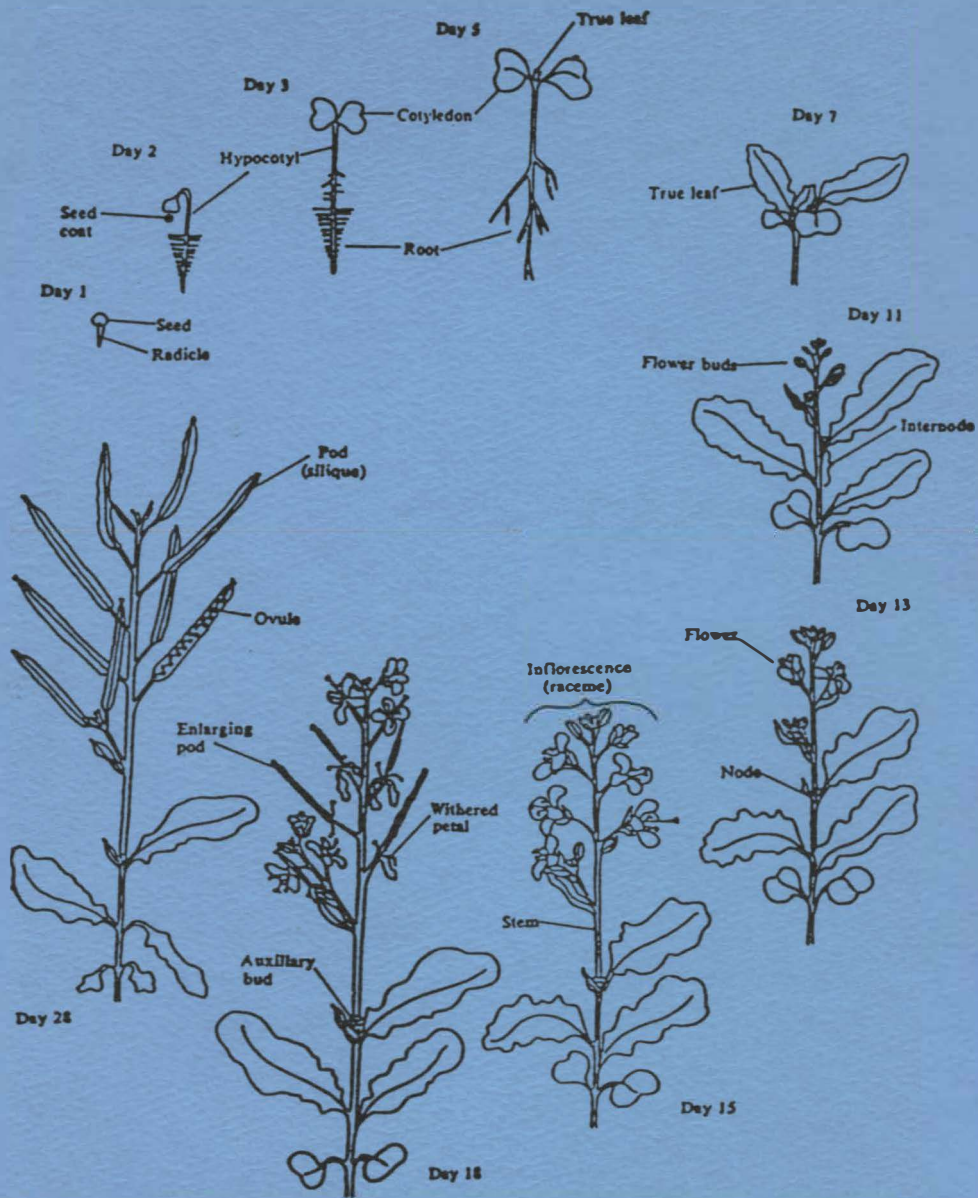


Midwest Bioscene



Volume 15 Number 1
June 1989

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Cover: *Life cycle of rapid-cycling Brassica rapa*. R.S. Hafner.

