evaporated on a slide, exhibits minute radiating or circular crystals, which exhibit nearly the same appearance under the polariscope, as the crystals of boracic acid, oxalurate of ammonia, &c.

16. *Carmine.*—This pigment is much used for staining tissues, and also for colouring the internal parts of the infusoria which absorb it, and to make the motion of the cilia of various animalculæ more apparent.

17. Gold size added to Brunswick black renders it less liable to crack. It is better to keep nearly all the cements some time before use.

18. *Chromic Acid* (Cro_2Ho_2).—If 5 measures of sulphuric acid (SO_2Ho_2) be added to 4 measures of bichromate of potass ($Cr_2O_5Ko_2$), beautiful crimson crystals of chromic anhydride are obtained. These crystals must be dried at a gentle heat on a brick or porous tile, after which a small quantity of water may be added to them, when chromic acid is formed. It is chiefly used for hardening and preserving nervous tissues, &c. It is best kept in a well-stoppered bottle and made when required for use. The test for chromic acid is acetate of lead, which gives a yellow precipitate. It is as well to keep a solution of chromic acid in glycerine.

19. Oxygen (O) is best prepared by mixing equal parts of oxide of manganese and chlorate of potass; they may then be thoroughly powdered and mixed carefully in a mortar, after which the mixture is placed in a retort, and a moderate heat from the spirit lamp applied; or if a larger quantity is wanted, it is better to make it in an iron retort placed in the fire. The oxygen will then pass off freely. It is better to let the gas pass through a wash or Woulff's bottle containing water, as it often contains a slight percentage of chlorine when made by this process. After the oxygen has thus been well washed, it may be stored or collected in the small gas-holder (see Fig. 17), where it will be ready for immediate use in connection with the gas or animalculæ cell. Many of these gases may be temporarily stored in these gas-holders, and their action if any on organic life noticed.

20. Hydrogen (H) is best made by adding diluted sulphuric acid (SO_2Ho_2) to zinc; the hydrogen then passes off and may be washed and collected as with oxygen (use caution when near fire, gas, &c.)

21. Nitrogen (N) is best made by heating nitrite of ammonia ($N'''O\ (N^vH_4O)'$, when the nitrogen passes off freely and may be collected like oxygen.

22. Carbonic acid gas (CO_2), or as it is more properly called carbonic anhydride, is best prepared by treating marble (calcic carbonate) ($COCao''$) with hydrochloric acid (HCl), when carbonic anhydride is given off and the useful substance, chloride of calcium, remains behind in a fluid state; if wanted for use, it must be purified, &c. (see Recipe 12): the gas may be collected and stored in a gas-holder like oxygen.

23. Chlorine (Cl) is best prepared by mixing to the consistency of cream some hydrochloric acid (HCl), and oxide of manganese (MnO_2). This must be put into the glass retort (Fig. 28), and care should be taken that the entire surface of the glass is wetted with the mixture, or the glass might break. A gentle heat from the spirit-lamp should then be applied, when the gas comes off freely. It cannot be stored in the gas-holder like oxygen, as it is absorbed freely by water; it must therefore be made when wanted. Great care should be taken in making this gas, and it is better to make it in very small quantities, as it causes great irritation to the lungs when breathed.

24. Sulphuretted hydrogen (SH_2) is best prepared by acting on sulphuret of iron (FeS) with diluted sulphuric acid (SO_2Ho_2), when the gas is given off freely without any heat being applied: it cannot be stored well in the gas-holder, as it is largely absorbed

by water. Great care must also be used in making it, as it is extremely deleterious and even dangerous when breathed. Small quantities only should be made at one time. All of the gases that can be stored for temporary use in the glass gas-holder should be done so, and when wanted the weights applied to the top according to the pressure required: one end of the India-rubber tubing must then be fixed on the gas-holder (Fig. 17) and the other on the gas-cell (Figs. 9 and 10). (See description, Chapter I.)

