How-To-Do-It

CATLAB—A Learning Cycle Approach

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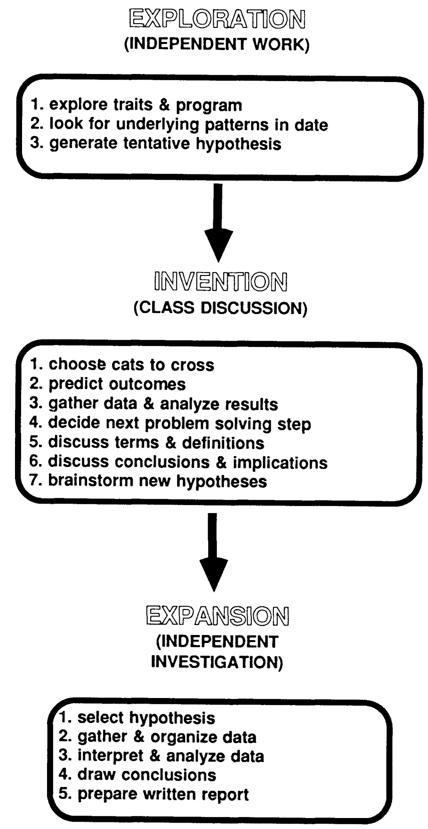

Figure 1. Learning Cycle Activity

Computer simulations are instructional resources that can motivate students to participate actively in learning scientific concepts and interact with models of reality (Lunetta & Peters 1985). Simulations can be used to introduce, review and complement concept learning and laboratory activities (Krajcik & Lunetta 1985).

CATLAB

CATLAB (Kinnear 1982), a genetics simulation, was designed to complement conventional genetics instruction. The program enables students to select traits, hypothesize about gene interactions, and decide which cats to cross. The traits students investigate with CATLAB include coat color (white/nonwhite), amount of white spotting (extensive/some/none), density of pigment in the fur (dense/dilute), distribution of pigment in the fur (agouti/nonagouti), tabby striping (mackerel/blotched), and tail or no tail (manx).

Learning Cycle Approach

This CATLAB activity was designed to provide students with opportunities to generate hypotheses, to decide what data to collect, to analyze and interpret data and to develop genetics concepts. The teaching model selected to fit the instructional goals was the *exploration* = *conceptual invention* = *conceptual expansion* learning cycle described by Renner, Abraham and Birnie (1985). In the *exploration* phase, students interact with the program by experiencing information and concepts before conceptual organizers are introduced. Students collect data and search for underlying patterns. The *conceptual invention* phase is teacher led, and concepts and precise scientific language are introduced to assist in more scientific explanations of students' observations and data. In the *conceptual expansion* phase, students apply concepts in solving problems by experimenting, redefining questions, investigating concepts and relating concepts to new information.

Exploration

The initial activity consisted of a "prediction sheet" containing items on probability, inheritance and combination of gametes. It was used to assess students' general knowledge about genetics and Mendelian problem-solving strategies, as well as to inform students about instructional goals. Subsequently, each student was scheduled to use the CATLAB software for a short time (about one-half hour) to explore traits in cats and to become familiar with the program.

Invention

During the *invention* phase, the teacher led group discussions during which students: 1) worked through an investigation using CATLAB; 2) discussed definitions of terms, kinds of crosses, predictions and conclusions based on the data gathered from CATLAB; and 3) brainstormed hypotheses about genetic traits in cats. During this phase, data was gathered using an Apple IIe computer with a 25-inch color monitor in front of the classroom.

The large group discussion focused on investigating a sample problem of black/grey coat color (black is the dominant trait). Students were asked how they would determine inheritance patterns of this trait. Several individuals suggested crossing two black cats, a black cat with a grey cat, and two grey cats. They were asked to elaborate on the information they thought particular crosses would provide about the inheritance pattern. Students reasoned black cat and grey cat crosses would provide information about dominant or recessive traits. Selection of actual crosses was determined by student consensus. The class was then asked to predict the characteristics of the kittens in the litter. When discussing strategies for testing predictions, many students used genetics terminology incorrectly. The teacher probed students' understanding by asking them to define and clarify terms and concepts, and then led a discussion on the correct usage of terminology.

