Scientific Illustration

A Guide to Biological, Zoological, and Medical Rendering Techniques, Design, Printing, and Display

Phyllis Wood

VAN NOSTRAND REINHOLD COMPANY
New York Cincinnati Toronto London Melbourne

To all my students, past, present, and future. *Learning to draw is learning to see.*

Library of Congress Catalog Card Number 78-2834
ISBN 0-442-29532-4

Printed in United States of America
Designed by Loudan Enterprises

Published in 1979 by Van Nostrand Reinhold Company
A division of Litton Educational Publishing, Inc.
135 West 50th Street, New York, N.Y. 10020, U.S.A.

Van Nostrand Reinhold Limited
1410 Birchmount Road, Scarborough, Ontario M1P 2E7, Canada

Van Nostrand Reinhold Australia Pty. Limited
17 Queen Street, Mitcham, Victoria 3132, Australia

Van Nostrand Reinhold Company Limited
Molly Millars Lane, Wokingham, Berkshire, England

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Wood, Phyllis.
Scientific illustration.

Includes index.
1. Biological illustration. 2. Medical illustration. I. Title.
QH318.W66 604'.2'61 78-2834
ISBN 0-442-29532-4

Acknowledgments

I first started working on this book in an independent and solitary manner, depending entirely on my own resources for the information and illustrations. As the book developed, however, contributions, advice, and support from my colleagues and friends became more and more important, resulting in an immense enrichment of these pages.

My first acknowledgment is to my students, not only those whose illustrations I have included but all those whom I had the privilege of guiding through a part of their artistic development.

I also wish to thank Jessie Phillips Pearson, first Director of the Department of Health Sciences Illustration at the University of Washington, who was an inspiration to work with for many years. Kathleen Schmitt has been my steadfast editor, guiding me through the paths of participles. Lee Haines and Michael McIntosh are responsible for the original photography and color transparencies not otherwise credited.

Two organizations to which I am privileged to belong are the Association of Medical Illustrators and the Guild of Natural Science Illustrators. Their standards of excellence and generous sharing of information have been of great value in the development of this book.

The experts who graciously reviewed portions of the text contributed their many talents and cumulative knowledge. Grover Gilbert, architect, dealt with the areas on perspective. Joel Ito, Director of Medical Illustration at the Oregon Regional Primate Research Center, shared his expertise with the airbrush. Janet MacKenzie, scientific illustrator, reviewed coquille-board technique. Cheryl Vigna, designer, added her special brand of creativity to the chapter on design and layout. Bert Hagg, Director of Printing at the University of Washington, reviewed the technicalities of printing and production methods. Professor Thomas A. Stebbins, Director of Health Sciences Illustration, made many thoughtful contributions to the chapter on exhibits. Russell W. Newman, attorney, helped to clarify the critical areas of career guidance and contracts. The Regional Primate Research Center and its Assistant Director, Douglas M. Bowden, M.D., and the Health Sciences Learning Resources Center and its Director, Robert S. Hillman, M.D., gave me both direction and support.

Contents

Preface

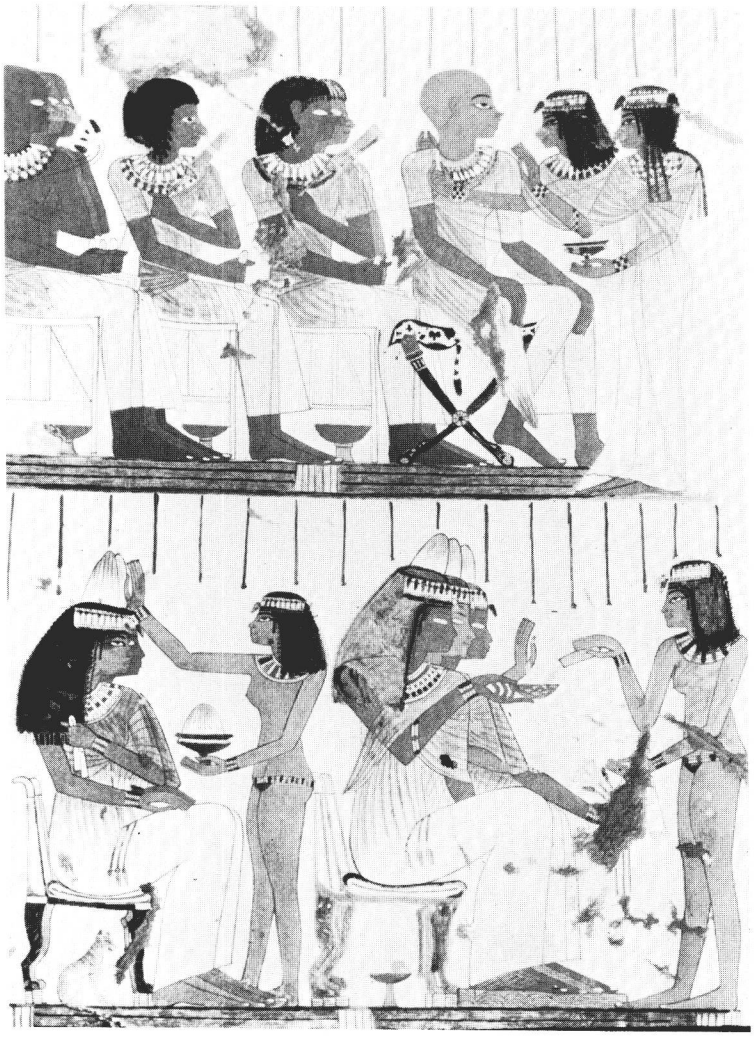
Scientific illustration is produced for a specific kind of visual communication in the sciences. This communication can pass from scientist to colleague, teacher to student, or research foundation to layman. The artist must therefore be aware of the viewer's level of knowledge and must relate the message in a logical sequence without confusing him with too much or too little information. The art must be rendered with scientific accuracy and artistic integrity within the production framework of its ultimate use: print, projection, or display.

This book is directed to the artist/scientist who wishes to produce bioart for print (books and publications), projection (slides, television, motion pictures), or display. The emphasis is not on the original piece of art but on the final form in which it will be used. In order to control the production process, the artist must understand the mechanics of transferring the original art to paper or transparency form. He must be able to communicate clearly with the typographer, the platemaker, the printer, and the photographer, using the correct technical terminology. He must understand the capabilities and limitations of these technical processes and be able to prepare his artwork to take advantage of them. He must know why most artwork is reduced rather than enlarged, how much information can be put on a slide or a printed page, and how to handle overlays and screens.

Although scientific illustration is serious and factual, it need not be handled in a dry or monotonous style. It can and should be designed as thoughtfully and innovatively as any piece of art, using current styles and methods and combining traditional with advertising and computer techniques. At present there is a tremendous proliferation of scientific information, both written and spoken, that is competing for an audience. This means that the illustrator has the important responsibility of creating a greater number of accompanying visuals that will attract viewers, communicate clearly and quickly, and be easy to remember. This book is designed to enable him to meet these needs.

CHAPTER 1.