25. *Millon's Test.*—This test is prepared by dissolving mercury in an equal weight of nitric acid. "When the acid is poured upon the metal, nitric oxide (N_2O_2) is freely evolved: after this ceases a gentle heat must be applied until the whole of the metal is dissolved; and after some time when crystals have been formed, the remaining liquid may be poured off and kept in a stoppered bottle. When a substance requires to be tested, it must be placed in this fluid and the test tube held over a gas jet or spirit-lamp until it boils, when the substance will be coloured red if it answers to the nature of the test. Albumen, caseine, chondrine, crysalline, epidermis, feathers, fibrine, gelatine, gluten, horn, legumine, proteine, silk, wool, are all coloured by this test, and the following when pure are not: Cellulose, chitine, cotton, gum (Arabic), linen, and starch."

26. *Bichromate of Potass* ($Cr_2o_5Ko_2$).—This salt is chiefly used for the preparation of chromate of lead (CrO_2Pbo''), which is largely used in opaque injections. It is made as follows: To a saturated solution of bichromate of potass ($Cr_2O_5Ko_2$) acetate or nitrate of lead (N_2O_4Pbo'') is added, when a yellow precipitate, which is the chromate of lead, is almost immediately

obtained; well wash and store for use. The crystals of bichromate of potass form a beautiful object, more especially under the polariscope.

27. *Schultze's Test.*—The action of this test is as follows: Wash the substance which is to be examined in water, pour off the water, and then moisten it with a drop of syrup; add sulphuric acid (SO_2Ho_2) one drop The reaction produces a purplish red colour, if the substance contains either muscular tissue, corpuscles of blood, pus and mucus, epidemic and epithelial scales, hairs, feathers, horn, whalebone, cellular parts of algæ, &c.; the reaction is not produced in areolar tissue, elastic tissue, gelatine, and chondrine, chitine, silk, cellulose, gum, starch, or vegetable mucus.

28. *Schulze's Test.*—This, according to the Micrographic Dictionary, is prepared as follows. It is used as a test for cellulose, which it colours blue:

"Dissolve zinc in hydrochloric acid (HCl), evaporate the solution with excess of zinc until it acquires the consistence of syrup, and dissolve in this enough iodide of potassium to saturate it; iodine is then added, and the solution diluted with water if necessary. This re-agent has the consistence of strong sulphuric acid, and of a pale yellowish brown. It must, of course, be kept in a stoppered bottle. It is also well to keep this and the before-mentioned tests in a small drop bottle (see Fig. 12, drop bottles)."

29. *Staining fluid for tissues.*

Soluble aniline blue, ½ grain.
Distilled water, 1 ounce.
Alcohol, 25 drops.

This fluid is not acted upon by acids or alkalies.

30. Solutions of nitrate of silver (NO_2Ago) may be used of various strengths; it will also be found useful when dissolved in glycerine. In experiments with staining tissues it is better to begin with a solution of a moderate strength—

Nitrate silver, 1 scruple.
Water, 2 drachms.

31. *Solution of osmic acid* (OsO_2).

Osmic acid, 1 part,
Distilled water, 100 parts,

is the strength generally used for staining; although, of course, circumstances will alter this. It is chiefly used for distinguishing nerve fibres from the surrounding substances; this fibre it generally colours almost black. Fat cells and oil globules are also coloured.

32. A solution of tannin is much used, for although it does not stain animal membrane, yet it alters its character to such a degree that points of structure may be often known by this change.

33. *Injecting fluid* (*Prussian blue*).

"Glycerine, 1 ounce.
Spirits of wine, 1 ounce.
Ferrocyanide of potassium, 12 grains.
Tincture perchloride of iron (Fe_2Cl_6), 1 drachm.
Hydrochloric acid (HCl), 5 drops.
Water, 4 ounces.

"The ferrocyanide of potassium is to be dissolved in one ounce of the water, and the tincture of perchloride of iron added another ounce of water. These solutions should be mixed very gradually, and well shaken in a bottle, the iron being added to the solution of the ferrocyanide of potassium. When mixed these solutions should produce a dark blue mixture, in which no precipitate is observable. Naphtha is to be mixed with the spirit, and the glycerine and the remaining ounces of water added; lastly, this colourless fluid is to be mixed with the dark fluid, it being well shaken up in a large bottle during the admixture. The tincture of perchloride of iron is generally sold at the druggists under the name of the muriated tincture of iron."

