# Modeling in the Laboratory

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The science teacher usually experiences many difficulties when trying to impart adequate lucid truth to elementary science students. Time is always limited, students are frequently unresponsive and inattentive, equipment is meager, confreres unappreciative, and the teacher's own store of dynamic enthusiasm and earnest zeal an exquisitely delicate asset that can easily be overdrawn.

In a recent paper[1] several different techniques which can be used in the laboratory to facilitate teaching, and which aid in imparting information were discussed. The use of biological models as teaching assets was especially stressed because models enable students to visualize objects as they exist in nature, that is, in terms of length and breadth and depth. A student sees the three dimensions of flowers or cells or protozoa and forms relatively correct concepts.

An elaboration on various kinds of modeling materials, laboratory technique, and finishing steps may enable students in secondary schools and colleges to make inexpensive, yet very correct and satisfactory models of various objects. Such models can be turned out by the neophyte, with very little help from the instructor, and at a negligible cost to the department.

## Materials

Different grades of clay and dry asbestos were used in making the models pictured in the accompanying illustration. The more expensive clay ($0.25 a lb.)[2] is excellent to use for making the delicate parts of models, such as chromosomes (mitotic sets) or the thin-walled cup of a vorticella. The better clays have higher adhesive properties and are more easily manipulated.

A cheap clay that is very satisfactory ($0.05 a lb.)[3], and clay found locally along river fronts or in deep excavations, can be used for many of the models. If the heavy part of the body is made from local clay and a thin layer of commercial clay added, the finishing can be done more easily. Local clays tend to shrink and crack more readily than the commercial clays, but the cracks can be filled with clay or putty and will not show when the models are completed.

Another superior modeling medium, which can be obtained from local plumbers at a nominal cost ($0.02 or so a pound) is dry asbestos. This material is homogeneous and clean to work up, and when dry, is lighter than a similar amount of clay.

Dry asbestos is prepared for modeling by stirring small amounts of it into a quart of water in which a cup of flake glue has previously been dissolved. Asbestos is added until the mass has a consistency of stiff dough. Flake glue (obtained at the hardware store) makes the particles of asbestos adhere together firmly and the models dry with relatively hard surfaces. A thin coating of the dissolved glue, added after the models are thoroughly dry, acts as a sizing or filler.

[1] Payne, M. A. 1938. "The Third Dimension in the Teaching of Biology," *Transactions Kansas Academy of Science,* Vol. 41, 1938, p. 295.

[2] American Art Clay Co., Indianapolis, Indiana, Mexican Pottery Clay.

[3] Red Wing Clay Co., Red Wing, Minnesota.

Thin flat surfaces such as petals or sepals for a diagrammatic flower model can be cut from screen wire, shaped properly, and painted with a thin coat of asbestos. Several coats can be applied, allowing sufficient time between paintings for the previous coat to dry.

Accessory materials, such as wire, cardboard, beads, excelsior, celluloid, and many other items that are potential parts of perfect models, can be salvaged from the school or home basement. Naive ingenuity and unusual resourcefulness on the part of the students are repeatedly brought to light during the interim of modeling periods. The supporting wires for the tentacles of the hydra in the illustration, for example, are wire handles from discarded syrup buckets.

Flat house paint, preferably gray or some light shade, is applied to the models when they are dry. The models are covered completely, and later on a second coat of enamel is added. One can of white enamel and several small tubes of oil paint enable the student to prepare sufficient quantities of colored enamels as they are needed. A basic coat, similar to the color of the living organism or to standard differential stains, is made by adding green, red, or violet, etc., to about half of the can of white enamel. Most of the surface of the model is enameled with this color, and then details of structure painted in harmonious and contrasting shades. One coat of enamel is usually sufficient to give an excellent finish.

The cells illustrating plant mitosis, for example, are painted a light green; the cell walls, plastids, and cytoplasmic inclusions, various shades of darker green; the spindles are a yellow-green, the spindle fibers, gray, the chromosomes, blue, and the karyosome, orange.