Perspective



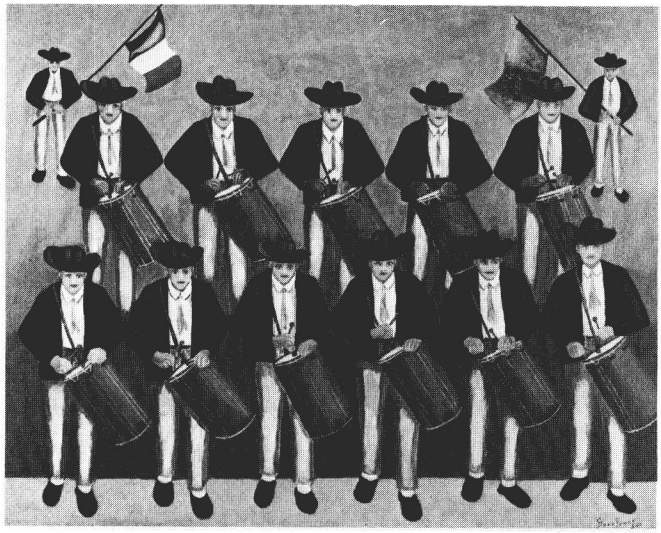
1-1. Theban tomb painting. *Guests at a Feast.* C. 1411–1375 B.C.

Perspective drawing is learned, not instinctive. Unless trained in the rules of perspective, an artist will draw what he knows, not what he sees. Ancient Egyptian drawings are beautiful examples of this tendency (1-1). The body is drawn in the most honestly recognizable position: the eye viewed from a frontal plane, the nose in side view, the upper torso from the front, the lower torso from the side, the hands from the back, and the feet in profile. There are few overlapping figures or objects, and one object does not recede behind another. The size of a person or thing does not relate to its proximity to the viewer but to its importance. Kings were drawn very large; slaves and women were drawn small.

Many of these same characteristics appear in primitive paintings of the 19th and 20th centuries (1-2) and in children's drawings (1-3). Modern art may deliberately defy the rules of perspective in search of another truth (1-4). Plato wrote that perspective was "a kind of trick which took advantage of the weakness of our senses, for in reality the width and length of a bed or table do not contract, but remain constant, as mathematical measurements show. . . . Painting, therefore, is busy about a work which is far removed from the truth."

DEFINITION

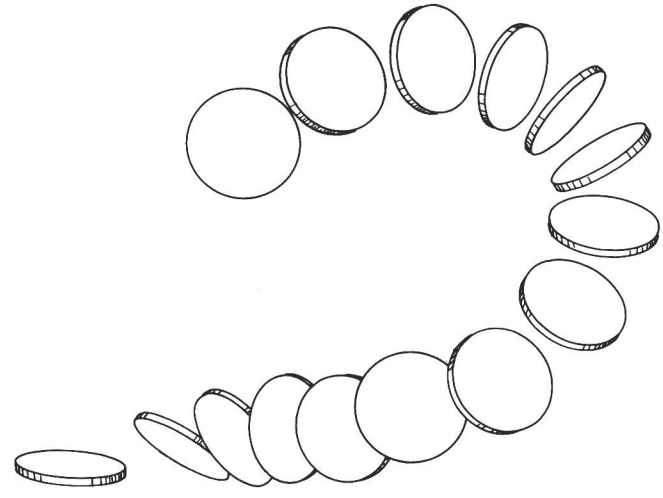
Perspective may be defined as the appearance of reality and is determined by the position from which it is observed. Every change in the observer's viewpoint changes all the perspective relations. The eye can see the object in its true shape only when it is parallel to the face or picture plane. In any other position the object is foreshortened (1-5). The elements of linear and atmospheric perspective that govern the drawing of all objects are: relative size, relation of angles, overlapping, and distinctness. These elements are examined in the exercise presented later in the chapter.



1-2. Flora Fryer. *Drummer Boys.* Acrylic, 32" X 22", 1968.

1-3.

1-4. Jacob Lawrence. *The Swearing In.* Serigraph, 1977. Executed at the request of President Jimmy Carter.



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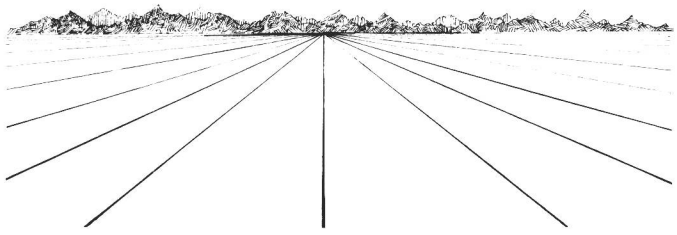
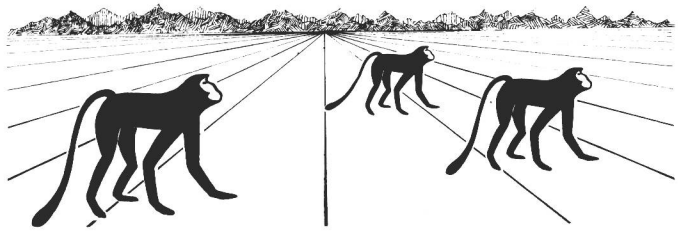


1-6. Reed Eastman.



1-7. Phyllis Wood.

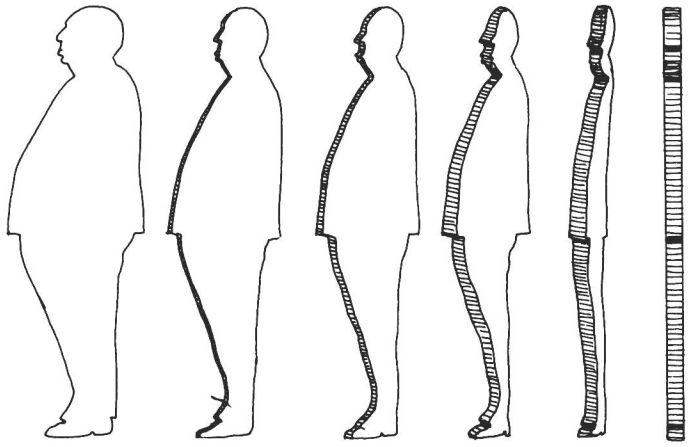
RULES

The rules governing perspective that concern the scientific illustrator are simple.

1. Receding parallel lines seem to converge away from the eye to a common vanishing point (1-6).
2. Objects appear smaller in relative proportion to their distance from the eye (1-7).
3. Surfaces that are parallel to the picture plane appear in their true shape (1-8).
4. Surfaces are foreshortened in relative proportion to their angle away from the picture plane (1-8).
5. A circle that is parallel to the picture plane appears as a circle (1-9).
6. A circle observed at an angle to the picture plane is foreshortened and appears as an ellipse; in the most extreme foreshortening the circle appears as a line (1-9).
7. An object appears less distinct in proportion to its distance from the eye (1-10).

THE PICTURE PLANE

The picture plane is an imaginary plane between the viewer and the object. Imagine a pane of glass hovering over the object at an angle parallel to the face and at right angles to the line of sight. It is on this plane that the object is measured (1-11). If the object were traced onto the surface of the glass, it would be drawn in correct linear perspective.



