

## Appendix III: Sketching Techniques

This appendix introduces skills and equipment needed for the sketches assigned in the laboratory exercises and provides examples, both good and bad, of important drawing techniques. Many people are intimidated at the notion of illustrating; making claims of “I can’t draw,” or “If I could draw, I’d be in art school.” Whereas many biological illustrations are beautifully rendered by artists, scientific illustration requires only the most basic artistic skills. It is better conceived of as drafting: a technical skill that can be taught to, and mastered by, most everybody.

The sketching assignments in the laboratories become successively more advanced; beginning with the basic pencil line drawing, then introducing shading and ultimately ending with students preparing ink plates suitable for publication. This chapter follows a similar course; first introducing a technique and then discussing the most frequently encountered difficulties and possible means to avoid them.

### **Equipment:**

#### **Sketching supplies:**

- Dissecting tools (see Appendix II)
- Dissecting stereomicroscope with ocular grid (or camera lucida)
- Sketch pad -- heavy sketching paper, preferably 11" x 14"
- Drawing pencils of varying hardness (2B, 3H & 6H are good starters)
- T-square
- Ruler with a raised edge
- Photo blue pencil
- Kneadable eraser
- Eraser guard
- Red pencil

#### **Inking supplies:**

- Drafting film (e.g., mylar, acetate, etc.)
- Drafting film primer powder (e.g., Pounce ®)
- Rapidograph pens of various thickness  
0.3mm (00), 0.35mm (0), and 0.5mm (1), are good starters
- Ink eraser
- Stiff cardboard / mattboard to back illustrations
- Tracing paper

### **The grid method**

All of the sketches and ink plates are drawn using the stereomicroscope and ocular grid. This method is a variation of a common technique used to manually duplicate, enlarge or reduce artwork. In basic applications, a square grid is placed or drawn over the original artwork. In this case, the specimen is viewed through a microscope that has an ocular grid inserted into one of the eyepieces. Either way, the illustrator essentially maps the lines of the original artwork or outline of the specimen, onto a piece of paper with a similar grid drawn on it. The grid serves as a reference point and ensures that the reproduction is of the same proportions as the original. By varying the size of the second grid (the one being drawn onto), the illustrator can enlarge or reduce the original.

The following exercise demonstrates this procedure. On the left is a drawing of an ant's head. A grid has been placed over the drawing. A second grid is positioned to the right. Try to duplicate the original head using the grid lines as references. One of the antennae has already been drawn to show how the lines will correspond to the original.

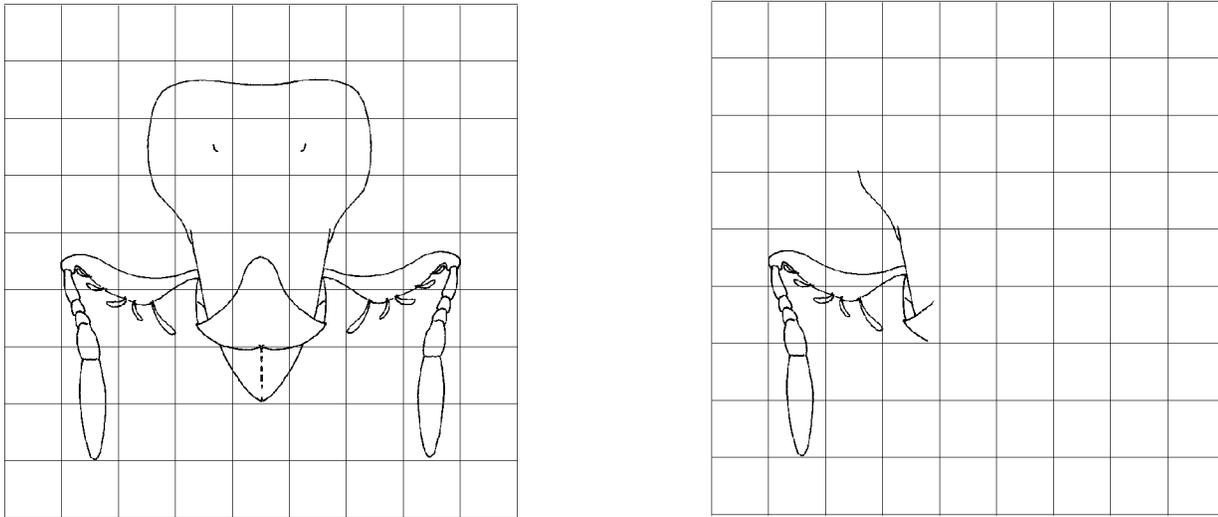


Figure 1

Drawing an actual specimen is similar, except that the specimen is three dimensional and often pigmented. You must train your eyes to search out the outlines (edges) of the sclerites and to follow them with reference to the ocular grid. Generally the outlines of the sclerites are drawn first, then the important sutures and sulci, and lastly details in surface sculpture, setal patterns, etc. The following example shows how this is done.

