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ILLUSTRATING BIOLOGICAL MANUSCRIPTS

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Learn drawing—"*that you may set down clearly and usefully, records of such things as cannot be described in words, either to assist your own memory of them, or to convey distinct ideas of them to other people.*" Ruskin.

Although many excellent books have been published concerning drawings and the processes involved in reproducing them, a beginner in science can consume hours in attempting to find within their covers the kind of information he desires. The books on drawing are usually written for artists who desire effect and not scientific accuracy, and those that deal with methods of reproduction serve as text-books for journeymen interested in the commercial phases of the work. In this article, therefore, an attempt will be made to set forth simply and concretely what points should be considered in making a drawing; to tell which media are best for certain classes of work; to give some idea of how the drawings are reproduced, together with the limitations imposed by photo-mechanical methods.

A black picture on a white background gives the best contrast for reproduction. In numerous subjects the form and texture can be brought out equally well in black ink, in crayon, in water-color, or a combination of these. One of these media may show the points which need emphasis better than another. Therefore, before making drawings for a paper, an author should study the illustrations in the journal in which he expects to publish and select the style best suited to his subject. Skill may well be considered also, as a simple outline in ink is preferable to an elaborate picture poorly executed. Manuscripts which contain drawings that can be reproduced as line or half-tone engravings are more readily accepted by editors as they can be published with less expense. The extra cost of plates requiring lithography, heliotypy, or photogravure sometimes must be paid by the author.

I. Methods of Illustration

This is no place to enter into the history of graphic reproduction, interesting as it is, nor to describe all the processes in commercial use to-day. Processes available for reproduction may be divided into three distinct groups: (1) intaglio; (2) planographic; and (3) relief.

Intaglio

The intaglio processes include all those in which the impression is printed from incised or depressed surfaces. Engraving, the oldest known of these methods, consists of lines cut by hand into a copper or steel plate with a graver. On account of its cost, it is seldom used except by the government where it is employed in the making of plates for paper money and maps, as many copies may be printed without injuring the plate.

Planographic

Planographic methods include Lithography, Photolithography, and Photogelatin or Heliotype, in which printing is done from a flat surface. In all these, the surfaces are so treated that certain parts repel ink while other parts take it.

Lithography. In Lithography advantage is taken of the fact that grease unites with limestone to form a substance insoluble in water. Zinc and aluminum plates may be substituted for the stone, using practically the same procedure. The picture to be reproduced may be drawn in reverse order upon a smooth, flat piece of limestone with a special ink or chalk composed of wax, shellac, tallow, and soap. For a shaded, scientific drawing, the surface of the stone is grained, either a fine or coarse grain, depending upon the effect desired. Instead of drawing directly upon stone, the picture may be drawn in proper position upon a smooth or grained paper with lithographic chalk, as it is then reversed when transferred to the stone. To transfer, the paper is dampened and placed upon the warmed stone, then both are run through a press. Considerable skill is required in making scientific drawings upon grained transfer paper as a smudge results in the transfer if the chalk is too soft or the lines too heavy. On the other hand, if the lines are too light, the transfer is blotchy. Sometimes a thin, gelatine sheet is placed directly over a drawing, every detail of which is outlined on the gelatin with a fine etching point.

After ink is rubbed into the lines, the gelatine is dampened and a transfer made upon stone.

Dilute nitric acid applied to the surface attacks the parts of the stone free from ink, producing a chemical change so that the gum arabic solution next put on renders the surface grease-resisting. For chalk work an equal mixture of gum and nitric acid is added. More than one acid bath and several coats of gum may be given in preparing the surface. Often powdered rosin or asphaltum is dusted over the surface. It adheres to the ink, thus protecting it from the acid.

Before a print is taken from the stone, the gum is washed off, leaving the etched parts wet. These, then, repel the printing ink. The latter adheres to those parts of the stone covered with lithographic ink or chalk. The clearness of the print depends to a large extent upon the skill of the operator.

Photolithography. In Photolithography, the picture is photographed and from the negative thus obtained, a print is made upon paper coated with bichromatized gelatine. The picture to be used for the illustration is placed in front of a camera which contains a piece of glass coated with a film of gelatine or collodion mixed with a salt sensitive to light—a photographic plate. When the camera shutter is opened the white parts of the picture reflect light upon the plate and cause a chemical change. The dark parts of the picture have little or no effect upon the salt. Colors reflect light in varying degrees, thereby modifying the plate. The plate is next treated with the chemicals which cause the parts unaffected by light to wash out while the other parts become opaque. A negative is thus produced in which the light parts of the picture are opaque and the black parts clear. If this negative does not present enough contrast between the opaque and clear parts, it is put into a solution which makes the opaque areas denser.