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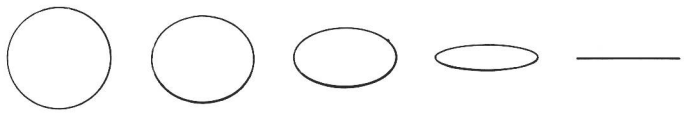

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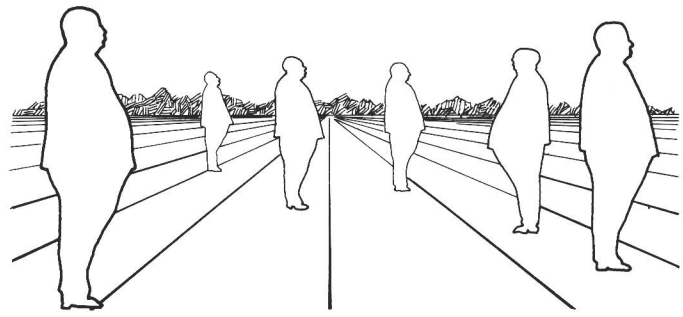

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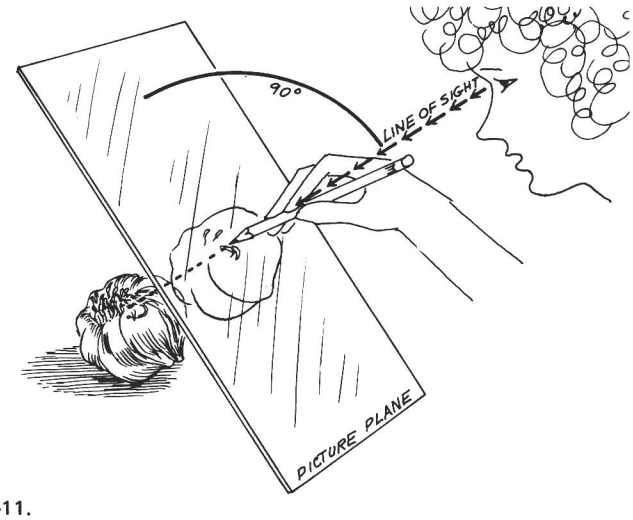


1-11.

EXERCISES

We are going to explore perspective by using the basic shapes of the cube and the cylinder. These shapes illustrate the elements of perspective that are relevant to the scientific illustrator and can be related to biologic shapes. With complicated shapes you can fool yourself into believing that your drawing is accurate, but any error in a simple geometric shape is immediately apparent. If we first learn to observe and to draw solid geometric shapes that are stable, precise, and predictable, we can transfer that ability to biologic shapes that are variations and combinations of geometric shapes.

In drawing small subjects such as these the perspective variations in foreshortening and angle change are very slight. Careful and accurate interpretation of these subtleties of measurement is the purpose of this precise way of drawing. Such subtleties, drawn without exaggeration, produce the realistic look that is the goal of the scientific illustrator.

The cube

The 2″ cube is a good subject with which to start studying perspective. If you draw it accurately, your illustration can be turned sideways or upside down and still appear as a realistic equal-sided cube.

One-point perspective

Obtain a cube that measures about 2″ on each side. Draw it with one side parallel to the picture plane. Since this front side is parallel to the picture plane, it will be seen in its true shape, as a square. None of the other sides is visible (1-12).

Pretend that the cube is transparent and draw the other sides. The back side is smaller because it is further away. The other four sides are foreshortened and are bordered with parallel edges. These four parallel edges converge toward a common vanishing point. This is called one-point perspective (1-13).

Two-point perspective

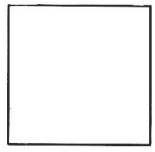
Now turn the cube so that you can see some of the top. The front side is no longer exactly parallel with the picture plane. It is slightly foreshortened, and its vertical edges eventually converge. Parallel lines converge away from the eye: the vertical edges parallel to each other in this drawing therefore converge downward to a vanishing point. The lateral edges on the top of the cube are also parallel to each other and converge upward away from the eye toward a second vanishing point (1-14).

If the cube were transparent, you could see that all parallel edges converge toward these two respective vanishing points. The plane that is furthest from the eye (at top or bottom) is proportionately wider. This is because it is at a smaller angle to the picture plane (1-15).

As you move the cube, viewing more and more of the top, the angles and surfaces change in relation to their distance from and angle to the picture plane. The only constant is the closest or leading edge, because it is the only part of the cube that is on the picture plane.

Three-point perspective

Turn the cube so that only one corner is on the picture plane. Every surface is foreshortened, and three groups of parallel lines converge towards three vanishing points (1-16).



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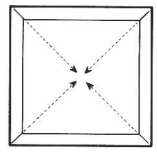

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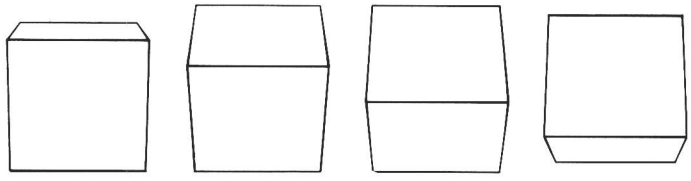

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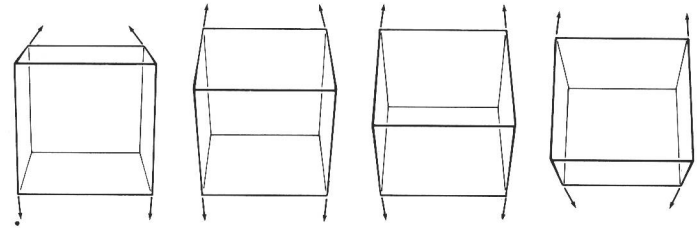

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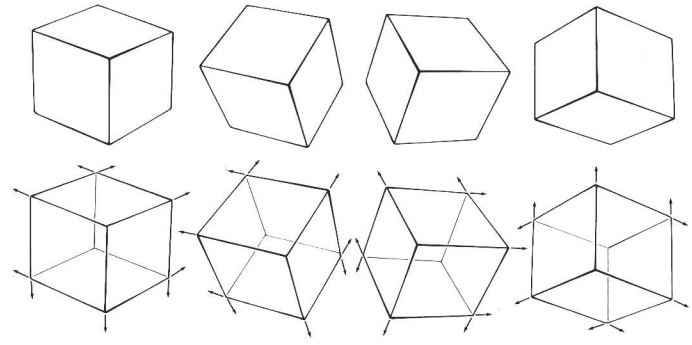

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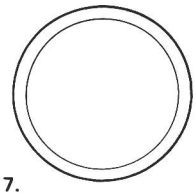

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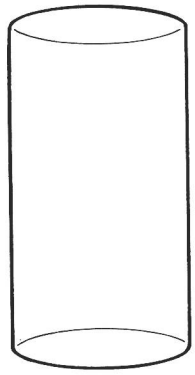

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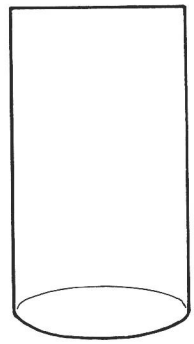