34. *Staining fluid* (*Turnbull's blue*).

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

The iron is to be dissolved in a little of the water and mixed with the glycerine; this is then to be gradually mixed with the solution of the ferricyanide, as in the last recipe.

35. A greenish fluid for injecting may be made by using one grain, or less, of the sulphate of iron to ten grains of the ferricyanide of potassium, the other ingredients to be the same as in the last recipe.

36. *Injecting fluid* (*Carmine*) *Dr. Beale.*

Carmine, 5 grains.
Glycerine, with about eight or ten drops of hydrochloric acid (HCl), $\frac{1}{2}$ ounce.
Glycerine, 1 ounce.
Alcohol, 1 drachm.
Water, 6 drachms.
Ammonia (NH_4Ho), a few drops.

Mix the carmine with a few drops of water, and when well incorporated, add about five drops of liquor ammonia (NH_4Ho). To this dark red solution about half an ounce of the glycerine is to be added, and the whole well shaken in a bottle; then, very gradually, pour in the acid glycerine, frequently shaking the bottle during admixture. Test 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. Lastly, gradually and thoroughly mix the alcohol and water, then add to the glycerine portion, and again thoroughly mix. This fluid, like the Prussian blue, may be kept all ready prepared, and injections may at any time be made with it rapidly.

37. *Dr. Carter's carmine injecting fluid.*

Pure carmine, 60 grains.
Liq. ammon. fort. (P.L.), 120.
Glacial acetic acid, 86 minims.
Solution of gelatine (1 to 6 water), 2 ounces.
Water, $1\frac{1}{2}$ ounces.

The carmine is to be dissolved in the solution of ammonia and filtered if necessary. With this mix thoroughly an ounce and a half of the hot solution of gelatine. The remaining half ounce of gelatine is to be mixed with the acetic acid, and dropped, little by little, into the solution of carmine, stirring smartly during the whole time. For an injecting fluid which will run freely through the most minute capillaries, and one that will not tint the tissues beyond the vessels themselves, there perhaps cannot be a much better recipe for the purpose. It is also well adapted for specimens which are to be mounted in Canada balsam, but not for those to be preserved in glycerine (see Injection, Chapter V.)

38. *Red injection* (*opaque*).

Vermilion, 164 grains (apoth. wt.)
Gelatine (swollen), 4 ounces (avoid. wt.)

Dissolve the gelatine in one ounce of water; then add the vermilion, stir well, and strain.

39. *Yellow injection, opaque.*—This is prepared with chrome yellow, formed by adding acetate of lead to bichromate of potass.

Acetate of lead ($C_2(Me_2)O_2Pbo''$), 380 grains.
Bichromate of potass ($Cr_2O_5Ko_2$) 152 grains.
Gelatine (swollen), 8 ounces.

Dissolve the gelatine in one ounce of water, and if too thick add more water; then dissolve the acetate of lead in this warm fluid, and finally add the bichromate of potass. This is the only yellow (opaque) injection that is wanted.

40. *Blue injection.*

Prussian blue, 73 grains.
Oxalic acid, 73 grains.
Gelatine (swollen), 4 ounces.

Dissolve the gelatine in one ounce of water, reduce the oxalic acid to powder in a mortar; then add the Prussian blue and dissolve in the warm gelatine fluid.

41. *White injection* (*opaque*).

Acetate of lead ($C_2(Me_2)O_2Pbo''$), 190 grains.
Carbonate of potass ($COKo_2$), 83 grains.
Gelatine (swollen), 4 ounces.

Dissolve the gelatine in 1 ounce of water; then add to the warm fluid the acetate of lead, which dissolve and filter. Dissolve the carbonate of potass in $\frac{1}{4}$ ounce of water, mix the acetate of lead solution, and strain. It is best to prepare all these opaque injections when wanted (see Injection, Chapter V.)

42. *Blue injecting fluid* (*transparent.*)

Glycerine, Price's, 2 ounces.
Tincture of perchloride of iron (Fe_2Cl_6), 10 drops.
Ferrocyanide of potassium ($K_4Fe''Cy_6$), 3 grains.
Strong hydrochloric acid (HCl), 3 drops.
Water, 1 ounce.