From the negative, a print is made upon transfer paper first coated with gelatine and then immersed in bi-chromate of potash and dried in the dark. The negative is placed upon the coated side of the paper and both are exposed to light in a printing frame. Gelatines, gums and other organic compounds when sensitized with certain chromic salts are rendered insoluble wherever exposed to the action of light rays. The gelatine protected by the opaque parts of

the negative are still soluble whereas that under the clear spaces is made insoluble by the light. The print when sufficiently exposed is taken out and covered with ink. It is now placed in cold water which causes the gelatin surface to swell in the soluble spaces. When rubbed over with a sponge, the ink comes away from all parts not affected by light, leaving a print of the picture in ink slightly in intaglio. This is then transferred to stone which is prepared as for any lithograph.

Heliotype. A negative and print are made in the same manner as described above, except that the negative is reversed before it is printed and the gelatine coating on paper or glass is thick enough to be detached from its original support and printed from directly instead of transferring it to a stone. The gelatine acted upon by light takes ink, the other parts absorb water and repel the ink.

Relief

In the photo-mechanical processes such as zinc-process and half-tone, the plate is so treated that the picture remains in relief upon a sunken background.

Zinc-process. From the negative, a print is made upon a piece of polished zinc which has been coated with a sensitized substance such as a mixture of egg-white, fish glue and ammonium bichromate. The negative is placed upon the coated side of the zinc and both are exposed to light in a printing frame. Instead of developing as a photographic plate, the zinc is covered with an even coating of special ink put on with a roller—"rolled up," is the printer's phrase. This ink is rather thick and contains wax and tallow to make it greasy. When the inked plate is placed in water, the parts of the coating not affected by light wash away, leaving the image in black lines upon a metal background.

The plate is now covered or powdered up with a red, resinous powder called dragon's-blood. This powder is obtained from any one of several different kinds of tropical trees. Upon warming the plate the powder unites with the ink and makes it more resistant to acid. After painting the back with a varnish, the plate is put into nitric acid which acts upon the uninked and unvarnished zinc surface. Usually the plate is sufficiently etched after four treatments in the etching bath so that the image stands up in relief upon the metal

surface. When finished the thin metal plate is mounted upon a block, type-high. Cuts of this kind can be printed as text-figures if the details are not so fine that a slight spreading of ink in printing will destroy the contrast.

Half-tone. In this process a screen is placed between the camera and picture before the negative is made. This screen usually consists of two glass plates, each engraved with lines an equal distance apart which are filled with an opaque black substance. The plates are cemented together in such fashion that the lines cross at an angle. The number of lines per inch vary from 50 to 400 and the crossing may be at various angles. For microscopic enlargements 200 to 250 lines per inch are used and the plates are fastened together so that the lines cross at an angle of 45°. When a picture is photographed through the screen, the negative is covered with small dots the shape of which depends upon the camera diaphram. The contrast of the original picture is lessened since the white parts are covered by black dots and the black areas by white dots.

If a coarse screen is used the negative can be printed upon coated zinc and etched as for zinc-process. A coated copper plate is necessary where the dots are fine. After the copper plate has been exposed under the negative it is heated until the sensitized coating turns brown where it has been affected by light. This brown oxidation product is insoluble in water and acids. The plate is now etched in a solution of perchlorid of iron until the picture stands out in relief. If clear white spaces are desired in the print, the dots produced by the screen must be tooled out of the plate in these places. As this is done by hand, it adds to the expense of the plates. Prints may be made directly from the plate which has been backed with base metal or wood, or electrotypes may be made from the original.

In printing there is an increase in the size of the black dots and a decrease in size of the white dots due to the spreading action of the ink. If the block is printed on a coated paper, this spreading action is reduced somewhat and can be overcome through the use of an overlay, which is a pad placed on the roller.

Various modifications of the half-tone process are obtainable through the use of different screens—such as mezograph, but the principles involved are the same.

II. Drawing for Publication

Outline

In free-hand drawing of objects, care must be taken to get a properly proportioned outline. First, determine the size the drawing should be. A small object can be represented several times natural size whereas a large one needs reduction. Upon two faint lines which cross at right angles in the middle of the field, indicate by dots the length and breadth of the object. Other important points can also be marked with dots which, when connected with light lines, roughly block in the object. For this preliminary mapping, an HB pencil lightly clasped between first finger and thumb, and resting on the second finger, should be held in such a manner that the side of the lead comes in contact with the paper at a small angle. Lines thus made can be easily erased as the surface of the paper is not injured by the lead. This crude picture can now be worked over until the finished outline consists of a continuous line of uniform thickness with no overlapping edges where the pencil has been removed from the paper and put down again. The pencil lines should be removed with an art gum eraser until the outline remains only as a faint impression which must be gone over again with the pencil. If guide lines and dots are drawn in light blue, they do not need to be erased since pale blue photographs as white in the reproduction of the picture. In picturing microscopic sections and objects, a correct outline is easily obtained by tracing around the image projected upon the drawing-paper by a camera lucida.

