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TEACHING AIDS IN BOTANY, II. DIAGRAMS

S. M. Dietz

The use of prepared diagrams in general botany at the college level is a controversial subject. There is a general agreement that their use is economical of students' time but some instructors maintain that prepared diagrams curtail the opportunity for critical observation by the students. This paper does not purpose to deal with the controversy but rather to illustrate certain methods of effective use.

During a period of ten years the Botany Department at Iowa State College has been experimenting with the use of prepared plates in the general botany course. In the beginning, four detailed drawings were furnished. The objective at this time was economy in student-time. These four plates were photographed at first but this method was too expensive for general use. Zinc etchings were subsequently made. The most economical and satisfactory method, however, was reproduction by planographing. Twenty-eight additional plates have been added during subsequent years, making a total of thirty-two prepared plates in the introductory general botany course. The use of completed set of plates has been under experimentation for the past four years.

The prepared plates do not entirely replace original diagrams and drawings by the student. The decision of what to draw is optional with the student. Whenever, in the student's opinion, an idea may be better portrayed by a drawing than by writing, it is good judgment on his part to draw. This option may afford the student an opportunity for improving his judgment through experience.

The prepared plates range from simple outline diagrams to critical detailed drawings. They are all drawn from the same type of material the student uses for observation in the laboratory. These drawings may be labeled or unlabeled depending upon their usage. All of the drawings are designed to facilitate their use in a number of different ways.

The acquisition of a technical vocabulary is one of the problems in an introductory general botany course. Many of the unlabeled plates are used as places to record terminology, others have prepared labels. All the plates serve as handy references for the