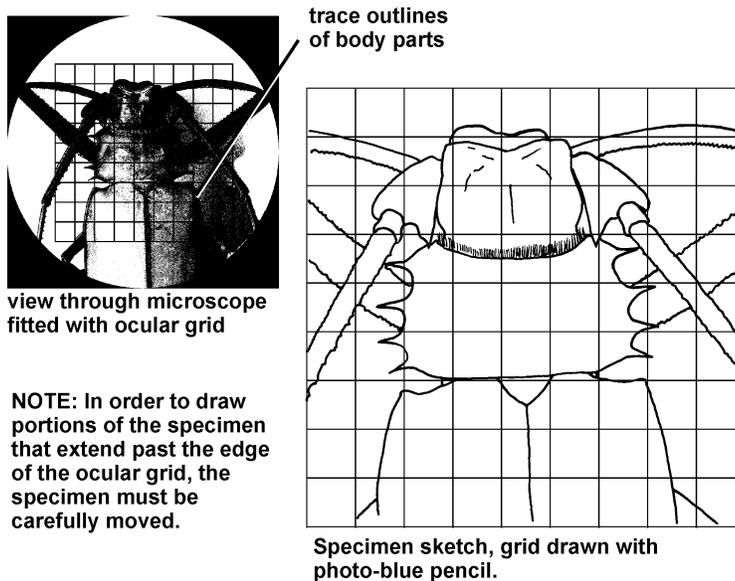


Figure 2

## Getting started with a sketch

The first, and perhaps most important, step of any sketch is the time spent **preparing the specimen**. Careful dissections are far easier to draw than are torn/damaged specimens. Additionally, the orientation of the specimen can greatly aid in the ease, and success of the finished drawing. Important structures should be clearly visible under the scope. Insects with scales and/or long setation must be shaved using a scalpel blade if the underlying sclerites are to be drawn. If the dissection is conducted under liquid (e.g., Ringer's solution or alcohol), the specimen and any positioning pins (minutins) holding it down that are in view *must be completely submerged*. Appendages and/or pins that emerge from the surface will form a meniscus that will distort the image. The specimen should be as compact as possible, which may require pins or minutens to be placed strategically to hold the specimen (or its appendages) in a certain arrangement. Lastly, an attempt should be made to keep the specimen in a single plane relative to the observer (e.g., the entire specimen in focus under the scope at the same time). If it is impossible to view the entire specimen in focus at one time (for example: rounded specimens or specimens with large projections such as horns), see the section below on *foreshortening*.

After the specimen is prepared, the next step is to **create the grid** on which to draw the sketch. To do this, first count the number of grid squares you will need to draw the entire specimen or structure of interest. Try to use the highest magnification that allows the majority of the structure to fit within the 10 x 10 ocular grid. For large specimens (such as the one depicted in Figure 2 it may be necessary to draw the illustration in several parts; first drawing on 10 x 10 grid, and then carefully moving the specimen under the scope so that another 10 x 10 square area can be drawing. If you need to do this, make sure that the multiple drawings are aligned correctly with respect to the grid. Magnifications of 25x or 16x are typically good to work with. Draw the appropriately sized grid on the sketch paper using a sharp photo-blue pencil. Try to maximize the size of the grid on the paper but leave a border around the edges and a place for a legend of pertinent information (e. g., your name, the species being drawn, the view, etc...). You will also need space to put labels around the specimen.

If the specimen to be drawn is symmetrical, it may be possible to draw only half of the specimen. The drawing can then be copied, inverted and traced onto the original to create the other half. This time-saving method will make your illustrations look more professional, but should only be used after the specimen has been carefully examined and the illustrator is completely certain of its symmetry. Note that the beetle illustrated in Fig. 2, although it is roughly symmetrical, if you look carefully, you'll note that the labrum at the head's anterior is distinctly asymmetrical.

The specimen can now be drawn. Begin by drawing the outlines of the important sclerites with light lines using a sharpened pencil of moderate hardness (3H or higher). Draw each sclerite individually rather than drawing entire organs, tagma or the outline to the entire organism. For example, drawing each antennal segment separately tends to produce a more realistic image than if the whole antenna is drawn first and then subdivided. This is also true of abdominal segments, limbs, etc.. This technique works because it forces the illustrator to look at small details of shape and form inherent to the individual parts which are often overlooked when viewing the "whole".

Constantly check the accuracy of the lines relative to the grid. It is easy to miscount grid squares and realize later in a sketch that things aren't lined up correctly. (**Comment:** you should spend more time looking at the specimen than at your sketch. If you find that you haven't looked into the scope for a few minutes while drawing: you might want to take a quick glance to ensure the accuracy of what you've just drawn).

Once you are certain that a line looks correct, go over it with a darker line using a softer (but still sharp) pencil. Lines should be confidently drawn and should be of even thickness and darkness. If you need to erase a line, use the kneadable eraser. Also, if you have sketched multiple light lines (a common sketching

technique) where only one should be, use the eraser guard to erase all but the intended line. Remember to keep your pencil sharp since lines of a sharp and dull pencil differ greatly in thickness.