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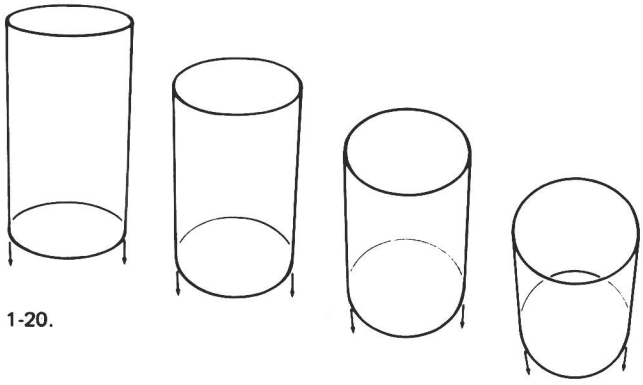

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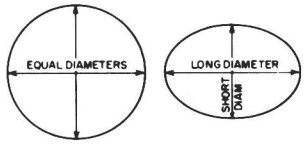

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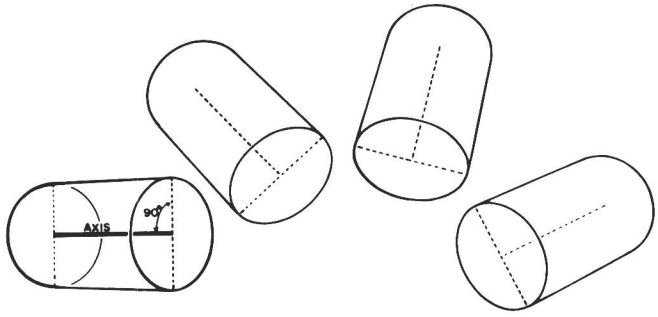


1-22.

The cylinder

The cylinder, which includes the elusive ellipse, is often translated into biological shapes. You should achieve an intimate familiarity with this shape so that you do not need to think consciously about the rules that govern the perspective views as you draw it.

Top view

Obtain a cylinder that is easily held in the hand. View it from the top. It appears as a circle, the only part on the picture plane. Imagine that it is transparent. The further rim is a smaller circle because it is further from the eye. Neither one is foreshortened because both are parallel to the picture plane (1-17).

Side view

Observe the cylinder from the side with your line of sight centering on the middle of the long axis. You cannot see either the top or the bottom of the cylinder. Both top and bottom edges are curved, representing the front parts of ellipses. Draw the cylinder as if it were transparent (1-18). The ellipses are very shallow. Lower the cylinder until the top edge centers on the line of sight. It appears as a straight line, while the lower edge is rounder because it is further from the eye and therefore at a smaller angle to the picture plane (1-19), illustrating the rule concerning parallel ellipses that the one further from the eye appears rounder. Drop the cylinder gradually and study the increasing roundness of the ellipses. Raise the cylinder: you will notice the same result. The vertical sides of the cylinder recede from the eye and therefore seem to converge away from the eye.

Oblique view

Place the cylinder at an oblique angle and observe the same changes (1-20). The cylinder does not change shape if it is observed at an oblique angle. The same drawing, if done accurately, can be turned in any direction and still be correct.

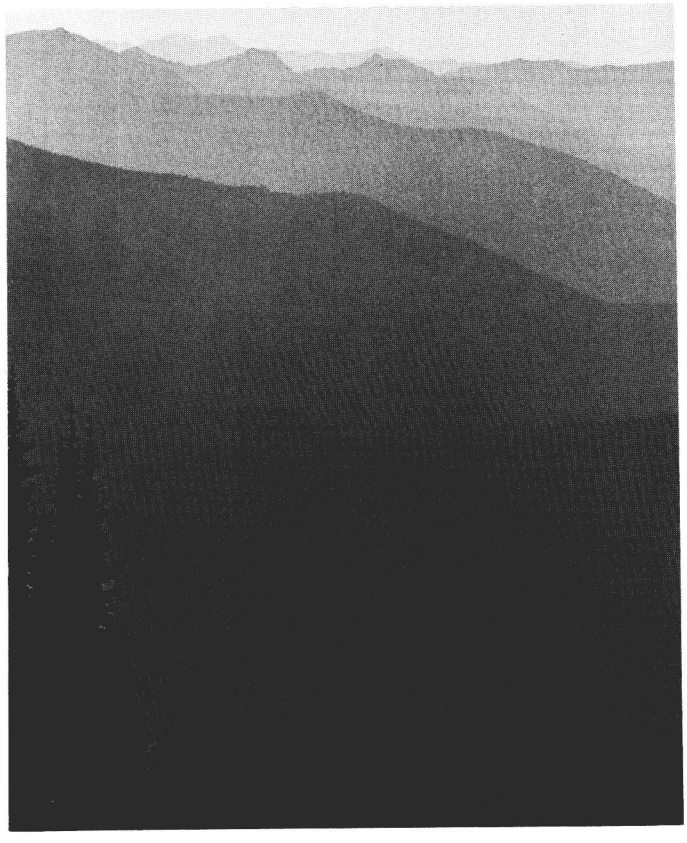
The ellipse

Always remember that an ellipse is a foreshortened circle. Circles do not have corners: the peripheral ends of the ellipse must therefore be rounded because it is evolved from the circle shape.

The circle can be divided into four equal parts with two equal diameters. The ellipse can also be divided into four equal parts but with a shorter and a longer diameter (1-21). A good way to check the accuracy of an ellipse is to draw the short and long diameters and to see whether each quarter is identical in size and curvature.

An ellipse that is part of a cylinder has a stable relationship with the cylinder. The axis of the cylinder is represented by a measurement of its exact center. This axis is always at a right angle to the long diameter of the ellipse (1-22).

In drawing only part of an ellipse it is helpful to check your accuracy by completing the figure and by drawing the axis of the cylinder and the long and short diameters of the ellipse.