Mix the tincture of iron with one ounce of the glycerine; and the ferrocyanide of potassium dissolved in a little water with the other ounce. These solutions are to be mixed very gradually in a bottle, and to be well shaken during the admixture. The iron solution must be added to the ferrocyanide of potassium, and lastly, the water and hydrochloric acid are to be added. Alcohol, one or two drachms, is often added to the above mixture. This fluid does not deposit any sediment, and it may be kept for a long time if wanted. Injections coloured with it may be stained with the following carmine fluid:

43. *Carmine staining fluid.*

Carmine, 10 grains.
Strong liquor ammonia (NH_4Ho), $\frac{1}{2}$ drachm.
Glycerine, Price's, 2 ounces.
Distilled water, 2 ounces.
Alcohol, $\frac{1}{2}$ ounce.

By agitation and the aid of heat, the carmine is to be dissolved in the ammonia. This ammoniacal solution to be boiled for a few seconds in a test-tube, and allowed to cool. When an hour or so has elapsed, the excess of ammonia will have escaped; the glycerine and water may then be added, and the perfectly clear supernatant fluid poured off and kept for use. If after a time it is found that carmine is deposited at the bottom of the bottle, owing to the escape of ammonia, a few drops of liquor ammonia may be added to the solution.

44. *Fluid for preserving embryonic tissues* (H. Muller.)

Bichromate of potass ($C_2O_5Ko_2$), 30 to 40 grains.
Sulphate of soda (SO_2Nao_2), 15 grains.
Distilled water, about 3 ounces.

45. *Canada balsam and slackened lime* ($CaHo_2$) will be found a good cement for many purposes.

46. *Ground borax*, mixed with plaster of Paris, makes a good cement. Might be used for large cells, &c.

47. *Polishing powder for lenses and metal work.*—Mix equal parts of solutions of oxalic acid ($C_2O_2Ho_2$) and sulphate of iron. Dry the precipitate, calcine, and use as a fine powder.

48. *French cement.*—A certain quantity of india-rubber scraps are carefully melted over a clear fire in a covered iron pot, but they must not be permitted to catch fire. When the mass is quite fluid, lime in a perfectly fine powder, having been slacked by exposure to the air, is to be added in small quantities at a time, the mixture being well stirred. When moderately thick it is removed from the fire and well beaten in a mortar and moulded in the hands until of the consistence of putty. It may then be coloured by vermilion or other colours. This cement is quite safe

for mounting large and thick objects in fluid, as it rarely gets hard.

49. *Essential oil of lemon* is much used in the examination of pollens and other structures, as it tends to render them more transparent.

50. *Iodine.*—Chiefly used for dyeing and rendering objects more distinct; also as a re-agent for starch, &c. An aqueous solution is best for ordinary use, but a much stronger solution may be made by dissolving it in alcohol; the strongest is made by dissolving it in a solution of iodide of potassium (KI). Solutions of iodine in chloride of zinc ($ZnCl_2$), and iodide of zinc (ZnI_2), are useful re-agents for cellulose (see Schulze's Test, 28).

51. *Mica*, often called *talc*, is now used principally for burning objects to a red heat, being much cheaper than platinum. The object is placed on a small piece of mica and held over the spirit-lamp until the required state of examination or preparation is attained.

52. Carbolic acid, 1 drachm.
Alcohol, 2 drachms.
Distilled water, 12 ounces.

Dissolve the carbolic acid with the alcohol, and add to the water; then boil for ten minutes and bottle for use. This forms a good preservative fluid for many animal and vegetable tissues.

53. Arsenious acid ($AsHo_3$) saturated solution, 1 part.
Camphor water, distilled, 2 parts.

Mix and bottle for use. A tolerably good preservative for animal tissues; but very poisonous, and not much used.

54. Acetate of aluminium ($C_2(Me_2)O_2'Al_2'''$), 1 part.
Distilled water, 4 parts.

Very good for preserving vegetable colours, as in the case of desmids and other algæ.

55. Chloride of zinc ($ZnCl_2$) 20 grains.
Distilled water, 1 ounce.

Perhaps the best preservative for most animal tissues, though it exerts a slight coagulating action on the tissues. A lump of camphor should be kept in it.