Often times an illustrator wishes to draw a structure that is hidden entirely or partially underneath another sclerite. If this is the case, the underlying structures should be drawn using dashed lines. In the example below, the beetle's spiracles are not directly visible because they rest on membranes occluded from view by sclerites; as a result, they are drawn in dashed lines.

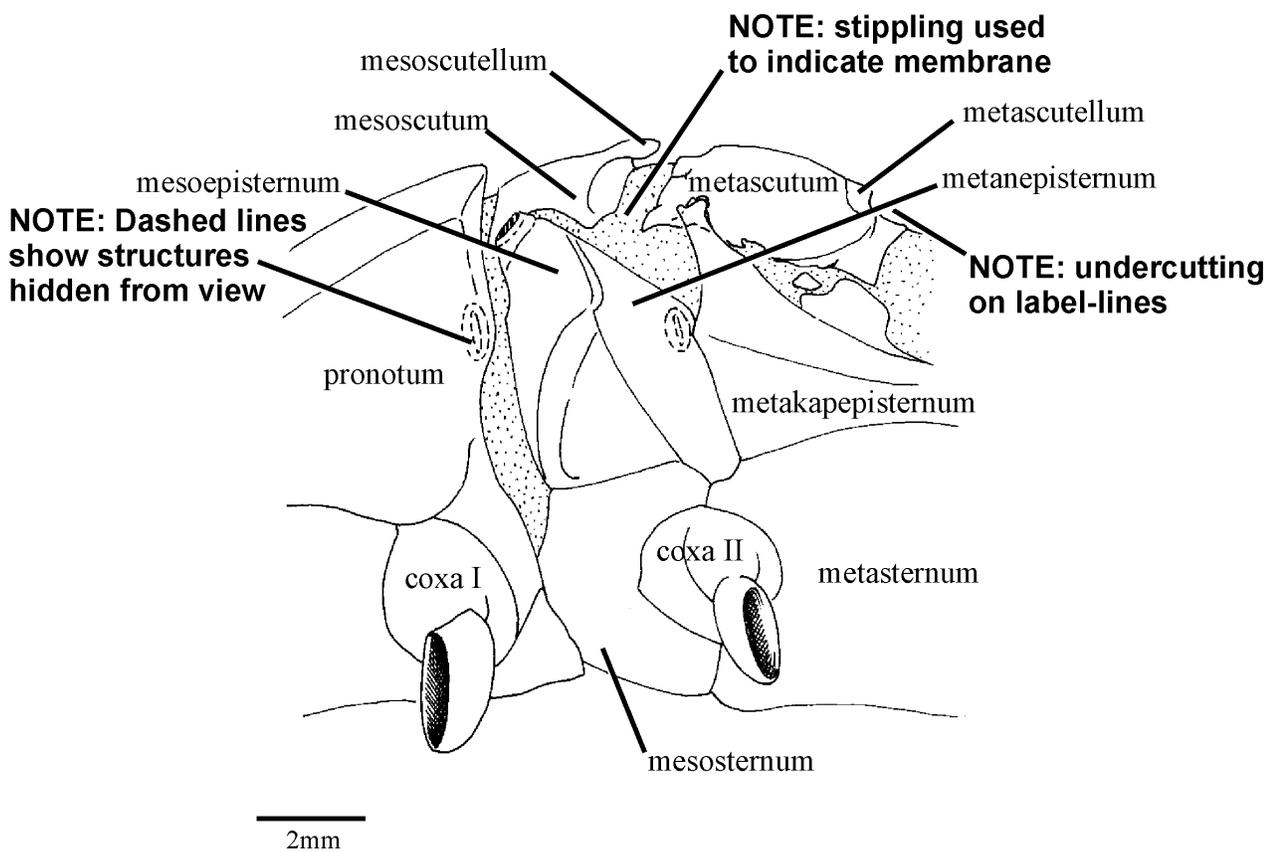


Figure 3

If the specimen consists of both sclerotized and membranous regions it is necessary to indicate membranous regions with stippling. When done correctly, stippling consists of uniformly sized dots that are arranged in a semi-random fashion. If the dots are placed in a pattern (see below) it tends to be distracting. Likewise, if the dots are placed too irregularly this will also be distracting. Hence, the trick to stippling is to place the dots in a “pseudo-random” pattern. This takes concentration. Keep the pencil sharp so as to ensure uniform stipple size. Lastly, the stipples need to be spaced so as to be the correct density. If the stipples are placed too sparsely, the membrane will appear faint and washed out, and if placed too densely, the membrane will appear darkened or even black (especially if reduced; such as for publication).

Below are some examples of stippling. The squares are reduced by 50% to illustrate the effect of reduction on stippling pattern.