Perspective

Perspective, a subject which can not be treated in any great detail here, must be considered in drawings in which three dimensions are depicted. Objects should be drawn as they appear to the eye and not as they are known to be. They present their true appearance only on that side parallel to the eye. The apparent change in shape which takes place when an object is situated at an angle to the eye is known as foreshortening.

Since drawings of tubes and cylindrical objects are frequently made in biological papers, an understanding of a few principles of the perspective of a cylinder is necessary. If an ordinary tumbler is raised, the visible top becomes narrower and narrower until it appears as a straight line when directly opposite the eye—or at eye-level, as

it is technically called. When the tumbler is lowered from eye-level, the top, though actually round, first appears as an ellipse. Moreover, this ellipse is narrower than that formed by the round bottom, for the latter is farther below the eye-level (Fig. 1). In drawing a tube, the

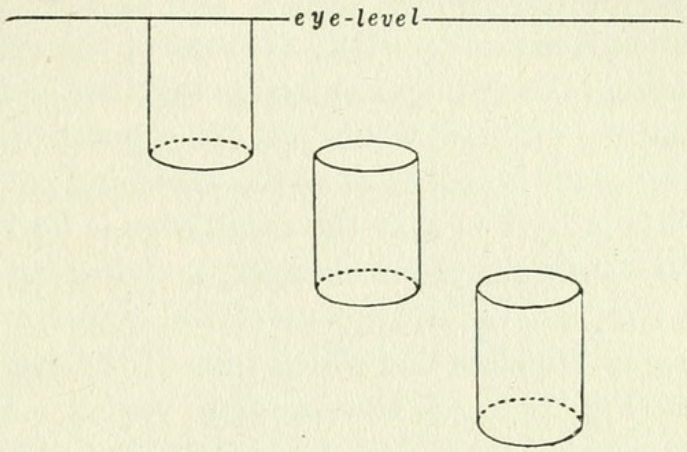


Figure 1. Three cylinders drawn to show the appearance of the top and bottom at different distances below eye-level. Reproduced ½ original size by zinc-process.

bottom edge will be more curved than the top as it represents one side of an ellipse broader than the one at the top (Fig. 2).

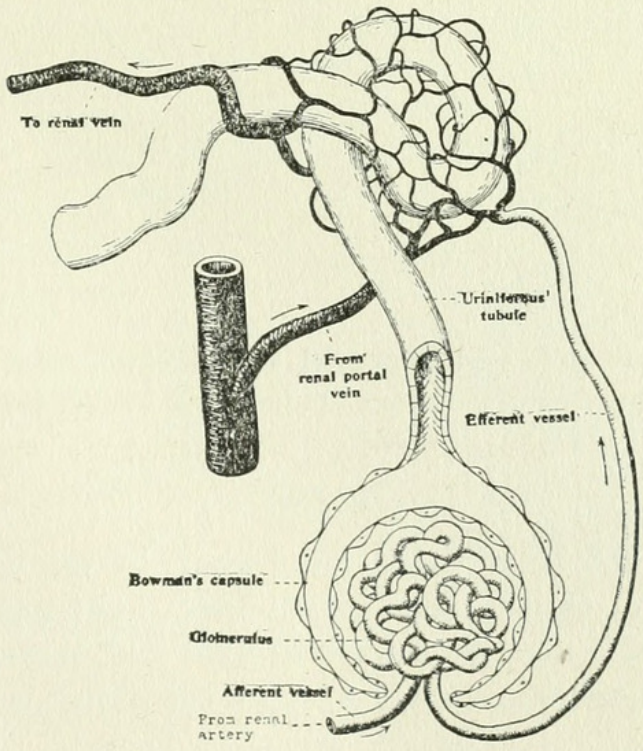


Figure 2. Diagram to show relation of Malpighian body and uriniferous tubules to the blood vessels. Reproduced ⅓ original size by zinc-process. Taken from Laboratory Directions by M. F. Guyer. Labels typed and pasted on drawing.

It is a familiar fact that from the rear coach of a train the rails of a straight piece of track converge toward a point in the distance directly in front of the eye. If all the outlines of a building seen through a window should be traced on the pane, they would converge so that if continued they would meet at two or more points. Likewise, if a book is placed horizontally in front of the eye, the parallel lines which represent the sides appear nearer together at the back than in the front, and if continued would meet at a point directly in front of the eye. This point is spoken of as the vanishing point.