56. Litharge, 1 ounce.
Plaster of Paris, 1 ounce.
Resin (powdered), 1 ounce.
Treacle, 1 ounce.

Mix with gold size until a soft putty consistency is acquired; then use. This cement will be found useful for mending, and making, parts of different apparatus, aquaria, &c.

57. Plaster of Paris mixed with a weak solution of chloride of calcium, will also be found useful for the same purpose.

58. Castor oil is much used for some crystals where the balsam or dammar does not suit. Care should be taken that it is pure.

59. A strong syrup, made by boiling loaf sugar in distilled water until it crystallizes, when a drop is dropped upon a slip of glass. It may then be stored in a stoppered bottle with a small lump of camphor floating in it. This solution will be found very useful for preserving many animal and vegetable structures; if it crystallizes too much a few drops of chloride of calcium solution should be added to it.

60. *Glycerine jelly.*

Gelatine, 1 ounce.
Glycerine, 6 drachms.
Camphorated spirits of wine, $\frac{1}{4}$ ounce.

Soak the gelatine in cold water until it swells up and becomes soft; then place it in a small jar, which stand in a basin or larger jar of boiling water, and dissolve by the action of the same heat continued; when dissolved and quite cool, but not set into a jelly, add a small quantity of the white of an egg; then boil the mixture until the white of the egg sets; filter through fine flannel, and add the glycerine, to which has been previously added $\frac{1}{4}$ ounce of strong camphorated spirit of wine. Mix thoroughly, and store in bottle for use. When wanted it must be placed in a jar of boiling water, which renders the jelly fluid and ready for use.

61. *Films to exhibit absorption spectra.*

Gelatine, 1 ounce.

Soak in water until quite soft and swollen; then dissolve with heat, and, if necessary, add a small quantity of water; pour the fluid into flat evaporating dishes, or common plates will do. The dishes or plates must be previously greased to prevent the gelatine sticking. Let the water evaporate from the gelatine until it becomes nearly hard; then separate it in sheets from the plates and cut up into small squares about $\frac{3}{4}$ or $\frac{7}{8}$ of an inch square. These squares may then be kept in a box for use. When wanted they may be soaked in the fluid that is to be tested with the spectroscope, and placed between glass slips. This plan will be found much easier and cleaner than putting the various solutions in glass cells. In many cases these prepared plates may be kept. The gelatine is also sold in sheets by most artists' colourmen.

62. *White gutta percha.*—Dissolve gutta percha in chloroform; then put it into a small two-necked Woulff's bottle (see Fig. 18.) Pass chlorine gas through it until it is nearly, if not quite, white. Pour into a dish, let the chloroform evaporate if slabs are wanted; or mix any powdered colour or tint with it, and then evaporate. It will be found very useful for opaque mounting (see Chapter II.)

63. A good plan to render wood plastic is to place it in hydrochloric acid (HCl), and subject it to a severe atmospheric pressure under the air pump, when the hydrochloric acid enters into all the pores and makes the wood softer; it is then much easier to cut with the section cutter. But as hydrochloric acid will slightly attack the edge of the knife, it is necessary both to well wash the wood and also use plenty of water while cutting it. If care is taken the position of the fibres will not be altered much, if at all. Well wash the sections in water before mounting.

64. Gold size and gilders' whiting mixed until of the consistency of thick treacle, makes a good cement for sealing cells, &c.

65. *Canada balsam cement* should be made by evaporating nearly all the turpentine from the balsam by the aid of heat. To test when it has arrived at its right stage drop a small drop on a glass slip, when, if right, it should be quite hard, but not brittle. This cement is chiefly used for fixing bone, teeth, shells, &c., to glass whilst they are being cut and ground.

66. Berlin black, which can be obtained at most oil and colourmen's, makes a much better varnish for finishing cells, &c., than Brunswick black and others. It dries with a slightly dull surface.

67. Gum water thickened with gilders' whiting until of the consistency of treacle, and to which two drops of glycerine to every $\frac{1}{4}$ ounce has been added, will in certain cases be found a very useful cement.