After a litter of kittens was generated and displayed on the large monitor, students were asked to explain how the results fit their predictions and hypotheses. After four or five crosses, one or more students generally suggested that enough data (12-15

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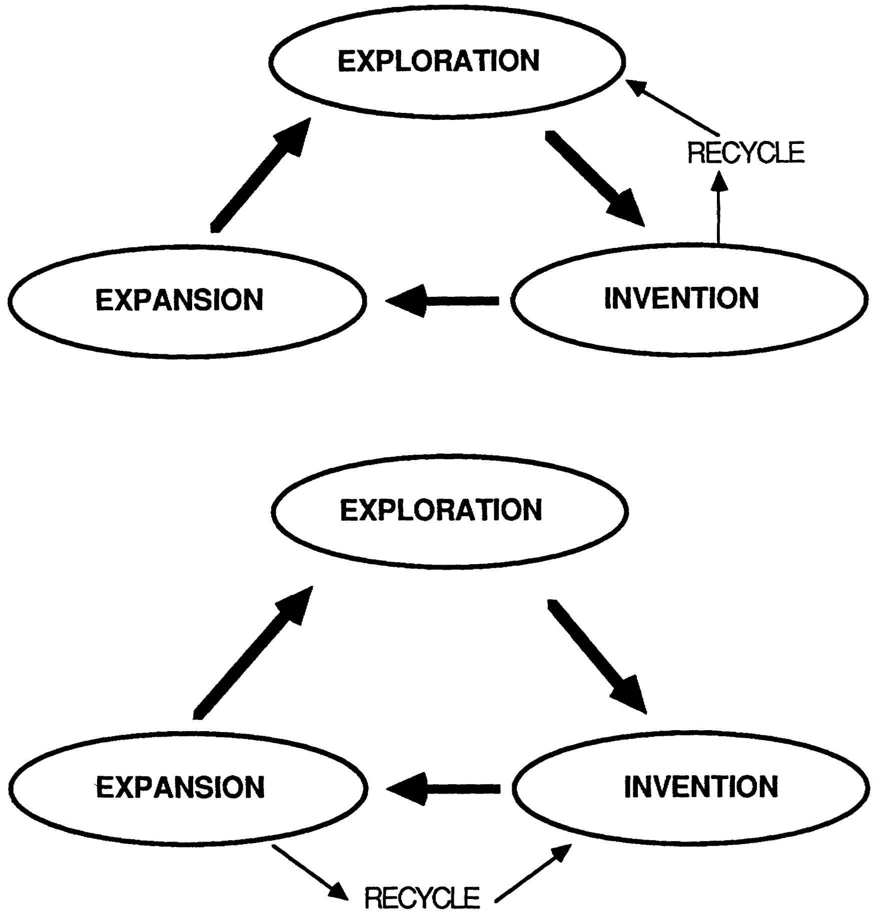

Figure 2. Possible Sequences of Learning Cycle Activity

offspring) had been collected to make inferences about the inheritance pattern. The teacher then introduced the idea of appropriate sample size. The class discussed and compared conclusions based upon outcomes from one litter, several litters and a large number of litters. Subsequently, implications of the data for supporting or rejecting hypotheses were examined and discussed.

Students brainstormed hypotheses about cat genetics which they had developed during the exploration activities. Finally, all students were asked to investigate two hypotheses thoroughly and independently. All students were to investigate a common hypothesis involving the mackerel/blotched tabby striping trait and a second hypothesis to be selected by each student during the final phase (expansion) of the Learning Cycle.

Expansion

Students were asked to gather data enabling them to support or reject their hypotheses. Before beginning their investigations, they were asked to develop a plan to organize and record data. The students suggested and used tables, charts or pedigrees. The method of recording data was left to individual preference. Students had as much time as they needed to test their hypotheses. In their individual written reports, they discussed hypotheses, interpreted findings and drew conclusions.

The CATLAB activity concluded with a quiz containing items on the prediction sheet and items assessing the understanding of genetics concepts. An attitudinal questionnaire indicated that a majority of students found CATLAB to be helpful.

Results

In our studies involving 100 beginning and advanced high school biology students, a large percentage of students felt CATLAB was helpful, enjoyed using the program and felt that it helped improve their understanding of genetics. More than 75 percent of the students changed responses that were incorrect on the pretest to responses that were correct on the posttest. (It is important to note that correct responses included an acceptable written explanation on the pretest and posttest items.)

Several misconcepts about genetics principles surfaced while students were interacting with CATLAB. The most prevalent misconcepts dealt with the interpretation of Punnett square probabilities and with the definition of "dominant trait." The dominant trait was defined by some students as the phenotype with the greatest number of kittens. Using CATLAB and a learning cycle model provides opportunities for a teacher to confront students about discrepancies between their concepts and more scientific concepts that better explain their data. The teacher can suggest that a student pass through the learning cycle or parts of the cycle several times (Figure 2), each time redefining research questions, testing improved or new hypotheses and drawing more valid conclusions. Our results suggest that appropriate use of a learning cycle teaching model can promote appropriate conceptual linkages and the development of higher level cognitive skills.