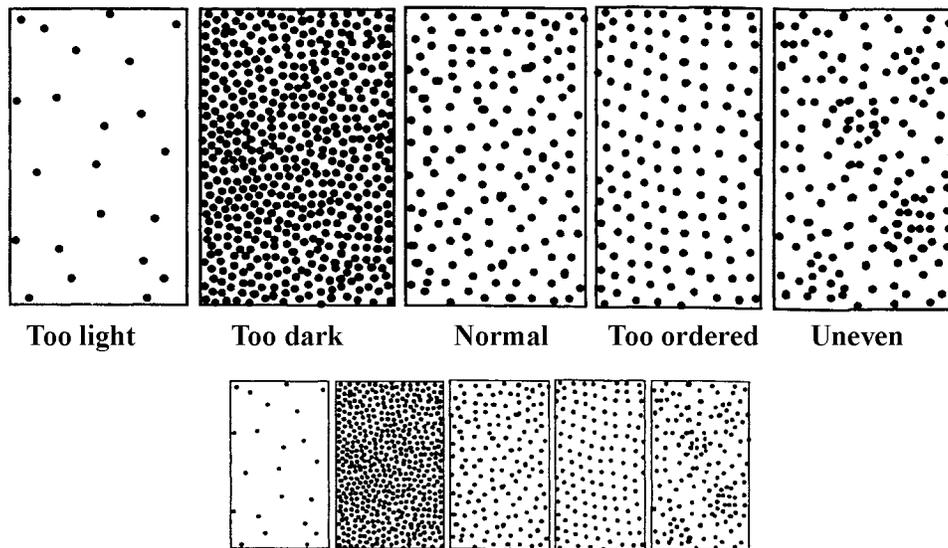


Figure 4

Once the entire specimen is drawn and you’ve checked the proportions against the grid, you may want to view the specimen under higher magnification so as to include details that may not have been as visible at lower magnification. The grid will no longer be appropriate at the new magnification. Thus, you will need to make these additions to your drawing by relying on the relative proportions and positions of the new structures you wish to add to the structures you have already drawn.

At this point, the only necessary to finish the line sketch is to: (1) label the important structures, and (2) include a scale bar.

## Labeling

Illustration labels should be positioned parallel to the bottom of the illustration. A guide line, drawn with the photo-blue pencil, should be placed where the label is to be written. Use a consistent size and style of lettering throughout a single illustration, or sets of illustrations intended for a single publication. Labels that fit within their corresponding structures on the illustration should be placed there, such as “coxa I” in Fig. 3. Labels that do not fit within their corresponding structure (e.g., "mesepimeron" Fig. 3), are placed on the periphery of the illustration. Use a ruler to draw a single straight line with a red pencil connecting the label and the relevant structure. Place peripheral labels so that the red lines do not obstruct other important parts of the illustration, nor appear confusing and/or distracting.

## Scale bar

The scale bar should be calculated using a stage micrometer. Place the micrometer underneath the scope and measure the distance between 10 grid squares on the micrometer (in mm.). Then measure the width of one of the squares on your drawing (in mm.). Use the following equation to calculate the final length of a 1mm scale line:

$$(10 \times \text{length of 1 paper grid square}) / \text{length of 10 ocular squares} = \text{length of a 1 mm scale line}$$

Draw the scale bar horizontal or vertical, near to, but not on, the illustration.

## Shading/3-dimensional representation

Three dimensionality is depicted in illustrations through various forms of shading. Conventionally, specimens are drawn as if light is hitting the specimen from the upper left corner of the illustration. By drawing shadows and/or highlights produced by this light, the illustrator conveys the illusion of 3-dimensions.

Shading correctly requires that the illustrator examine the structure to be drawn and understand how and where light hits the structure. As much light as possible should be aimed at the specimen for the initial sketch. However, when shading is to be added, it will help to place the light source so that it is directed only at the upper left corner of the specimen. After some practice, you will begin to understand the behavior of the light, and predict where it will hit the specimen. Thus, you will be less dependent on an actual light source for shading. It is here where students with previous art training will seem more adept, since they are already accustomed to using these conventions. However, the conventions can be practiced and learned by anyone in a surprisingly short amount of time.

Generally, highlights appear on any surface of the specimen that faces the upper left corner and shadows form on surfaces facing the bottom right corner. Ridges and bumps have bright highlights, whereas groove and indentations produce dark shadows.

There are several ways to create highlights and shadows. The first and most basic method is used in line drawings. The illustrator uses **varying line thickness** to show highlighted vs. shadowed regions. Thin lines are used in regions of the drawing that are hit by light, whereas those portions that are opposite the light are drawn with thicker lines. Even if there is only minimal difference in line thickness, the viewer sees the slightly thicker lines as if they were shadows and therefore a subtle illusion of depth is perceived. Below is an example of an illustration that uses this technique to help render 3-dimensions.