If the book is moved so that the front edge is no longer parallel to the eye, the vanishing point changes, and instead of one point there are now two, one on either side of the object. These points, however, are on an invisible line which runs at the eye-level. Study the illustration (Fig. 3) to see how the lines vanish. All lines of the object that are parallel vanish to the same point. If two books do not lie at the same angle there will be four vanishing points, two for each book, but these points all lie on the line drawn at the eye-level.

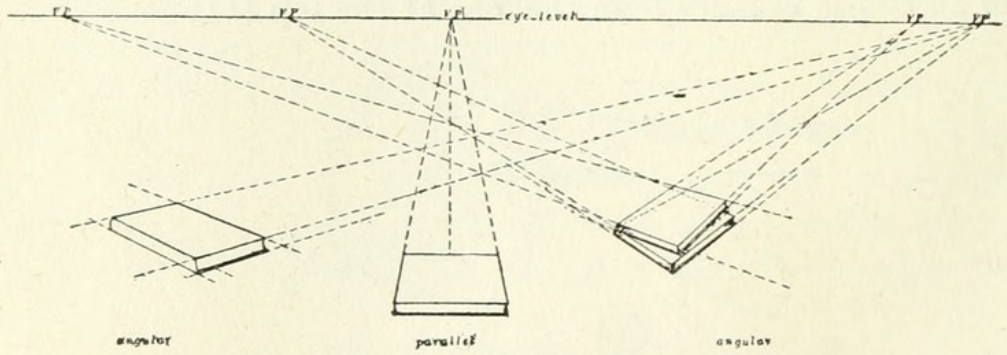


Figure 3. Diagram to explain parallel and angular perspective. The printed letters cut out and pasted on the drawing are too small for the reduction used. Reproduced ⅓ original size from a zinc plate.

Shading

Often form can be rendered more aptly by the use of light and shade (Plate I). Objects exposed to direct light generally appear lighter on the side near the source of light and darker on the other side. Furthermore, the shadow cast by the object is always darker

Plate I. Crayon drawing illustrating shading on plane, convex and concave surfaces. From a half-tone cut ½ the size of the original. Made with a screen containing 150 meshes per inch.