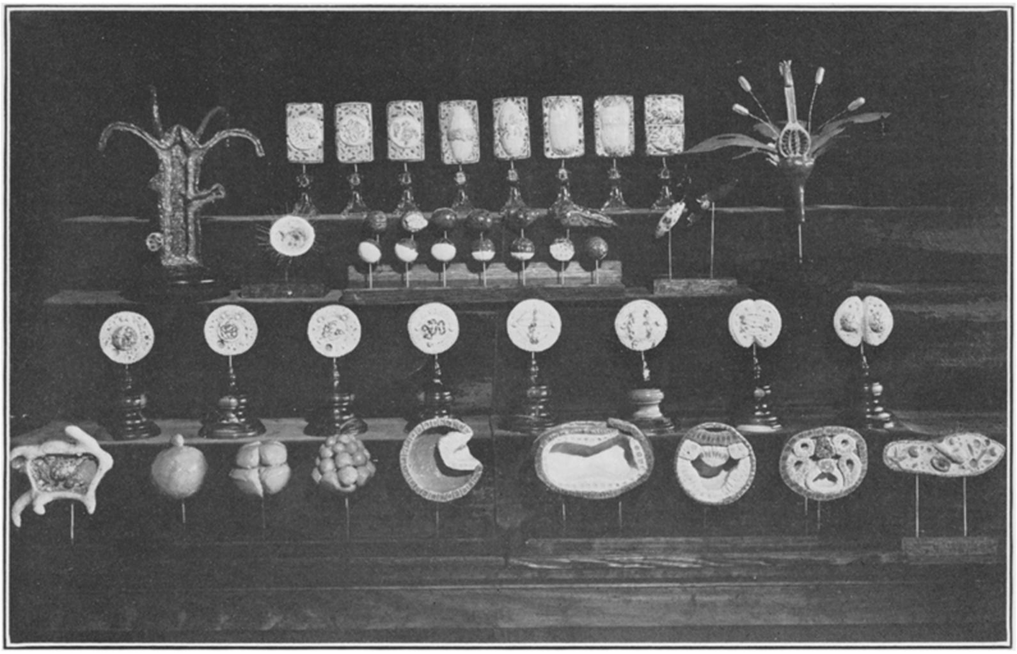
Before the models are dry, pieces of $\frac{1}{8}$ or $\frac{1}{10}$ inch wire, about twelve inches in length, are inserted deeply into the body of the object in such a way that it can later be mounted on a base or stand.

## Procedure

The procedure varies according to the shape and size of the model to be made. In modeling a hydra, a cardboard mailing tube about 7 inches in circumference is cut in half (lengthwise). One end is slit down an inch or so and the edges overlapped and wired in place. A semicircular mouth is cut into the overlapped edges. Then 4 or 5 strong wires are attached to the cardboard at the proper level and bent at suggestive angles. These wires form a support for the tentacles. Moulding clay or asbestos is added to this basic structure, a layer inside for the endothelium, and a layer outside for the epithelium. Ovary protuberances and testicular masses are modeled in. Cell walls are indented on the cut surfaces and nuclei enameled in later. A few long horse hairs can be inserted for exploded nematocysts. Further characteristic details of hydra are brought out with brush and enamel, the cardboard edge between the outer and inner layer making excellent mesoglea.