68. *Cement for glass, &c.*—Another useful cement is made by mixing, when wanted, plaster of Paris and the white of an egg. The egg must be well beaten and the plaster mixed with it until of about the consistency of treacle. Use it directly, as it soon sets; it must be made fresh when wanted. This cement is useful for fixing glass cells to glass slips, when any other cement could not be used on account of the solvent power of the fluid in which the object might be mounted, say, balsam or weak spirit. It will also be found useful for other purposes.

69. *Siliceous cement.*

Colloid silica, $\frac{1}{2}$ ounce.
Thick gum water, $\frac{1}{2}$ ounce.

Gilders' whiting sufficient to make it of the consistency of treacle. This cement will be found useful in protecting corks, &c., from the fumes of acid, &c.

70. Glycerine, 1 ounce.
Acetic acid, $\frac{1}{2}$ ounce.

Mix and bottle for use. Will be found a useful preservative fluid for many minute insect and other objects.

71. *Deane's compound.*

Gelatine, 1 ounce.
Honey, 5 ounces.
Water, 5 ounces.
Spirit wine, $\frac{1}{2}$ ounce.
Creosote, 6 drops.

The gelatine is soaked in the water until soft, and then added to the honey, which has been previously raised to a boiling heat in another vessel; boil the mixture. After it has slightly cooled, add the creosote, which has been previously mixed with the spirit, then filter through flannel. When either this compound or the glycerine jelly (Recipe 60) require to be used, they must be warmed, and a drop placed in the centre of a warmed slide; put the object in this and cover with a slightly moistened thin glass cover, clean the slide from the superfluous jelly, and finish by applying a coating of Berlin black. Both the Deane's compound and the glycerine jelly are best kept in one of the collapsible tubes (see Plate 4, Fig. 58.)

72. *Ralf's liquid.*

Bay salt, 1 grain.
Alum, 1 grain.
Distilled water, 1 ounce.

Dissolve and mix. This forms a good preservative fluid for many of the algæ and other objects.

73. *Cement for fixing metals to glass or earthenware.*—Mix alum and plaster of Paris (finest kind) with water to a liquid state, or to a convenient paste. It forms an excellent cement for many purposes, and resists the action of water for a considerable time.

74. *White cement.*—Dissolve gum mastic in chloro-

form, and add nitrate of bismuth until it is of a dead white colour. When the cement gets too thick by the evaporation of the chloroform, add more until it is of the right consistency. It answers well for sealing cells, especially where the objects are mounted in glycerine. It will also be found very useful for many purposes.

75. *Glycerine preservative fluid.*

Distilled water, 3 ounces.
Glycerine, 1 ounce.
Camphorated spirit, $\frac{1}{4}$ ounce.

(Made by dissolving camphor in spirits of wine.) Mix and store in 6-ounce phial bottle for use. This fluid will be found very useful in mounting algæ, especially desmids. It will also be found useful for other objects.

76. Sweet spirits nitre, $\frac{1}{2}$ ounce,
Glycerine, $\frac{1}{2}$ ounce,

is much used in preserving some of the delicate dissections of insects.

77. If cupric hydrate (hydrated oxide of copper) is dissolved in ammonic hydrate (liquor ammonia), it forms a blue solution; but if metallic copper is put into this it forms a nearly colourless compound, and when diluted with water will be found a useful preservative fluid for some substances.

"Most microscopic measurements are under the hundredth of an inch; one hundred-thousandth of an inch can only be measured with certainty when magnified by the $\frac{1}{25}$th or $\frac{1}{50}$. The requirements of the case, therefore, may be stated in decimals of an

English inch by ·00101, and if the two ciphers next the decimal point be struck out, and the first number be considered the unit, it may be written $1^{t}01$, in which a thousandth of an inch is the unit. This method will embrace nearly every microscopic magnitude in three consecutive figures.

"The foreign measures are the millimetre and the French and Prussian lines. The two latter are so nearly equal, that the same rule will serve for the conversion of both.