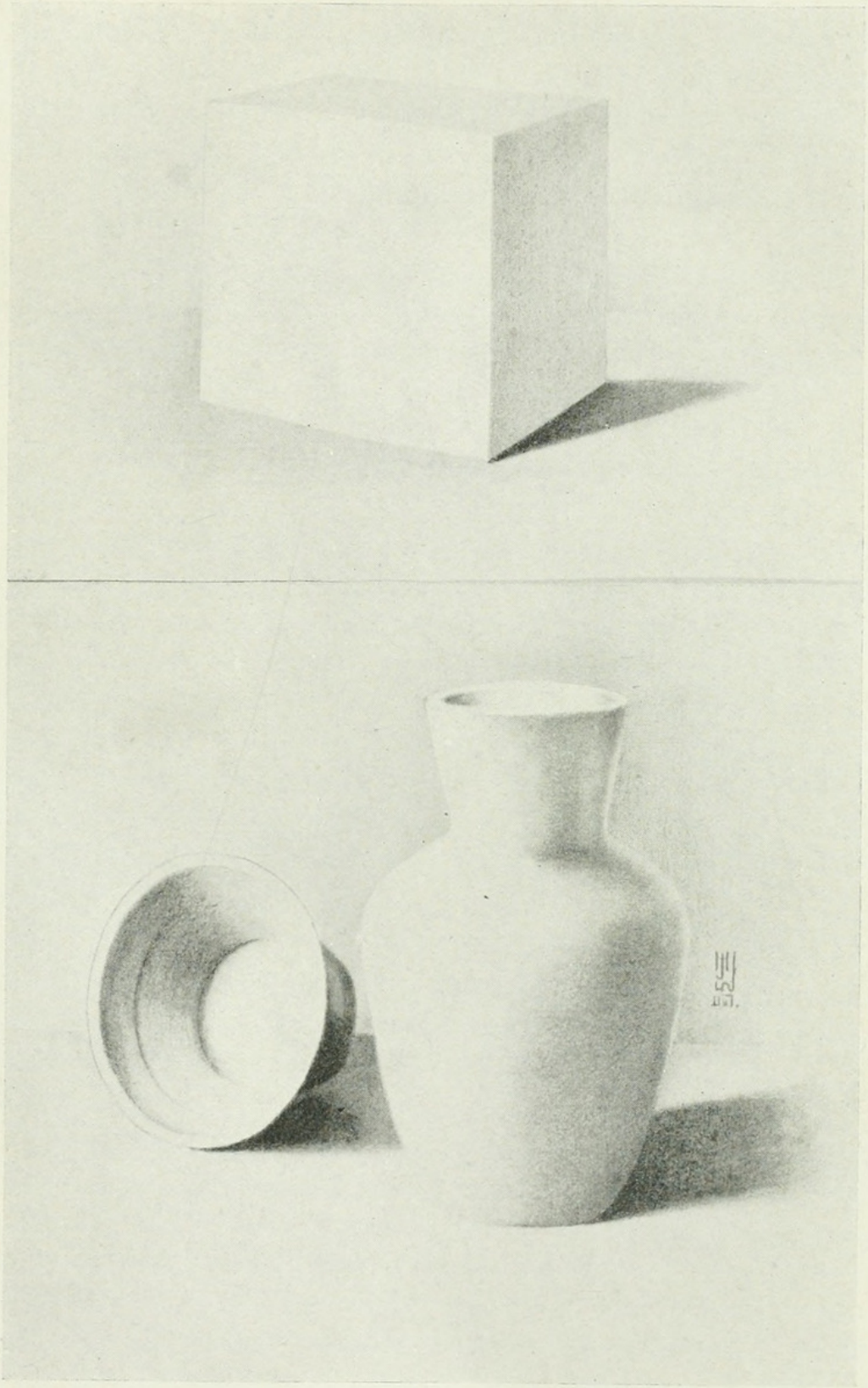


PLATE I

SMITH

than the shaded side of the object itself. In the zone between the lightest and darkest part of the object, the half-light or half-zone, details are most prominent. To indicate all the variations in shade would complicate the drawing unduly, hence it is the practice to use only those shadows which are necessary to bring out the form of the object disregarding all others.

Likewise, color, texture, and shape of the surface can be expressed through the proper placing of shadows. Shadows upon different colored surfaces have different values since colors vary in the way in which they reflect light. This is easily illustrated in photographs where a yellow surface takes dark, red shows up as black, and blue comes out white. Also the nature of shadows differ on shiny and on dull surfaces.

A flat surface usually has a continuous shadow of even tone, whereas on a curved surface the shadow must grade off into darkness on one side and into light on the other, with no sharp edges defining it. On a concave surface, the sunken appearance is produced by placing the darkest tone nearest the source of light, shading to a lighter tone away from the light. For here, the higher edge around the concavity prevents the light from striking the side nearest it. Convex surfaces, on the other hand, are illuminated on the side toward the light while the elevated center keeps the light from the opposite side.

Drawing

Ink Drawings. Pen drawings reproduce well by the zinc-process method as the black absorbs all light and the white back-ground reflects all, thereby producing great contrast in the negative.

For ink-drawings a good water-proof India ink such as Higgins' should be applied with pen or brush upon bristol-board (2 or 4 ply), upon Whatman's hot-pressed (smooth) water-color paper, or upon ledger paper. Whatman's paper is the same texture throughout; moreover, it can be used for wash or ink-work. Ledger paper, while little known, is excellent as erasure will not damage the surface. Gillott's pen points are satisfactory but inasmuch as each person handles a pen differently, exerting varying degrees of pressure in drawing, one number may not suit all workers. For fine line work and stippling, lithographic pen No. 290 is good. Fine red sable

brushes can be used although the pen drawing is likely to prove more successful.

After the pencil outline is correct, the drawing is ready for ink. On a clean pen-point place the ink by means of the quill attached to the cork of the ink bottle. A ragged line results if the pen is held so that one nib bears more heavily upon the paper than does the other, or if it becomes sticky with dried ink. To secure a line of uniform thickness the pen should be held at a wide angle to the paper so that only the very point touches, and a firm steady pressure be applied.