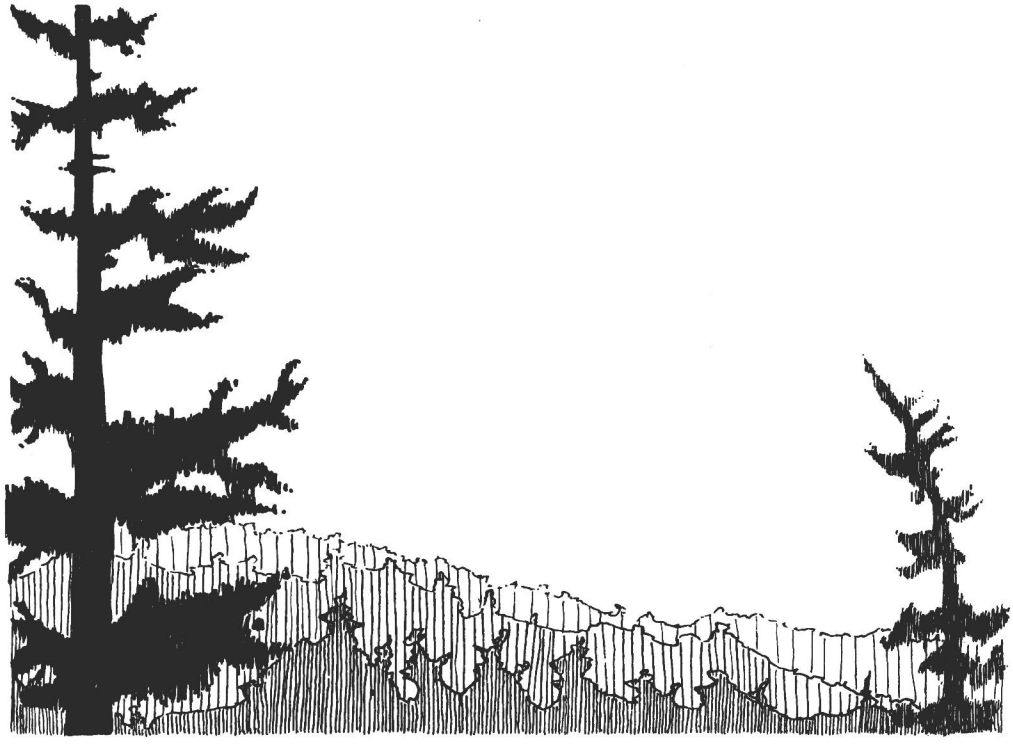


1-23. Johsel Namkung.

ATMOSPHERIC PERSPECTIVE

Atmospheric perspective is most easily illustrated by observing a distant view out of doors. The atmosphere contains a suspension of moisture and dust, which softens the definition and tonal values of an object in relative proportion to its distance from you. The leaves on a tree close to you are crisp and deeply colored compared with the less defined and softer-valued leaves in the distance; distant mountains lose their detail and are soft and grayed (1-23).

This phenomenon is not readily apparent when you view a single object that is resting on your drawing board, but it is a valuable principle in interpreting the distance between the eye and a specimen. Those parts of the drawing closest to your eye have the deepest shadows and the brightest highlights. They are the crispest and are defined by the heaviest outlines. More distant structures are less defined, and the tonal values are closer (1-24).

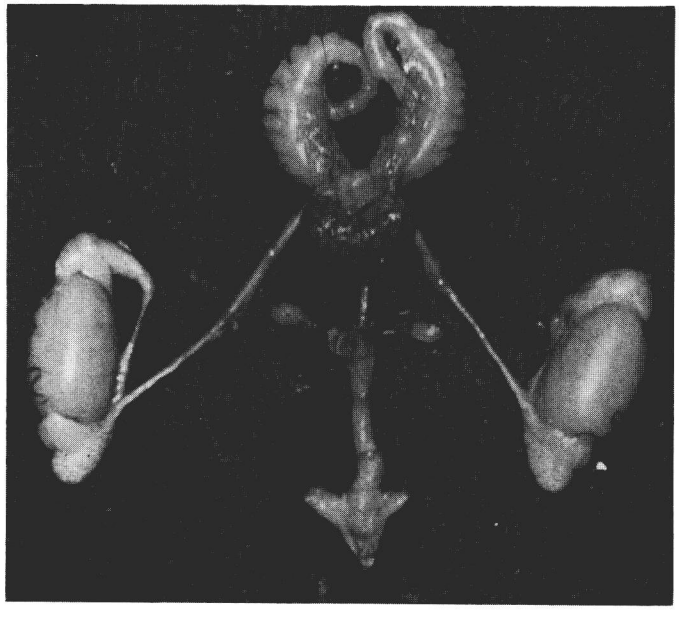


1-24. Reed Eastman.

CHAPTER 2.

Drawing

Inherent in the word "scientific" is the word "accurate": scientific illustration is by definition accurate drawing. The goal of the scientific illustrator is to show the observer the same image that he had when he looked at the specimen. This is not merely to say that the observer should get an impression of the subject: he would get that if he were looking at a photograph, sketch, or abstract interpretation of the subject. The observer must be informed so completely and precisely that, when he looks at the drawing, he is as aware of and enlightened about the subject as if he had seen it himself. While this kind of drawing requires disciplined precision, it must also be artistically pleasing. Meticulous accuracy and aesthetics should be combined.



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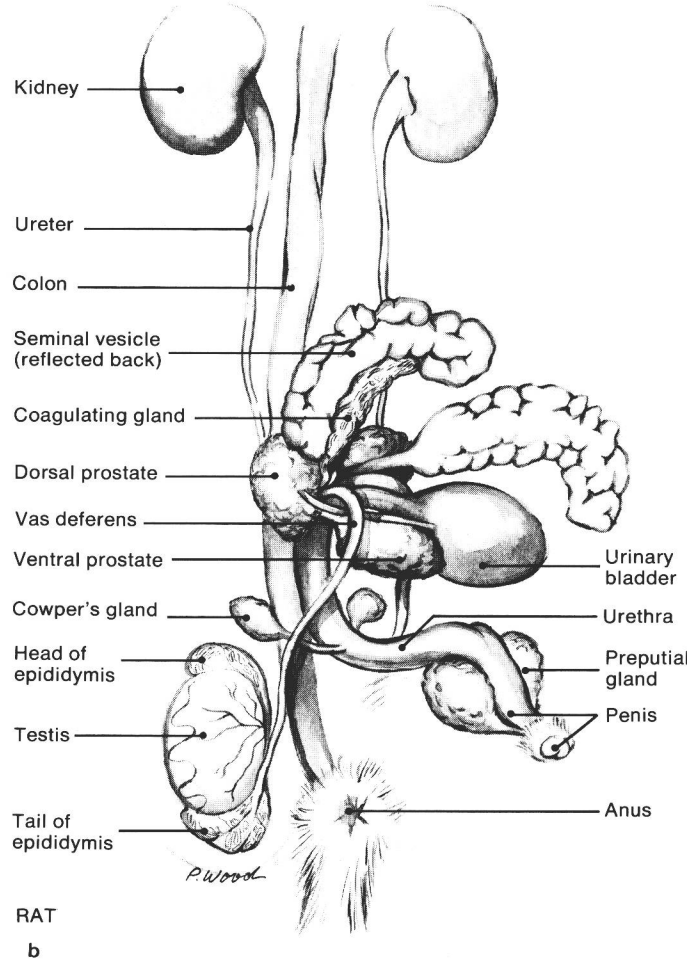
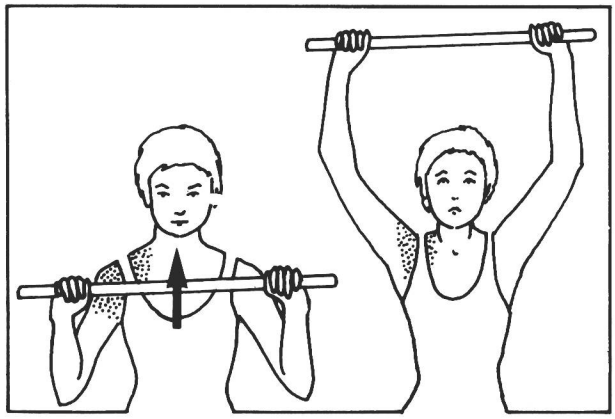


b

2-1. a. Miriam Barnes, dissection. Rat urogenital. b. From Glover Barnes. "Antigenic nature of male accessory glands." *Biology of Reproduction*. 1972, vol. 6, p. 385. Wash on cold-press illustration board.