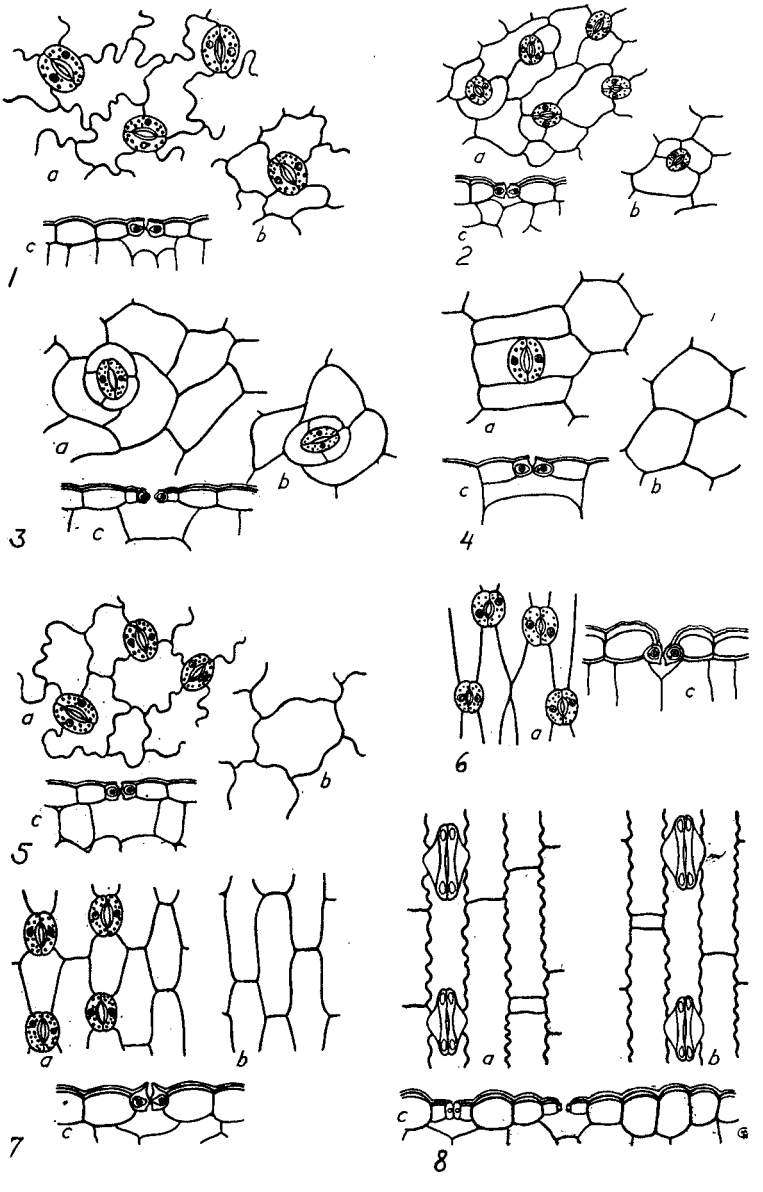

Fig. 1. A plate used as an aid in teaching the characteristics of stomata.

terminology necessary in the solution of problems. The fact that these plates are available to the student when he is solving problems and given other tests, stimulates him to label the diagrams completely and accurately. His constant use of the labeled plates has been a distrinct aid in the acquisition of a technical vocabulary.

One of the objectives in the general botany course is the development of judgment. In attempting to attain this objective the students are given many opportunities to use and thus improve their ability to evaluate. One of the important aids is the use of prepared plates. Figure 1, which is one of the prepared plates furnished the students, shows the stomata, guard cells and adjoining epidermal cells of the leaves of the following eight plants: 1. tobacco, 2. cabbage, 3. Sedum, 4. wandering jew, 5. Fuchsia, 6. onion, 7. Amaryllis, and 8. corn. In each case "a" represents the lower epidermis, "b" the upper epidermis and "c" the cross section. The above eight plants together with several other living plants are labeled and placed on the student's table. He is then given the opportunity to identify the eight plants represented in figure 1 by stripping the upper and lower epidermis from the leaves and observing under the microscope. During the process of critical examination the student is asked to make a list of all the observable characteristics of the guard cells and the adjoining epidermal cells. These data collected by the student are used as aids in the solution of such problems as how a stoma opens and closes, and the influence of the stomata in transpiration. In addition, Figure 1, after being properly labeled, serves as a ready reference of information necessary in the solution of many subsequent problems.

Figure 2 represents in cross section a portion of the leaves of 1. privet, 2. lilac, 3. tomato, 4. alfalfa, 5. rubber, 6. oleander, 7. lily and 8. sorghum. Samples of these eight living plants with five additional ones are placed on each student's desk. The procedure is somewhat similar to that recorded for the use of Figure 1, except labeled, prepared slides of the cross section of each of the thirteen leaves are furnished each student. The student then identifies each of the diagrams in Figure 2. The information collected in studying the detailed anatomy of these leaves is used as an aid in the solution of the problem of how green plants make their own food.

The starch grains from the twelve plants: 1. potato, 2. banana, 3. wheat, 4. barley, 5. rye, 6. pear, 7. corn, 8. lima beans, 9. oats, 10. rice, 11. tapioca, and 12. peanut are drawn to scale and repre-