A Key to Insight for Teachers

The learning cycle teaching model is especially suited as an organizer for students using a simulation like CATLAB. The model provides teachers with opportunities to gain insight into how their students think, learn and approach problems. For example, during hypothesis testing in the *expansion* phase, teachers can observe students gathering, recording and interpreting data. By talking with the students and probing the reasoning behind their hypotheses and their interpretations, the teacher can ask leading questions that help students make more sensitive observations, clarify their understanding of concepts and relationships and investigate particular hypotheses more effectively. By observing students and using that information, teachers can become more sensitive and responsive to students' individual learning styles and characteristics.

The evidence suggests that many students have serious misunderstandings of concepts in genetics after completing conventional genetics units. Using a simulation such as CATLAB enables teachers to help students confront misconcepts during learning. Students can redefine their questions and test new predictions. In this way, students also model the behavior of scientists designing new experiments and investigating discrepancies between predicted and actual outcomes.

A simulation such as CATLAB provides students with an opportunity to learn about genetics by interacting with an interesting model that is a good approximation of reality. CATLAB enables students to be engaged more actively in applying their knowledge about genetics principles and in problem solving by: 1) generating their own questions; 2) deciding which parameters or variables to investigate or control; 3) gathering, recording, interpreting and analyzing data; and 4) drawing conclusions to support or reject hypotheses. Our evidence suggests that appropriate teaching strategies incorporating microcomputers and good educational software (like CATLAB) can enable teachers to provide successful learning experiences for students.

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Book Reviews

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BIOLOGY LAB RESOURCE BOOK by Judith M. Hancock. 1985. J. Weston Walch (P.O. Box 658, Portland, ME 04104-0658). 232 p. $18.00 softback.

A variety of resource books and supplemental laboratory guides for junior high school life science and high school biology are currently available. Hancock's resource book offers teachers of these courses another option from which to select supplemental materials.

Hancock has selected 33 laboratory activities and a series of genetics problems for her resource book. These activities center on contemporary textual material and underlying principles of biology. Hancock provides suggestions for teachers to implement each activity. However, teachers will have to provide their students with sufficient background information if the students are expected to perform the activities, complete the data sheets and respond to the recall questions. That is, the student data sheets do not provide students with appropriate background information. But rather, the data sheets contain directions, isolated illustrations and recall questions.

An introductory section provides an overview of microscopy. The remaining activities are categorized into specific parts, each of which has a unifying theme. These themes include cells, comparative anatomy, variability, development, behavior, genetics and ecology. Teachers should find the activities in each of these parts easy to implement if appropriate information has been previously taught. The materials they will need for the activities are usually stocked in most introductory laboratories. A number of data gathering worksheets are provided for the students to progress through the activities.

The author contends that extensive dissection cannot be justified educationally. She nevertheless includes four dissections for students to perform. Other traditional laboratory activities include diffusion and osmosis, chromatography, observation of cells, enzyme action, photosynthesis, respiration and mitosis. Attention is given to higher plants and specifically to angiosperms but lower plants have not been included. Additional activities include seed and flower dissection, germination and planaria regeneration. The section on behavior includes taxic behavior in the earthworm and snail as well as instinct behavior in insects. To complete the genetic problems that are included, the students will need a functional understanding of genetics concepts.

While Hancock's book does provide a quick reference to supplement many contemporary biology and life science textbooks, it does not provide a detailed treatment of any particular topic. Therefore, the resource book should not be considered a replacement for existing materials since it does not provide sufficient background information for each of the laboratory activities that is included. If a teacher needs a series of generalized laboratory activities that can be used at incidental times throughout a school year, then this book could be beneficial. If, however, a teacher needs a detailed and intensive treatment of specific topics tailored to carefully designed lesson plans, a treatment that depends upon richly labeled illustrations and higher level questions, then the book will fall short. Hence, this resource book appears most appropriate for biology or life science instruction that addresses traditional topics on a generalized level. It is unlikely that a teacher who has taught for many years and who has accrued a file of activities tailored to that specific classroom will find this resource book helpful. However, a teacher who is beginning to build teaching files and who is seeking a variable collection of laboratory activities will find value in this resource book.

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