Paramecium and other protozoa are modeled freely. Clay is rolled on a glass plate which has been moistened with glycerine. The roll is cut in half and the flat surface placed down in the glycerine. A half-body is shaped and longitudinal rows of hexagonal areas impressed on the soft surface with a small hexagonal stick (one can be made from a soft pencil). Into the center of each hexagonal area a stiff horse hair cut about one and a half inches long is forced in at an angle of

LABORATORY MODELS



| | | | |
|---|---|---|---|
| 1st Row | Hydra | —Plant Mitosis— | Diagrammatic Flower |
| 2nd Row | Vorticella | —Frog Embryology— | Euglena and Trypanosome |
| 3rd Row | | —Animal Mitosis— | |
| 4th Row | Ameba | —Early Embryology of Amphioxus— | Paramecium |

about 30 degrees. These cilia[4] should point toward the posterior end of the model which has been made slipper-shaped and smoothed with glycerine previous to the marking. After the model dries 48 or more hours it can be turned over and the face worked in. A hollow gullet ending in a food vacuole, made from a thin layer of clay, can be partially raised above the surface. Nuclei, contractile vacuoles, food balls, and anal apertures are readily modeled.

A realistic finish is obtained by enameling the ''animal'' in a basic coat of light tan, while pellicle, anus, and some of the cytoplasmic inclusions are painted in deeper shades of tan and brown. The food vacuoles may be painted pink and the contractile vacuoles gray.

Dishes serve as suitable forms for modeling rounded cells or rectangular bodies. The cells demonstrating animal mitosis (illustration) were modeled in a small round oatmeal dish and the plant cells in a rectangular glass butter dish.

Dishes are lubricated with a generous amount of glycerine. Then a layer of clay is put in after the manner of lining a pie tin with dough. The clay is packed tight with excelsior or ''Spanish moss'' and a layer of clay placed over the filler even with the rim of the dish. The edges are worked together and the whole cell

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[4] Newman, H. H. 1926. *Outlines of General Zoology*, Macmillan, p. 123.

week and fresh pond or aquarium water added.

Tubifex or small earthworms chopped fine should be fed daily. Small minnows or insects can be used as food also.

### Earthworm (*Annelida*)

Earthworms may be found in moist humus.

These may be kept for long periods of time, if kept in suitable containers such as one-gallon tin cans which may be obtained from most any restaurant. Holes should be punched in the bottom of the cans with *tacks,* not nails, since the worms will escape if the holes are too large.

The soil in the bottom of the can should be kept moist, but not wet since the soil will quickly sour. The holes in the bottom will aid in taking care of excess moisture.

Place dead leaves or coffee grounds on the top of the soil occasionally.

Glass jars will not work well.

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turned onto a glass plate covered with glycerine. Cross walls must be built into the cells illustrating late anaphase and telophase. After drying for several days the set can be turned over and the faces completed.

A filler does not have to be used in making the cells but it makes the finished product much lighter than solid clay or pure asbestos. A filler is particularly desirable when large cells, such as are seen in the Amphioxus set (illustration), are modeled.

Fine wire, the kind that is used in making paper flowers, can be inserted on the face in spindle-form as spindle fibers. Spireme threads and forming chromosomes are made of cord or fine beads strung on wire. These can be prepared while the backs of the cells are hardening, and will be ready to insert when the faces are designed.

Many common objects can be used as modeling material. Small spongy rubber balls (2 for $0.05) form the base for most of the models, representing the early embryological development of the frog (illustration). They were mounted on wires, covered with clay, grooved, and painted. A small hollow rubber ball was halved and used as a base for the blastula.

Undulating membranes for trypanosomes can be cut from celluloid and the stuffed enameled fingers of a soft rubber glove form excellent pseudopodia for an arcella, the shell of which is modeled in a small deep saucer.

There are many tricks to the trade, it seems, but when all is said and done, modeling is easy. The resourceful and persevering student, besides learning much that is already known, will make discoveries. He will find new methods, new materials, new modes of expression well worth recording. He will develop a fruitful interest in science.

These few suggestions may serve as a stimulus to the beginner. Instructors might advise students to start modeling something in which they are interested and which they can make. After a modeling project is undertaken, the teacher should not permit the student to stop until the model has been completed, for it is the mounting and the enameling and the last clever finishing stroke that bring satisfaction and success.