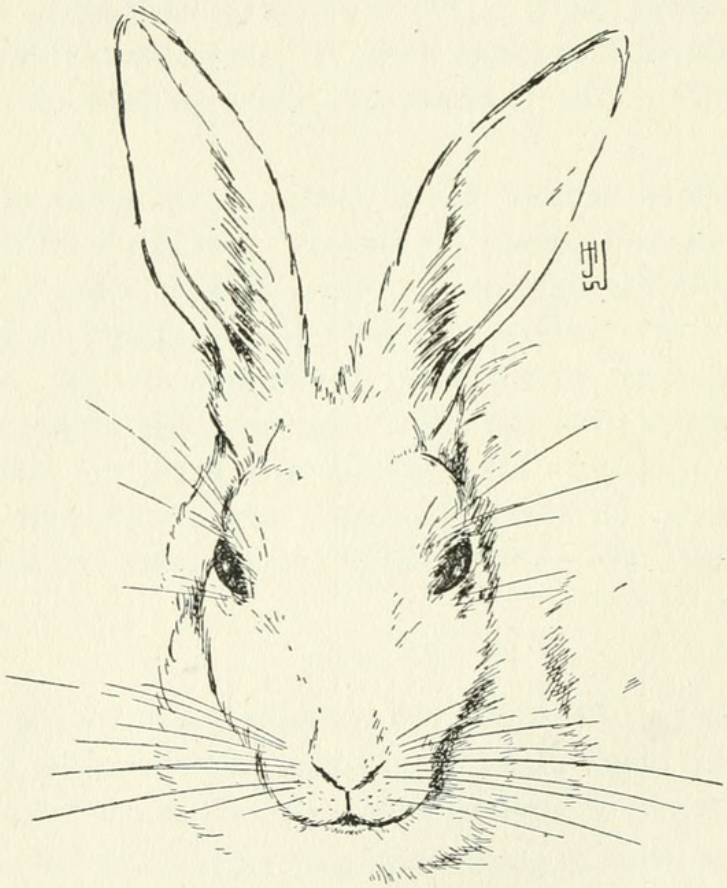


Figure 4. The fur is suggested by the use of uneven lines. Reduced ½ and reproduced from a zinc plate.

While ink thinned to a gray gives a difference in tone in the original drawing, in reproduction gray lines may behave erratically, often appearing as broken black lines. To avoid graying black lines the pen must be wiped frequently and refilled.

Effects may be obtained by the use of lines alone, either by varying the thickness of the lines or the distance between them. How-