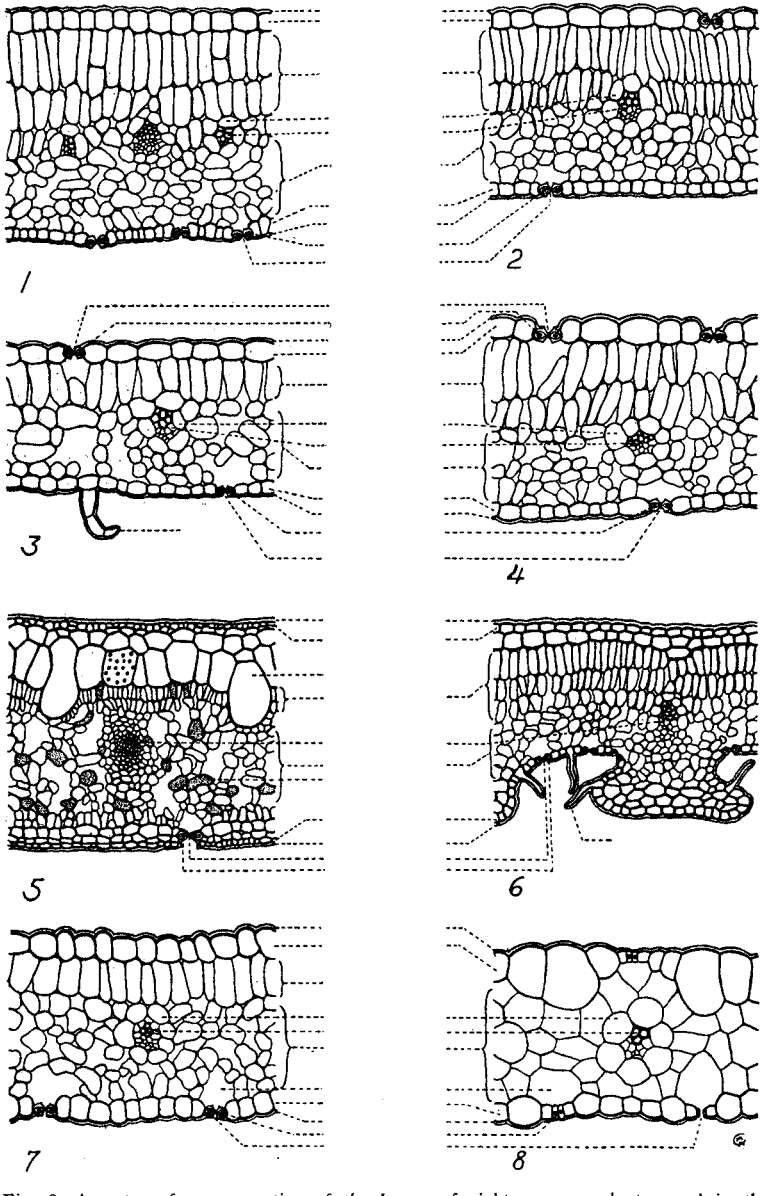

Fig. 2. A sector of across section of the leaves of eight common plants, used in the problem of designing an ideal, efficient, food-making leaf.