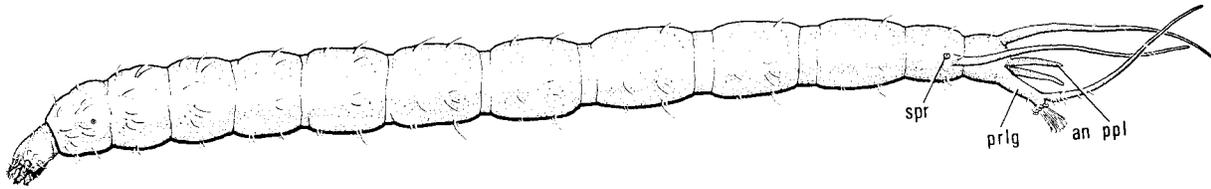


Figure 5 -- Illustration using different line thickness to provide depth, note the heavy lines on the ventral surface of the fly larva. Stippling has also been used to show some shadows on the membranous body. (Illustration: McAlpine et al. 1981)

To further the effect of depth in a line-drawing, **undercutting** can be used. This technique helps depict overlapping structures such as the outlines of two sclerites. The outline of the underlying sclerite is “cut” or terminated, just before the two outlines merge. Undercutting is extremely good for drawing setae, overlapping sclerites and ball and socket joints. The illustrator of Fig. A.2. used undercutting to help show the label lines. Notice how they appear to “float” on top of the illustration.

### Pencil Shading

When more complicated structures need to be shown, such as surface contour or texture, line-thickness is not very effective, and a half-tone method, such as pencil shading must be used. Once again, the light should be shining from the upper left corner of the illustration. To begin, use the side of a hard pencil (3H-5H) to **lightly color in** the entire area to be shaded. Do not press hard on the pencil at this point -- the idea is only to give the form a background grey tone that will make it easier to see both the highlights and the shadows as you work. After this step, use the kneadable eraser to place highlights where they are appropriate (with forethought, you can put the highlights in during the first step simply by not shading these regions). Then, use a softer pencil (2B-HB) to lightly shade the regions where shadows are needed (always start out lightly...you can always add more shading).

Begin blending the shadows into the grey areas. Smudging tools are inexpensive and work well for blending, but a clean tissue works satisfactorily. Start light and work darker slowly, it is easy to over-shade a sketch and difficult to repeatedly erase in the same area multiple times.

You may have to re-define the highlighted areas with an eraser. As you continue to blend the grey-tones, you will notice the image begin to “pop” out of the plane of the page. The trick to shading is smoothly blending from dark grey or even black, into a light grey or white. If the changes are too sharp, the shading will be distracting and the overall drawing will appear unnatural. Don’t get discouraged by a few false starts, shading takes practice and is the most difficult part of any sketch.

### Difficulties with Shading

One of the greatest difficulties in shading is learning where the shadows and highlights are on a specimen. Dark pigmentation on a specimen is easily confused with shadows. A black beetle and a white tingid bug should both be shaded in similar tones. It is often difficult to see shadows on a heavily pigmented specimen. In these cases, you must figure out, based on the shape of the specimen, where the light and shadows will fall. You may also want to bleach or peroxide a dark specimen so that pigments are no longer a problem. Analogously, nearly transparent or white structures might be easier to draw if faintly tinted using a number of biological stains.

Commonly, too much shading is put on the illustration, producing a dark and smudgy image. Begin

lighter than you think you have to. Even small shades will show up against the white paper and it is much easier to add shading than to remove it. Blending takes practice and can also cause frustration. Try using the side of sharp pencils rather than the point. By varying the pressure on the side of the pencil you can control the darkness with greater ease.

Color patterns or reflective or metallic surfaces can be exceptionally tricky to shade, especially for a beginner. Attempting to reproduce colors in a black and white illustration can be difficult (and sometimes impossible). If a color is an important attribute it may be necessary to investigate methods of color illustration. Metallic surfaces will reflect light differently than dull surfaces. Beginning students are recommended to avoid specimens with extensive metallic surfaces. Technically, if a student faithfully draws every highlight and shadow they see through their scope, the illustration will appear metallic (meaning the same conventions will work for these complex drawings). However, the great many small highlights found on reflective surfaces can be overwhelmingly complex. If you must draw a metallic organism, you should refer to any of several more detailed works on biological illustration.

The last trick to nice shading is the relationship of shadows in a drawing to the outline of the sketch. If the lines of the sketch are very dark, whereas the shadows are of medium grey, the illustration will take on the appearance of a coloring book. It is recommended that the shadows merge with the outline edges. When this is done correctly, a viewer is more likely to perceive a shaded form rather than an outline with shading in it.