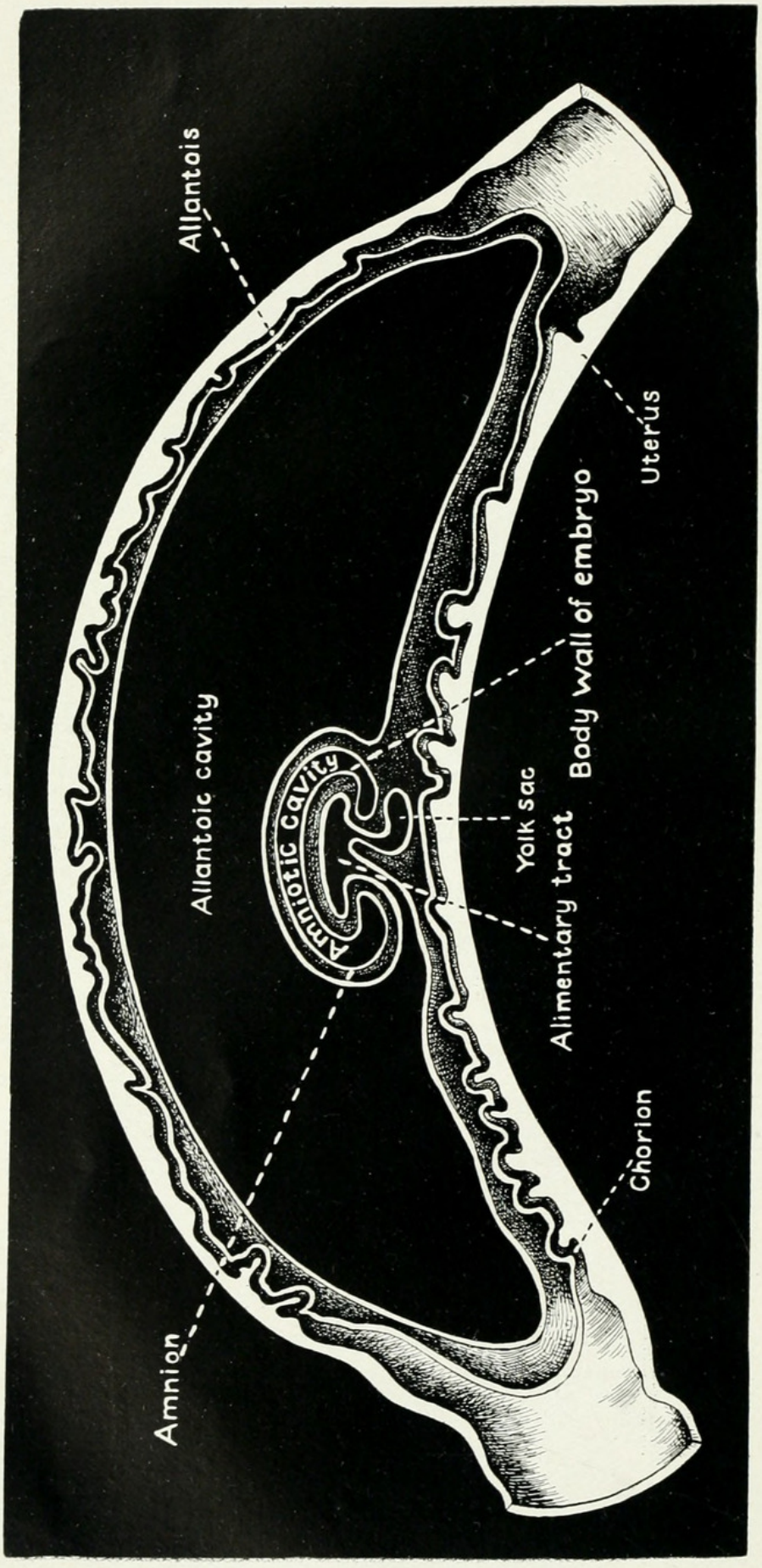


PLATE II

SMITH

ever, extremely fine lines may break, whereas coarse lines when placed close together tend to merge. Lines in the foreground should be heavier and farther apart than those in the background. Lines should follow the shape of the shadows, but they should end unevenly to avoid stiffness. In the darkest areas lines may be placed in an opposite direction across the first set.

Plate II is an ink-drawing in which the background and part of the cavities were inked, leaving the picture in white. This is an excellent method to follow in diagrams as the chief parts are strongly emphasized.

Texture and surfaces can be expressed by the use of lines of different character. Thus broken lines and dots indicate fur (Fig. 4), while fine, smooth lines may suggest feathers. Short, uneven lines in the depressions, suggest rough surfaces, while a few parallel lines on the heavily shaded areas are necessary for a smooth surface.

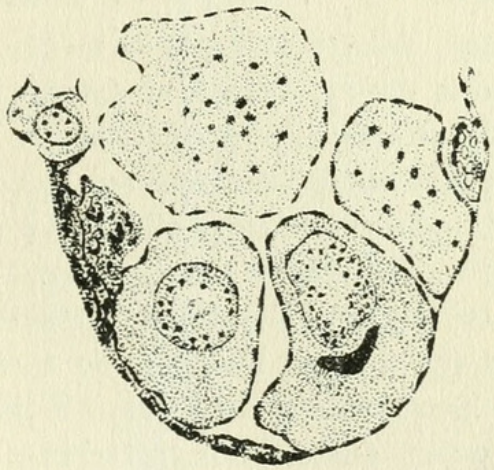


Figure 5. Ovary of frog in stippled ink. This drawing required much more time in its execution than A and B of Plate V. It was reproduced by zinc-process with same reduction as Figure 10.

Although bold line-drawing is admirable for some things, subjects often require the reproduction of the half-lights. These can be suggested by dots in a pen drawing (Fig. 5). All dots must be round and of the same size. Round dots are made by grasping the pen firmly and holding it in such manner that it meets the paper squarely. If it strikes at an acute angle, three-sided instead of round dots will result. Heavy shading is indicated by placing dots close together; light shading, by keeping them farther apart. Dots that are too fine

Plate II. Diagram of pig embryo surrounded by membranes. Lettering done by hand in white ink. Printed from a zinc plate ½ the original size.

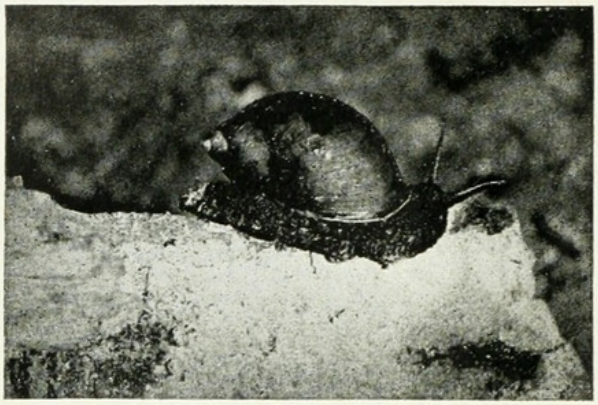
can not be reproduced on zinc as the acid undercuts the sides of the dots, thus destroying the stippled effect.

Slight irregularities and defects are easily removed from the drawing by scraping them away or covering them up with Chinese white paint. Before applying white paint clean away all pencil marks and completely cover the part to be obliterated with several coats if necessary. Alternations are then made as desired since the white paint does not interfere with inking. Only a little ink should be placed on the pen when attempting to re-ink a spot erased with a knife as the ink spreads on the damaged surface.

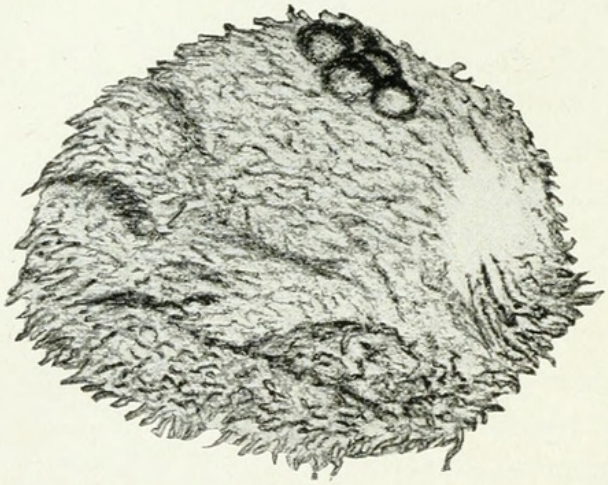
Wash drawings. Wash drawings are ordinarily reproduced by half-tone process. The contrast between the black and white parts of the original picture should be exaggerated, as the screen intersperses white dots in the black areas and black dots in the white spaces thereby lessening the contrast of the picture.