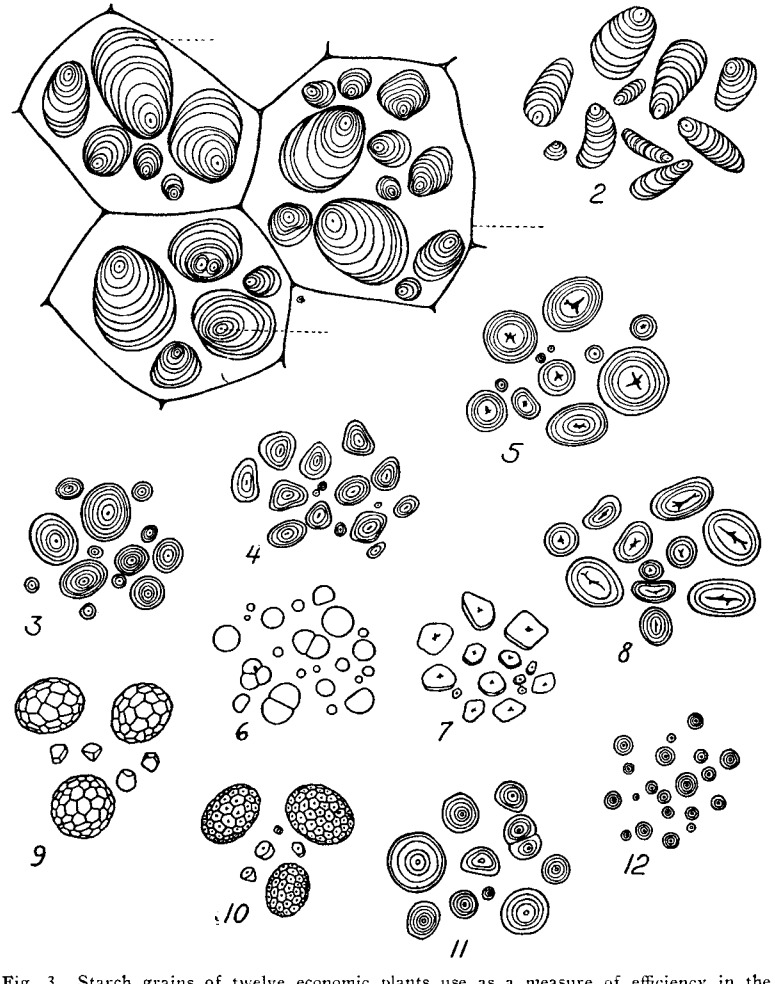

Fig. 3. Starch grains of twelve economic plants use as a measure of efficiency in the use of the microscope.

sented in Figure 3. After the student has identified these starch grains by comparing the labeled material with the diagrams in Figure 3, he is given a mixture of various starch grains to identify with the aid of the correctly labeled plate. Figure 3 is used about the third week in the course. In addition to giving the student the opportunity to develop critical judgment, this plate aids in evaluating the student's ability to use the microscope.

The application of information to the solution of a problem involving a situation new to the student, has proved an effective technique in the teaching of general botany. The prepared plates have served as tools when used to formulate such problems. In using Figure 4, the student is informed that each of the twelve plants diagramed is represented by a leaf. Since each morphologic structure is a leaf, it must possess something in common with all other leaves. The problem then resolves itself into: what does each leaf possess in common? The student, at first, concentrates on the divergent forms of leaves represented but ultimately arrived at the conclusion through observation that the leaf is an expanded portion of the stem located below a bud. The plate shown in Figure 4 is supplemented by field and greenhouse materials. The plate, however, serves as an important aid in the solution of the problem as at certain seasons the field and greenhouse materials have poorly developed buds.

In Figure 5 is represented a portion of a transverse and radial and tangential section of a pine stem cut in such a way that the cambium is shown at the extreme left. The student is given a prepared microscope slide showing these three planes and asked to complete the diagram by making the necessary observations from the slide.

A third type of problem is represented by Figure 6. This problem is used after the student has gained considerable knowledge through a study of growth in monocotyledenous and in herbaceous and woody dicotyledenous plants. Given Figure 6 and an unlabeled, microscope slide which bears a cross section of the rhizome of *Agropyron repens*, he is asked whether this figure represents a monocotyledenous or dicotyledenous stem or root. He is further asked to give reasons for his choice. Although the figure does not make the morphologic structures in the cortex distinctly appear as vascular bundles, critical observation of the microscopic slide reveals them as such structures.

In the group-conference method of teaching botany, as evolved at Iowa State College, the development of concepts plays an im-