### **Camera Lucida**

The camera lucida, or drawing tube, is an accessory available for most microscopes that facilitates biological illustration. The camera lucida may at first appear to be a lifesaver for beginning illustrators. However, achieving accurate drawings using a camera lucida is trickier than it first appears. Many poor illustrations published today result from an inability to correctly use this device. For several reasons, the ocular grid method is preferred by the authors of this manual, especially for beginning students. Over and above the direct cost of the tools, the most important reason to favor ocular grids is that they require students to scrutinize the relationships among anatomical parts -- mentally dis-assembling complex structures into their parts and training their eyes to recognize minute distinctions between various species and/or specimens. This is the ultimate goal of a morphology course -- understanding the anatomical parts and their relationships. The grid method also reinforces a student's knowledge of the 3-dimensional reality of an image as viewed through the scope (note: beginning attempts at drawing with a camera lucida characteristically result in "flattened" images). For students and instructors who wish to use a camera lucida, a brief description of the camera lucida and its use is provided below.

The camera lucida, is basically a mirrored device that sits between the oculars of a scope and the objective. It extends to the side of the scope, and has a mirror faced directly down, towards a drawing surface next to the scope. The device reflects the image of the drawing surface into one of the two oculars, allowing the illustrator to see both the specimen, and their drawing hand, simultaneously; the two images superimposed over each other. This allows the illustrator to literally "trace" the outline of the specimen onto the paper. Essentially, the illustrator sees himself/herself tracing the outlines through the scope.

Lighting must be adjusted carefully. There needs to be enough light on the paper so that the image is reflected strongly through the ocular. However, this additional light will make it more difficult to see the specimen. A balance must be achieved that maximizes both the ability to see one's pencil lines on the paper while also clearly seeing the specimen. The most difficult part of using a lucida correctly is accounting for the 3 dimensional form of the specimen. Only a single plane of the specimen can be in focus at any given time on the scope. If a student begins tracing regions that are not perfectly in focus, these regions will not be accu-

rately represented in the sketch. This is no different than in the grid method, although the diminished visual acuity imposed by the reflected light of the lucida can make it difficult to register when parts are slightly out of focus or gradually easing out of the plane of focus (such as the border of a rounded body form). Extreme care must be taken to trace only those parts that are truly in focus.

Once the specimen and the camera lucida are set up correctly, sketching proceeds much the same as for the grid method. In tracing the image, one should try to break up the specimen into clear morphological parts, tracing each separately. This should increase the accuracy of the illustration, even though it may seem to take longer.

Using the camera lucida reduces the ease of adjusting the size of the final sketch. The size of the sketch will be determined by the distance between the lucida and the drawing surface (the desk). Increasing this distance (e.g., by placing the scope on a stand) will increase the size of the sketch. You may need to experiment with this distance to achieve a suitably sized sketch (i.e., twice the size of the desired final plate). Alternatively, you can produce a rough draft of the illustration at whatever size and then use the xerox machine to increase or decrease the size of the illustration. Now trace this new, larger image back onto a sheet of drawing paper. Finally, re-examine the specimen and make any necessary changes to the final illustration. Remember to leave yourself enough room for labels and a heading.

Lastly, a scale bar must be placed in the drawing. To do this, place a stage micrometer under the scope and trace a scale bar of some standard length (e.g., 0.5mm, 1mm, etc.) onto the final sketch. Make sure the micrometer is also in focus.

## Appendix IV: Inking Techniques

### **Ink Plates**

Because of the many shades of grey used in all half-tone illustrations, including pencil sketches, they are difficult and expensive to publish. The vast majority of published biological illustrations are done without true grey tones, using various “black and white” techniques. The most commonly employed is to use line drawings. Traditionally referred to as “pen and ink” drawings, today this category includes many black and white computer generated illustrations. Although not produced with a “pen”, these illustrations rely on the same basic principles, they are merely executed using software tools instead of traditional manual tools. As with the preceding section, the following first discusses non-shaded line drawings and then introduces techniques of shading.

The most important step in producing a good ink-plate is to produce a good pencil sketch. The plate is drawn from the sketch, not from the specimen. Therefore, the sketch should be double-checked to ensure accuracy (both in morphology and in labeling) **before** the ink plate is begun.

### **Equipment**

Pens: Rapidograph pens are the most commonly used for pen and ink illustration. These pens possess a nib that is a fixed diameter and draw a line of ink with a correspondingly fixed thickness. To obtain different thicknesses of lines, different pens must be used. Traditional rapidograph pens are non-disposable and relatively expensive. Additionally, they can quickly become ruined if not cared for properly. Recently, several brands of disposable rapidograph pens have become available. These offer the student an economical alternative with less hassle and are therefore recommended. However, for important illustrations only new disposable pens (or traditional pens) should be used because the disposable nibs often degrade with age, resulting in uneven lines. Also, the ink from some disposable pens (especially older pens) is a noticeably lighter shade of black than the ink available for traditional pens.

Quill pens, or dipping pens, are less frequently used, but can offer the illustrator a wider range of effects than can a rapidograph. A crow quill nib is a good beginner nib for interested students. Crow feathers were originally used to make these nibs, hence the name. Quill pens produce a line that varies in thickness depending on the amount of pressure applied by the illustrator. This can be a useful technique, but can be hard to control at first, making uniform lines more difficult. Additionally, quill pens must be dipped in ink constantly while rapidographs have an internal ink cartridge. As a result, an illustrator must be certain there is enough ink on the nib to start and complete a given line, because once a pen is pick up off the drawing (e.g., to re-dip it), it is difficult (but not impossible) to continue the line without producing a noticeable “node” in the line.