DIFFERENCES BETWEEN ILLUSTRATION AND PHOTOGRAPHY

Modern scientific photography can document and record a subject accurately and beautifully, but it is the job of the illustrator to interpret it. The artist omits extraneous detail, he clarifies, and he selects. He can dramatize or emphasize the important parts, taking care not to exaggerate or distort for the sake of emphasis or design. The artist can simplify or summarize the essence of a subject and can ghost in what is inside or underneath it. He can reconstruct shards and pieces into a unified whole. He can idealize, ignoring specimen differences. He can recreate the vitality of a living specimen from a dead one. While the camera establishes the existence of a subject, the illustrator illuminates its essence (2-1).



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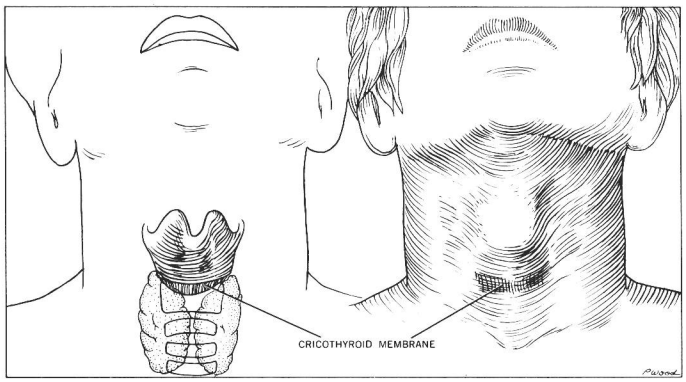


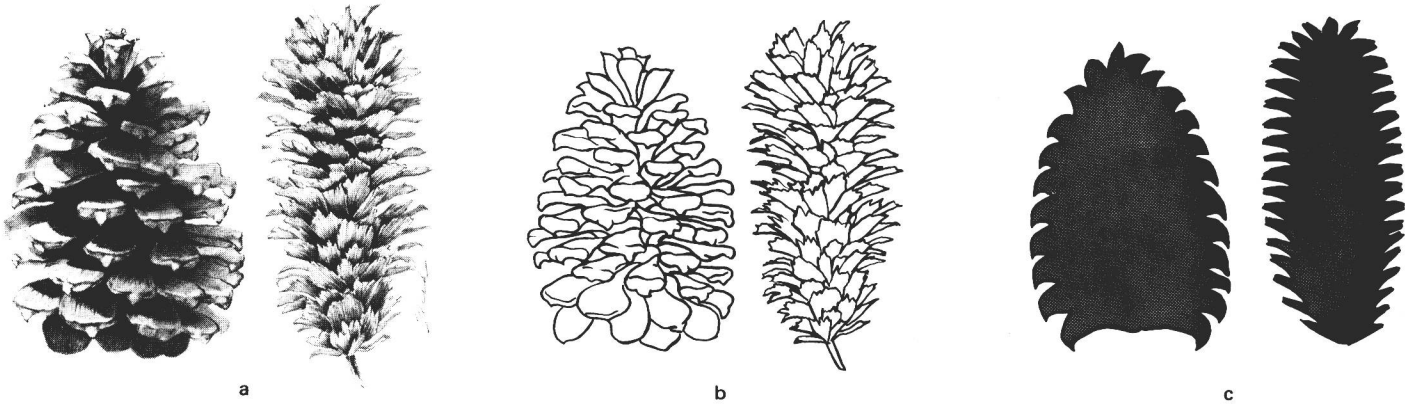
2-3. From Cynthia J. Leitch and Richard V. Tinker, eds. *Primary Care.* F. A. Davis Co., 1978. Ink on paper.

COMMUNICATING WITH THE VIEWER

In communicating with the viewer the artist assumes that they share certain basic perceptions. He must assume that the observer knows that an outline often separates positive and negative space (2-2). Of course, there is no such thing as a line around a specimen. Turn a sphere around and try to fix your eye on the "outline." The outline is one of the many conventions with which we are familiar without even being aware of them. Shading with lines or dots and the principles of perspective are others. A person who is not used to recognizing these codes or devices, however, would not be able to relate them to the subject. To such a person a drawing might be just a pile of squiggles, while to someone else it would represent a meaningful three-dimensional subject.

Another aspect of the understanding between the artist and the observer is that it is not necessary to draw everything. If only the head and shoulders of a person are drawn, we do not assume that they have been amputated from the rest of the body. The observer mentally adds a generalized body to the head and neck. In the same way the observer, if given enough clues, completes any drawing in his mind (2-3).

The scientific illustrator draws only enough to give a true and complete picture of the subject. What is included in a true and complete picture varies greatly, depending on the audience. A less informed audience generally requires more information in an illustration than does a more informed one. Plates reproduced in color or modeled in continuous tone that include many familiar landmarks are commonly used to teach beginning students. The same subject can be illustrated by a simple outline drawing, a portion of a section, or even a diagram when dealing with a well-informed and sophisticated audience (2-4). The artist simplifies and summarizes a subject according to the capacity of the audience to understand it.



2-4. a. Reed Eastman. Graphite pencil on paper. b. Phyllis Wood. Pen-and-ink. c. Phyllis Wood. Ink line with shading film.

THE STUDIO

Any serious artist should set aside a special room or part of a room in which he can control his materials and surroundings to the best advantage. It is difficult enough to draw without having to fight the environment.

Your chair should be positioned at a comfortable height and should have a back. Your drawing board should tilt slightly and be set at a height that feels right to you. It should have a smooth, hard surface and be clean and uncluttered. Of course, we all delight in a window that provides filtered north light. This is not always possible. Take advantage of all the natural light you can get plus some good general room light and a single well-directed desk lamp. The primary direction of the light should be from the left (or from the right for left-handed people) so that the shadow of the hand does not fall on the drawing area. A flat cabinet or table within easy reach can hold the necessary tools (2-5).

For basic drawing you will need some medium-hard pencils. If the pencil is too hard, the line will be gray; if it is too soft, the line will not be precise. An HB or #3 is preferable. Paper should be smooth for crispness of line. It should be rather thin so that a drawing can be revised in stages on several overlays and still retain the good parts of the first stages. Use a Pink Pearl or art-gum eraser.

Wash your hands thoroughly with soap and water, put some soft music on the radio, refrain from drinking coffee or other nerve poisons, and start to work.

2-5.

THE SUBJECT

Pick the subject up in your hands; turn it around, *look* at it, and *feel* its shape, its texture, the rhythms of its patterns; notice the variations in shape and size among its primary and secondary parts. All biological material is made up of interrelated parts (2-6), and growth patterns give you many hints about their relationships. Become familiar with all sides of the subject. Although you draw only the near side, you must know what is on the other side, inside, and underneath in order to interpret the subject accurately. This is one of the reasons why drawings done exclusively from photographs are not successful. Photographs can be a valuable aid in drawing, but, when used as the only reference by an artist not familiar with the subject, the results will not stand up. The artist's ignorance will be obvious.