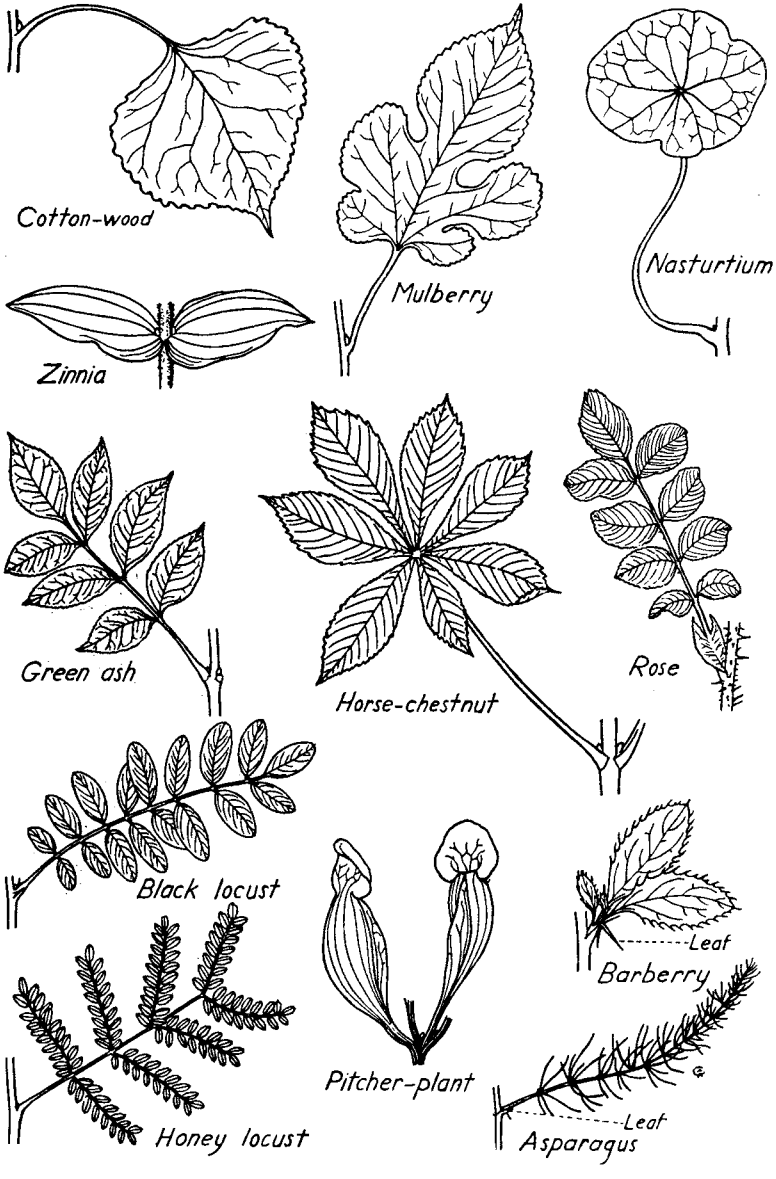

Fig. 4. A plate designed to aid in determining what constitutes a leaf.