Drawing surface: There are also a variety of drawing surfaces for ink plates. Drafting film, such as mylar or acetate, designed for pen work is most recommended. Lines will keep a uniform thickness on this surface while the ink often bleeds in paper surfaces. Paper drafting film is also available but its surface is not as smooth as film and therefore pens do not drag as easily across the surface. Also, it is impossible to erase ink from drafting paper, whereas limited erasing is possible on film.

Whether using drafting paper or film, the surface should be mounted on a stiff piece of cardboard or mattboard, that is larger than the film. Drafting tape, placed on each corner, will hold the film in place.

Erasers: Nobody’s perfect and a variety of erasers are designed to erase the ink off of film (erasing is impossible with drafting paper). These erasers are enlaced with an ink solvent. Drafting film has a thin, matte surface which can eventually be worn through if too much erasing is done in one spot or too much

pressure is applied to the eraser. Thus, care should be used in erasing. Electric, rotary erasers, although expensive, are extremely useful for erasing small areas of an illustration without affecting the surrounding regions. For minor mistakes, we recommend using white paint instead of erasing, since erasing can alter the surface of the film and make inked lines look smudged.

## **Getting Started**

Many journals have specific requirements for illustrations. If this illustration is to be submitted to a specific journal, these specifications must be met. Journals typically publish these requirements on the inside or back cover under the heading "Instructions to Authors".

The size of the plate: Plates are usually drawn larger than they are to appear in the final publication (approximately twice the size). For the most part, illustrations look better when reduced. Small errors or vagaries in line quality and shading are diminished and rendered less noticeable.

Generally the ink plate is approximately twice the size of the final illustration, but most journals will accept reduction from 30-70% of original size. Often the initial sketch is already larger than the final illustration and can be used directly. However, copier machines and scanners can be used to adjust the pencil sketch to the appropriate size.

Preparing the surface: First, avoid film that has any wrinkles, bubbles or creases in it -- these cannot be easily fixed and this film should be discarded. The drafting film should be primed before use. Contaminants such as oil, fingerprints, vestiges of erasing fluid or even water can drastically affect the surface of drafting film. New film does not require this step, but it never hurts to be careful. Drafting film primer, such as Pounce®, is available and should be sprinkled onto the film before beginning. A very soft brush can be used to brush the excess priming powder off the film. Avoid blowing on the film, even small droplets of water can affect the ink. Also, avoid touching the inking surface of the film. Even light fingerprints will leave an oily film on the surface that will affect the ability of the ink to stick and will be visible if you try to draw over this portion of the film. If the surface is badly soiled, a cotton swab with a mild soap solution can sometimes be used. After using soap water, the surface must be re-primed. If erasing is needed during the illustration, the area erased should be allowed to dry for a few minutes (to let ink solvent evaporate), and then re-primed before attempting to draw over this region.

Transferring the sketch to the film: The easiest technique is simple tracing. If the film to be used is moderately transparent, the sketch can be placed under the film and traced directly. Use of a light table will allow tracing to film or drafting paper that is not as translucent. If this is impossible, a double-trace transfer technique can be used. To do this, use tracing paper and a soft lead pencil to make a tracing of the pencil sketch. Remove the tracing paper from the sketch and flip it over (side B). Use a soft lead pencil to copy the traced image (on Side A) onto side B of the tracing paper. Now place the tracing onto the drafting film with side B down. Using a blunt tool or the side of a soft pencil, rub side A **gently**. When the tracing paper is removed, a light rendition of the original sketch should be present on the drafting film.

## **Inking**

### Line drawings

Although it takes some practice, good lines are drawn confidently and in a single stroke. Picking the pen up, off the film, and resetting it can produce visible breaks in the line. If using a rapidograph, hold the pen perpendicular to the film (not at an angle as with normal pens). A rapidograph will only keep the line width constant if held upright. Your hand should not touch the film, a small piece of clean tracing paper or extra mylar should be placed under your hand. Follow the traced lines of the sketch onto the film. If different thicknesses of line are needed, change rapidographs where appropriate. If using a quill pen, the thickness can be changed gradually in the middle of a line stroke by increasing the pressure. Experiment with drawing lines before you actually ink an illustration. Find out how you can draw the smoothest possible lines. For some people, moving the pen away from their body is easier than moving the pen toward their body. Experiment for some time to see how you can draw the best lines. Don't be discouraged if the lines look wiggly at first — the rapidograph pens will pick up even the slightest trembling in your hands and this will result in unsteady looking lines.