"A millimetre contains ·03937 English inch, or $39^{t}37$; according to the method proposed, the length to be converted will seldom amount to one-fourth of this. To convert millimetres into thousandths, shift the decimal point one place to the right and multiply by 4; if greater accuracy be required, subtract $1\frac{1}{2}$ from the second place of decimals for each of the nearest numbers of units of the product. Thus $0^{mm}{\cdot}250$ becomes 2·50, which $\times 4 = 10^{t}00$, from which subtract $^{t}{\cdot}15$; and $9^{t}{\cdot}35$ is obtained as the value in thousandths of an English inch, while $0^{mm}{\cdot}25$ is equal to $9^{t}{\cdot}84$, which differs from the former by a quantity too small to measure.

"To convert thousandths of English inches into millimetres, add $1\frac{1}{2}$ in the second place of decimals for the nearest number of units in the sum, divide by 4, and shift the decimal point one place to the left; thus to $9^{t}{\cdot}84$ add $^{t}{\cdot}15$ and the sum $6{\cdot}999 \div 4 = 2{\cdot}498$, and shifting the decimal point $^{mm}{\cdot}2498$, which does not differ sensibly from $^{mm}{\cdot}25$, the correct quantity.

"A French line contains ·0888 English inches. To convert lines into thousandths of an inch, shift the decimal point one place to the right, and multiply by

9; if greater accuracy be required, subtract $1\frac{1}{3}$ from the second place of decimals for each of the nearest number of units in the product. Thus $0'''\cdot 125$ becomes $1\cdot 25$ which $\times 9 = 11^{t}\cdot 25$, from which subtract $^{t}\cdot 14$, and the value in thousandths is found to be $11^{t}\cdot 10$, which is correct.

"To count thousandths into lines, add $1\frac{1}{3}$ in the second place of decimals for each of the nearest number of units in the sum, divide by 9, and shift the decimal point one place to the left, thus: to $11^{t}\cdot 10$, add $^{t}\cdot 14$, the sum $11\cdot 25$ divided by 9, and the decimal point shifted one place to the left gives $0'''\cdot 125$ as before. In most cases it will be unnecessary to apply the corrections noticed above; but by remembering the short rules given, anyone on reading a foreign work may correct the measurements as he reads, and insert them in the margin without delay or interfering with his progress."

TABLE FOR MUTUAL CONVERSION OF BRITISH AND FOREIGN LINEAR MEASUREMENTS.

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. British Inches into Old Paris Lines	11·25936	22·51872	33·77808	45·03774	56·29680	67·55616	78·81552	90·07488	101·33424	Paris Lines.
3. 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	·19685396	·23622474	72·558553	·31496632	·35433711	British Inches.
5. Millimetres into Old Paris Lines	·44329	·88658	1·32987	1·77316	2·21645	2·65974	3·10303	3·54632	3·98261	Paris Lines.
6. Millimetres into 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	7·99335	British Inches.
8. Old Paris Lines into Millimetres	2·25586	4·51172	6·76758	6·02344	11·27930	13·53516	15·79102	18·04688	20·30274	Millimetres.
9. Prussian Lines	1·03494	2·00988	3·10482	4·13976	5·17469	6·20963	7·24457	8·27951	9·31445	Prussian Lines.
10. Prussian Lines into British Inches.........	·085817	·171633	·25745	·343267	·429083	·51490	·600717	·686532	·77235	British Inches.
11. Prussian Millimetres into British Inches...	2·179704	4·359408	6·539112	8·718816	10·89852	13·07822	15·25793	17·43763	19·61734	Millimetres.
12. Old Paris Lines.........	·9662407	1·9324814	2·8987221	3·8649628	4·8312034	5·7974414	6·7636848	7·7299255	8·6961662	Paris Lines.

ILLUSTRATIONS OF USE OF THE ABOVE TABLE.

Example I.

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

Example II.

Given, ·00215 millimetres. Required, the value in British inches.

By line four of Table—

Millimetres.		British Inches.
·002	=	·0000787415
+ ·0001	=	·000003937079
+ ·00005	=	·0000019685395

British Inches......·0000846471985

Example III.

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

2·4591 Paris lines very nearly.

This Table is taken from Dr. Beale's work on the Microscope. British foot = 1; Metre = 3·2808992; Old Paris foot = 0·06578; Prussian foot = 1·0298.

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