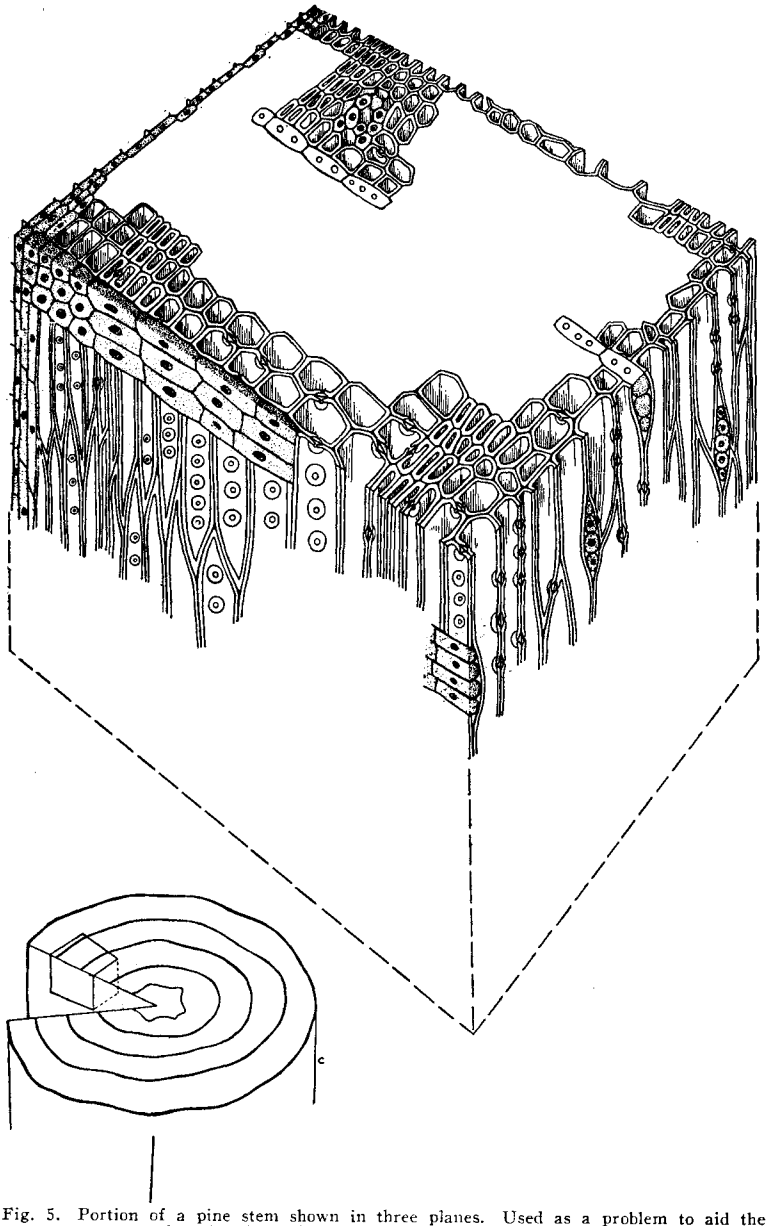

Fig. 5. Portion of a pine stem shown in three planes. Used as a problem to aid the student in visualizing plant tissues in three dimensions.