We recommend using a variety of line widths for each illustration. If you do your drawing with a single line width the image will appear “flat” and with little three-dimensionality. Simply varying line width can make your illustration look much more professional. Here are some rules of thumb for choosing line widths: (1) Generally make the outline of the illustration thicker than any of the details on the surface of the illustration. (2) Generally use a thicker pen width along the bottom of the figure (remember, illustrations should always be drawn with the light coming from the upper left, so making the lower lines thicker is essentially a subtle form of shading). (3) Generally, use thinner pen widths when drawing weakly sclerotized or membranous structures, and thicker pen widths when drawing heavily sclerotized or melanized structures. Experiment with some of your illustrations and see what effect variable line widths can have.

Erasing on drafting film is possible, although a special ink eraser is needed. It is important to wait until the ink is completely dry before erasing -- otherwise smudging will result. Erasing should be done lightly since it is possible to wear through the film's drafting surface. To reduce the amount of rubbing necessary, let the solvents in the eraser soak into the ink. Use an eraser guard if needed. It is difficult to erase only a small portion of a drawing because the solvent in the eraser easily smudges ink surrounding the area of interest. Electric erasers make this less problematic, but do not eradicate the problem entirely. Again, we recommend using a small bit of white paint to correct minor errors.

If membranes are to be shown, stippling should be added using a single width rapidograph. Choosing the correct thickness of line and/or stippling is important. Because the illustration will eventually be reduced, the lines cannot be too thin or stippling too dense. If this occurs, the lines can disappear completely or become broken, and the stippling will become solid black -- two undesirable effects. Try making test strips on scrap paper and use a copier to reduce them to determine the correct line width and stipple density.

Labels should be added using printed lettering. A variety of rub-on letters are also available. Again, photo-blue pencil can be used to draw horizontal guide lines to help place the press-on letters. An easier means of producing labels is to print them out on a high resolution printer (laser printer) and simply paste them to the final plate. Printing labels directly onto sticky-back labelling paper (e.g., Avery label paper cat. no. 5353) can be a very efficient way to label illustrations. Remember to take the eventual reduction into account and use a corresponding font size (e.g., one that is twice the size of the intended final size). Most journals will specify the range of font sizes recommended in their “Instructions to Authors” section.

### Shading with Ink.

This is the most difficult aspect of producing a plate. Because there are no half-tones in a typical ink plate, illustrators must rely on other conventions to produce complex shading. Three methods are traditionally used: stippling, crosshatching and eye-lashing. Stippling is by far the most widespread, with cross hatching used occasionally. Eye-lashing, which can give incredible surface renditions, is hardly used at all by modern illustrators, and will not be covered here.

Stippling, as described above for sketches, can be used to shade an ink plate. By varying the density of the stipples, shadows and highlights can be created. Rather than blend the dots, the illustrator gradually adjusts the density to produce a gradient.

Stippling is typically used to depict membrane. Hence, using this method of shading for sclerites can make it difficult to indicate separate sclerotized and membranous regions in a single drawing. If both are desired, crosshatching can be used to depict the sclerites and stippling for membrane.

Crosshatching using lines, rather than dots, to create a gradient that will appear as shading. To begin crosshatching, decide where your grey tones will be and draw a series of parallel lines in this region (see step 1, below). Then, place a second set of parallel line, at an angle to the first (avoid 90 angles) but in a more restricted region (step 2, below). Additional lines are continually added in the shaded areas until a smooth gradient is achieved.

Most of the labels in an illustration shaded in these ways, if not all of the labels, should be placed outside of the illustration, with lines leading to their corresponding structures. Undercutting the label line will help to make it stand out from the illustration.

### **Foreshortening**

Foreshortening is a phenomenon involving the representation of 3 dimensional images in two dimensions. Drawings, or other 2-dimensional images, have height and width, but have difficulty displaying objects that come directly towards or away from the onlooker (e.g., legs of a specimen that extend away from view or a horn on the head that extends towards the viewer when viewed dorsally). To account for this, the illustrator should first draw portions of the specimen that are in clear focus. Then gradually adjust the focus of the microscope so as to view other parts (previously out of focus), and illustrate them. Ultimately, the entire specimen will be drawn. If structures are drawn while not in focus they will not appear in the correct place with respect to the rest of the drawing, and they will appear unnatural in the final sketch. To notice this effect, note that as you focus up and down on the organism, structures appear to move relative to the grid. Although it might seem counter-intuitive, in order for the final drawing to appear natural, you must only draw portions of an outline that are crisply in focus. This may require a great many small focus adjustments. Some anatomical parts may simply represent an aspect of the morphology that cannot be well-illustrated from a particular vantage point (i.e., even a photograph taken from this vantage point will fail to display the attribute well). If this occurs for an important feature, the illustrator may need to reposition the specimen or resort to more than a single image to adequately describe the morphology. For additional help on this, refer to a more detailed book on art or illustration.

For more information on illustration techniques we recommend the following reference:

Hodges, E.R.S. (1989). *The Guild Handbook of Scientific Illustration*. Van Nostrand Reinhold, New York.