For wash-drawings, Whatman's paper mentioned previously, or any smooth water-color paper, will prove satisfactory. A grained or rough surface usually causes unpleasant effects. Winsor and Newton's Ivory Black or Charcoal Grey makes a good working medium. These colors come in solid cakes from which the wash is prepared as follows: With a wet brush remove some pigment from the cake and put in water in a mixing pan. Repeat this process until the wash is slightly darker than the desired background as the tint lightens in drying. Good sable brushes keep their shape if they are washed after using, brought to a point, and kept inverted in a jar.

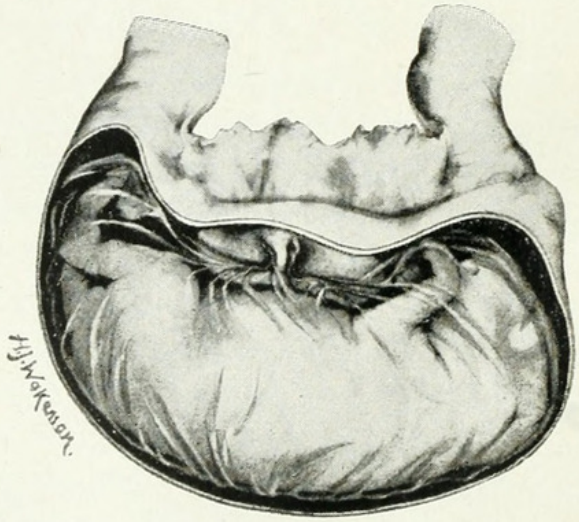
Although from the artistic standpoint the use of the brush alone is preferable, the accuracy demanded in a scientific drawing makes a faint pencil outline more practical; and a hard pencil is better than a soft one if the surface of the paper is not injured with pressure, as the graphite is not so likely to smear when wet. After the outline is finished, the paper should be fastened to a board with thumb tacks and the entire surface dampened with a large brush, removing the surplus water with brush or blotter. If the picture is large or complex a dampened blotter placed under the paper will keep the surface moist for a long period. The wash is applied over the entire background and the paper allowed to dry partly before darker tones are added. Where a very dark portion is confined to a small area, the



A



B



C

paper should be quite dry, otherwise the wash will run into the surrounding part. With wash alone, good effects may be obtained (Plate III, C). Details may be stippled either in wash or in ink or drawn in with lines.

Where several wash-drawings require the same tones, it will be found simpler to put in all the backgrounds first. Mix up plenty of wash for this purpose, as it is not easy to duplicate the exact shade. Wash allowed to stand becomes darker upon evaporation of the water; hence if, after the backgrounds are put in, the work must be deferred until later, the same wash will do for darker tints. When the work is continued it is not necessary to redampen the entire surface as the dark tones can be blended into the background with a clean, wet brush.

Some artists prefer a dry paper but this requires more skill in applying the wash. For, unless the work is done rapidly, the pigment dries leaving a dark line or water-mark where each brushful of wash ended.

With an air-brush beautiful wash-drawings can be turned out in a short time. The wash is placed in a receptacle and by air-pressure sprayed over the parts of the drawing in a fine stream. Considerable skill is necessary in regulating the spray. Moreover, the instrument is expensive and requires an air-gage and cylinder. But if the brush is at hand it will repay the time spent in learning its use, especially if one contemplates making many drawings.

Crayon. With crayons, drawings scientifically accurate and artistic as well are obtained with least expenditure of energy. Moreover, mistakes due to lack of skill in execution are more readily remedied.

While Conte crayons in pencil-form come in five numbers ranging from hard to soft, No. 2 is suitable for most work. Varied stipple effects may be produced by using them upon Ross stipple board. This paper has a grained chalk surface to which the crayon adheres in the form of dots when it is rubbed back and forth over the chalk. The grain of the paper differs in the different numbers. No. 8 is good for general

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Plate III, A. Reproduction of a photograph by the half-tone process. No reduction.

B. Crayon drawing of embryonic vesicle of young human embryo reproduced ½ size of the original by half-tone process.

C. A half-tone reproduction of a rabbit embryo in the uterus made from wash original reduced ½.