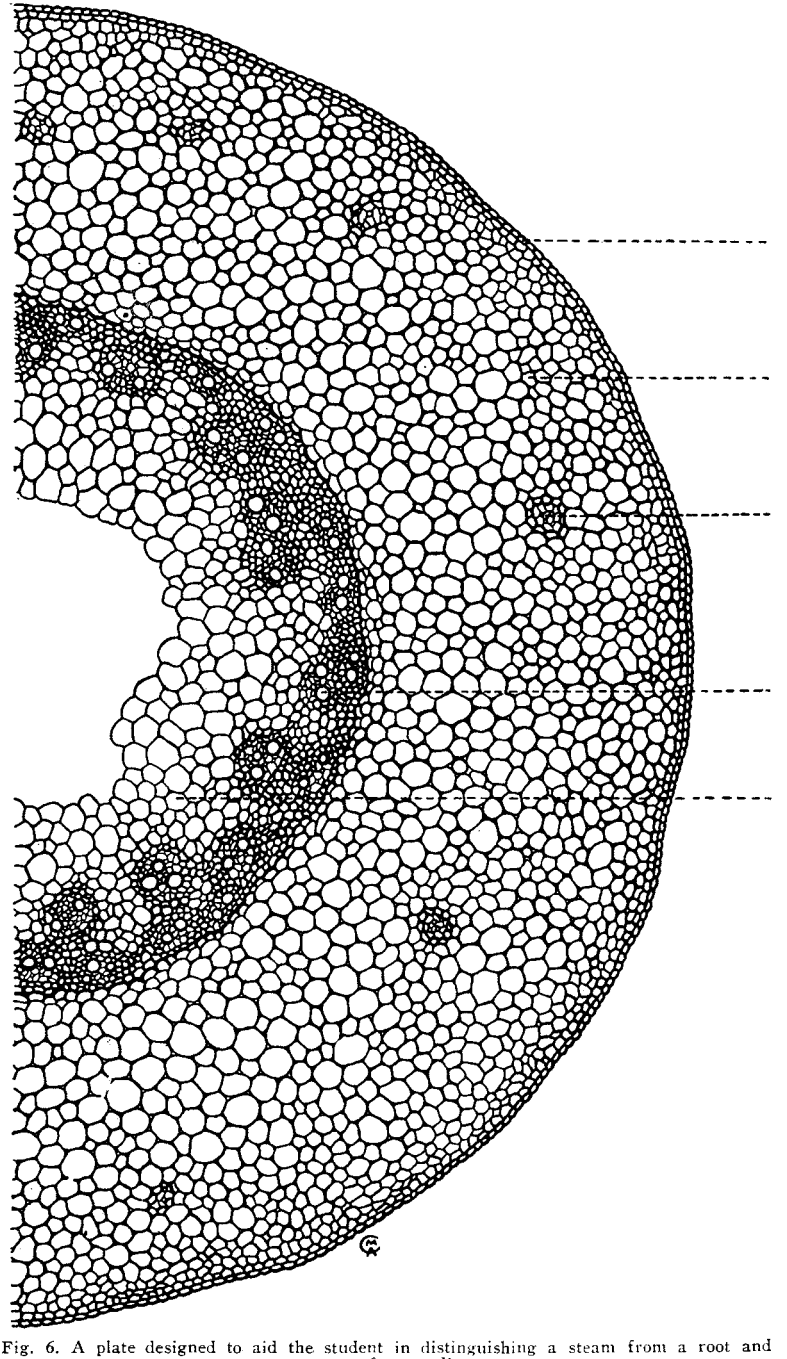

Fig. 6. A plate designed to aid the student in distinguishing a steam from a root and monocot from a dicot.

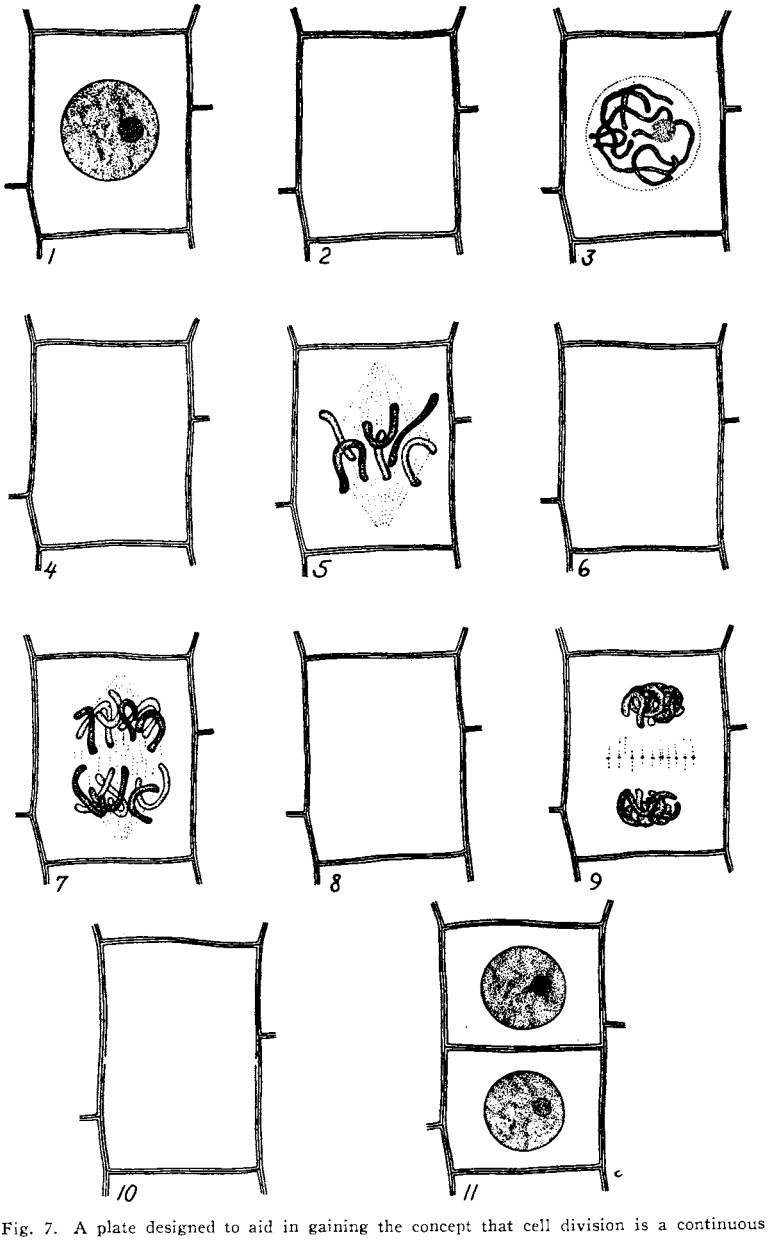

Fig. 7. A plate designed to aid in gaining the concept that cell division is a continuous process.