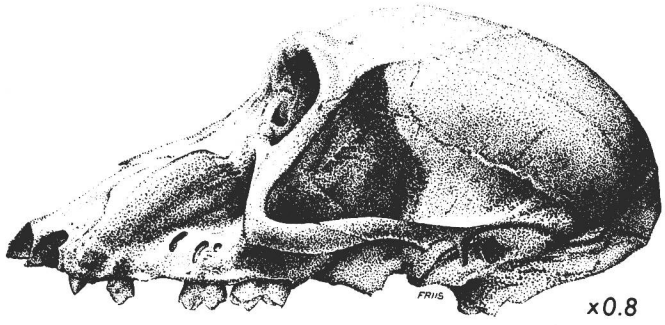
Analysis

Squint at your subject. This may seem to be a strange thing to do, because you see it less clearly. You can, however, see the abstracted essence of the specimen—it is broken into simple areas of dark and light through the veil of the eyelashes. Basic patterns emerge. The main form appears more clearly, with the details screened out (2-7). Squint at your subject often during all stages of the drawing. This counteracts the natural tendency to become enraptured with detail at the cost of the integration of the subject as a whole.

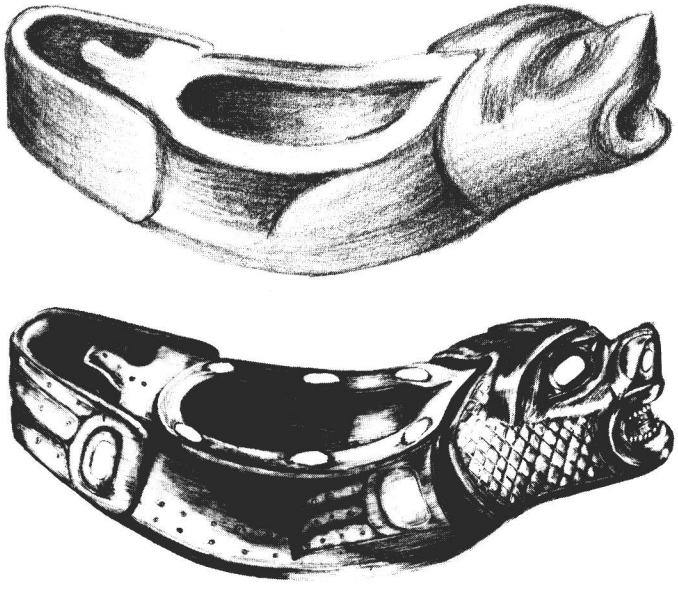
Rhythm and pattern

In order to interpret what you are looking at, try to identify the patterns of growth: the spirals and successions of curves, the methods of branching, the unequivocal design of the mosaics, the rhythms and repetitions, the symmetries and asymmetries. There is always some kind of inherent order in shapes, textures, and colors. Nothing in nature is random, although it may seem so at first glance. Conversely, none of the rhythms or patterns is mathematically precise: no line is perfectly straight, no progression is logarithmically perfect, no curve is geometrically exact. To alter them so that they are perfect would destroy the authenticity of your drawing, making it look artificial and mechanical (2-8).

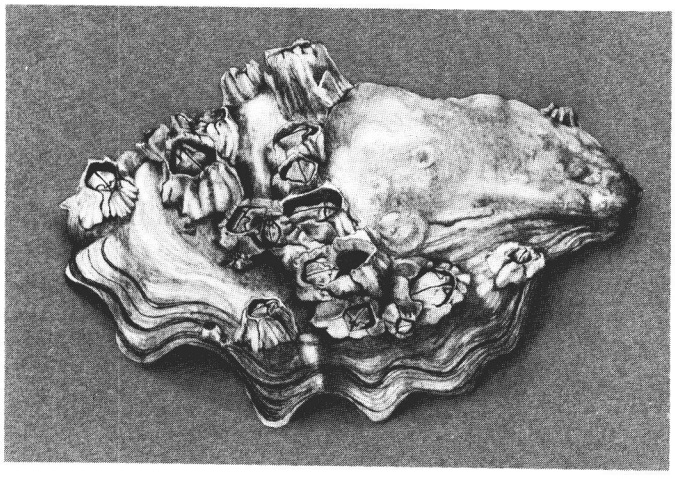
The pine cone has two oblique spirals, a vertical guide, and another group of circumference guides (2-9). The seemingly random venation of these leaves is apparently the most economical method of feeding its cells (2-10). Symmetric branching contrasts with asymmetric branching. The giant tortoise is a combination of various mosaics arranged in a consistently predictable pattern. Every tortoise has a similar pattern, but each individual tortoise and each individual mosaic are different (2-11). The murex shell has many intricate interrelationships, repetitions, and variations (2-12). Mirror-image symmetry combines with asymmetry of surface pattern in the metallic wood-boring beetle (2-13). All these patterns must be viewed in terms of structure and function. Even apparently decorative parts have some underlying explanation (2-14).



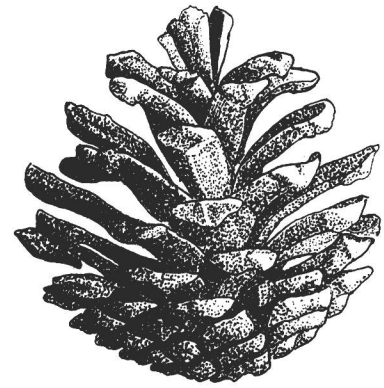
2-6. Anton Friis. Skull. Ink on plate-finish paper.



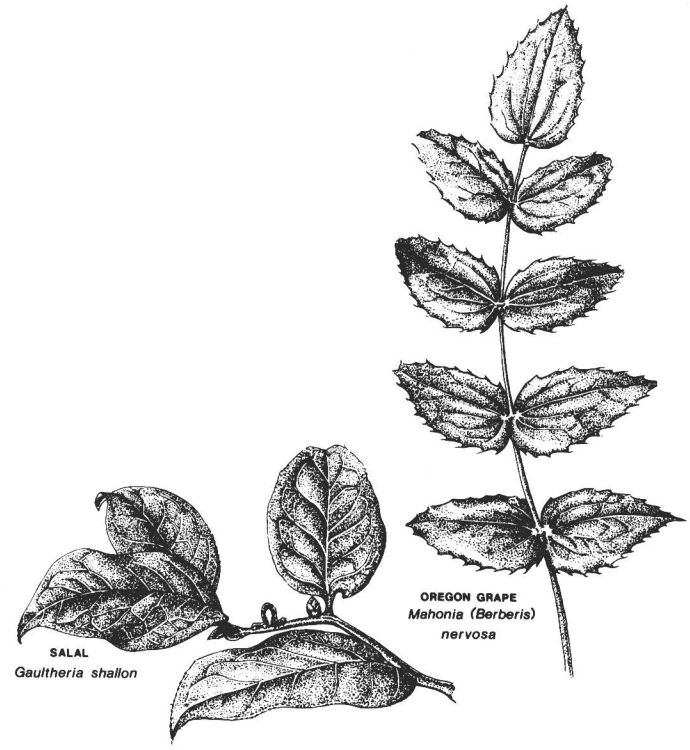
2-7. Jayne Lilienfeld. Indian grease bowls. Carbon dust on film.