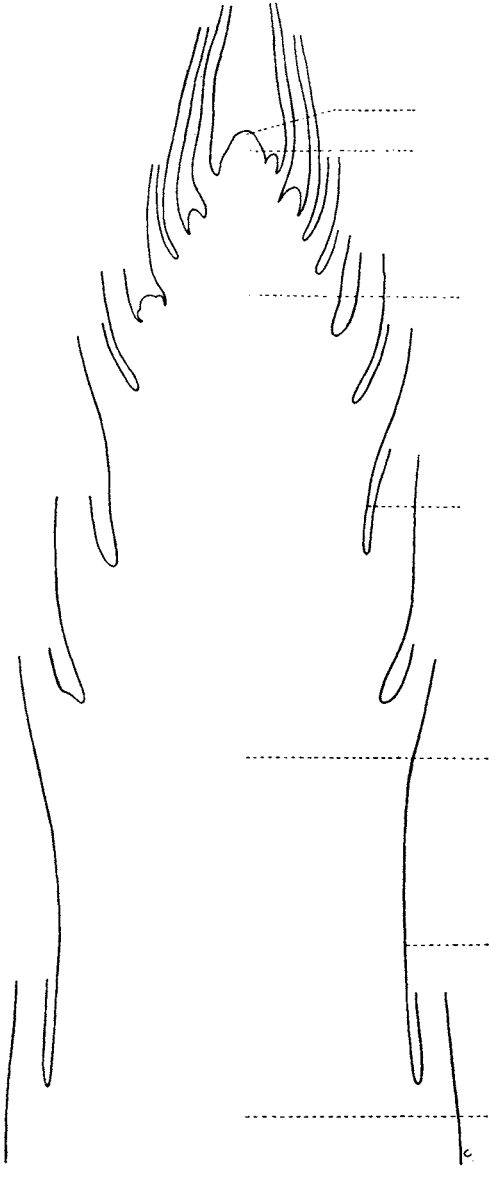

Fig. 8. A plate designed to aid in gaining the concept of differentiation.

portant part. Figures 7 and 8 show how prepared plates may aid in the formulation of certain concepts. Figure 7 is designed to aid the student in gaining the concept that cell division is a continuous process. Those cells with detailed protoplasmic structures represent the traditional "steps" in cell mitosis. The student is then asked to interpolate between 1 and 3 in figure 7 and graphically portray his ideas in 2.

After the student has progressed in gaining a concept of growth in higher plants to where he is familiar with the parts played by cell division and subsequent enlargement, figure 8 is introduced to aid in understanding the role differentiation plays in growth. This figure represents a median longitudinal section of the growing point of *Ricinus communis*. The student has just completed a study of cell division and is readily able to designate the promeristem as an area in which mitosis is taking place. Being told that all cells in this section came directly or indirectly from the promeristem, he can easily recognize that most of the cells are morphologically different. The gradual change from the cells typical of the promeristem to the youngest epidermal cells above the meristem and finally to the well differentiated cells of the epidermis on the older stem, is quite apparent. This same type of gradual change may be followed in the development of the pith and the provascular strands from the promeristem. The student uses the diagram to record a few representative cells typifying these progressive changes and gains a concept of differentiation.

SUMMARY

The use of prepared diagrams has been a distinct aid in the teaching of general botany at Iowa State College. The diagrams have been most effective as aids in gaining an accurate terminology, as aids in developing judgment and in formulating concepts. Many of the plates may be used as problems which require the application of acquired information to the solution of situations new to the student.

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