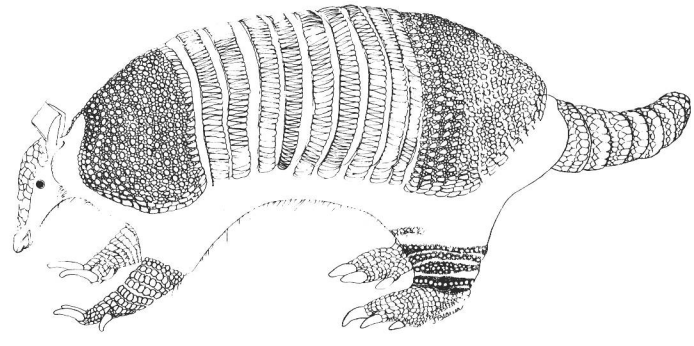
2-8. Nancy Williams. Oyster shell with barnacle. Pencil, watercolor, and ink on frosted film.



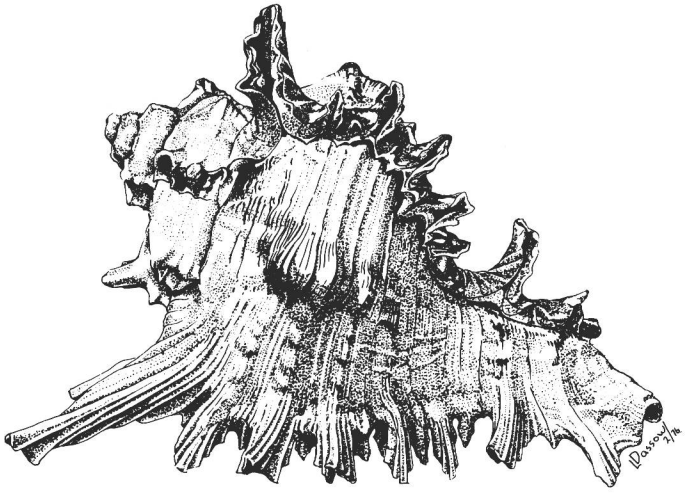
2-9. Phyllis Wood. Ink on paper.



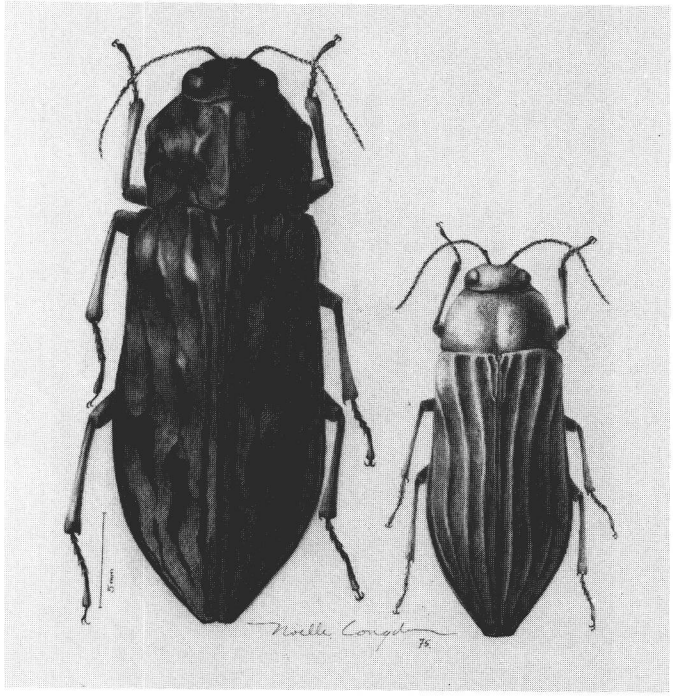
2-10. Laura Dassow. Ink on paper.



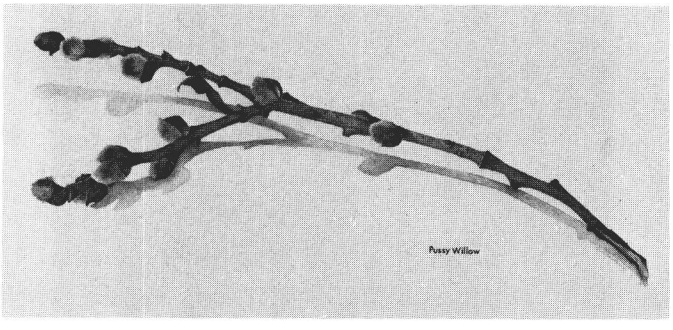
2-11. Janis Blauer. Ink on paper.



2-12. Laura Dassow. *Murex*. Ink on paper.



2-13. Nöelle Congdon. Metallic wood-boring beetles. Graphite pencil on film.



2-14. Nancy Williams. Wash on cold-press illustration board.

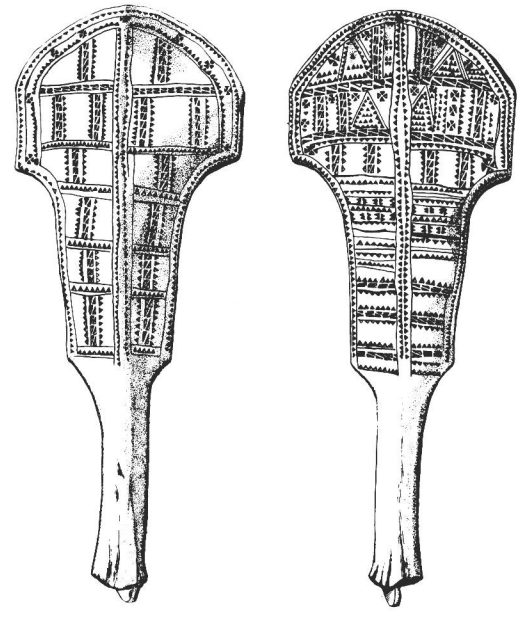
The trained eye

Both scientist and artist gain by training their observation skills with an eye to accuracy, rhythm, and pattern. The artist will understand the subject more thoroughly, and the scientist will be able to study and interpret his subject with a more discriminating eye.

The professional scientific illustrator must of course be familiar with his subject in more than a visual way. He must be aware of the structure and function of its various parts and recognize the anomalies (individual variations) in his specimen and the differences between related species. In other words, he must see not just an individual specimen but one specimen in relation to many species in the broader context of his entire field. This knowledge is necessary in order to produce the most effective selective drawings. For this reason most scientific illustrators specialize in one field.

Representative and individual specimens

To decide whether to render a specimen with all its individual idiosyncracies and peculiarities or to draw a representative specimen with the typical common characteristics of its species, you should consider the purpose of the drawing. If the drawing is to illustrate a unique prototype, the specimen must be drawn with every eccentricity in place. Usually, however, you are drawing a typical specimen and thus have the option of adding or straightening hairs, removing worm holes, repairing cracks and broken pieces, and moving or removing leaves and branches. You may use many specimens to produce one drawing based on their corporate characteristics, but take care not to misinterpret them while combining, simplifying, or synthesizing their elements. Never attempt to draw such a perfect and neat specimen that it loses its naturalness. None of nature is "perfect," and to draw it perfectly denies its inherent nature (2-15).



2-15. Colleen Hill. Indian war paddle. Ink on paper.