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RAPID-CYCLING BRASSICAS

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CLASSROOM SCENARIO

The students of a biology class are investigating the life cycles of angiosperms. They harvest and sow seed from a small, yellow-flowered plant in the crucifer (mustard) family. The entire class project, with each student growing four plants, occupies only a 40 centimeter square area of bench space under cool white fluorescent lights.

Over the next 48 hours, the entire germination of this flowering plant takes place. The students observe cotyledon emergence, hypocotyl extension, and pigment activation.

A number of students question the role of light in the morphological and physiological changes which they have observed, and they design experiments to test their hypotheses.

Other students record daily height measurements of their plants to quantify the growth process. They construct a growth curve by graphing average plant height versus days from sowing. The exponential phase of the resulting S-shaped curve indicates a maximum plant growth rate of over three centimeters per day just prior to flowering! Future investigations are planned to explore

where growth is localized in a plant and how the growth process is controlled.

Another group of students investigate plant tropic responses. They discover that an 11-12 day old plant, when placed on its side under the lights, will exhibit a 90 degree bending of its stem in just 90 minutes! Subsequent experimentation (with appropriate controls) to determine the source of stem bending indicates a negative geotropic response.

Still others observe and make drawings of the changes in the form, size, and relative location of the various plant structures as growth ensues. Their intent is to develop a functional interpretation of plant structure. Over the course of two weeks from sowing, all of the changes in outward form as well as the changes in internal structure and organization, which characterize vegetative growth and development in this unique flowering plant, have occurred.

On approximately day 13, flowering begins and continues for 4-5 days.

The students dissect and identify the structure of a flower and then that of a dead honey bee.

Class discussion helps to reveal the intricate functional and coevolutionary relationships between the flower and its pollinator, the honey bee. The students make 'bee-sticks' by gluing a honey bee

thorax to the tip of a toothpick. Using the bee-stick to collect pollen from the anthers of one flower, they transfer that pollen to the stigma of a flower on another plant in cross pollination. Pod elongation and swelling along the pods where the seeds are developing is noticed 3-5 days following pollination. At successive intervals over the next two weeks, students extract and observe embryos at different developmental stages. Mature seed is ready for harvest and subsequent planting 20 days following pollination.

Within the course of 35-40 days, the students have observed and investigated the entire life cycle of a flowering plant -- producing seed from seed (see cover).

The model plants involved in the above scenario represent six species of the genus *Brassica* which have been bred to have vastly accelerated reproductive cycles. Developed at the University of Wisconsin-Madison as models for basic and applied research in areas as diverse as plant breeding and molecular biology, therapid-cycling brassicas have characteristics which also make them ideal organisms for the science classroom. Supported in part from a grant from the National Science Foundation, Directorate of Science and Engineering Education, the Wisconsin Fast Plants Program is developing instructional materials centering on the use of the rapid-cycling species *Brassica rapa*. With rapid-cycling brassicas, students have the opportunity to learn biological principles through the observation and investigation of plants which grow fast enough to

exhibit all aspects of their growth and development over the course of several weeks. Instruction in plant anatomy and morphology; growth, development, and reproduction; genetics; physiology; ecology; and aspects of scientific research may be enhanced through utilization of these materials, from the elementary to the university level (Hafner 1987).

WHAT ARE BRASSICAS

Plants in the Crucifer family are so named because they have four-petalled flowers -- each resembling a cross or crucifix.

This diversified family contains over 3500 species in 300 genera which include such flowers as the silver dollar, alyssum and sweet stocks and weeds such as mustards, tumbleweed and shepherd's purse. Within the genus *Brassica* are crops such as cabbage, cauliflower, broccoli, turnip and Chinese cabbage. Brassicas are important to the diets and economic welfare of people throughout the world. The Chinese, for example, consume 0.25 kilograms of cruciferous vegetables per capita daily (Williams & Hill 1986). *Brassica rapa*, the subject of this article, as well as the other crucifer species, are represented by a diverse range of morphotypes (plant forms) (see Figure 2, pg. 5). These forms have been used extensively as sources of oil seed (turnip rape), animal fodder (turnip) and vegetables (pak choi, Chinese cabbage, turnip, and spring broccoli raab) (Williams & Hill 1986). Brassicas occur as common weeds throughout North America where they were introduced from Europe.

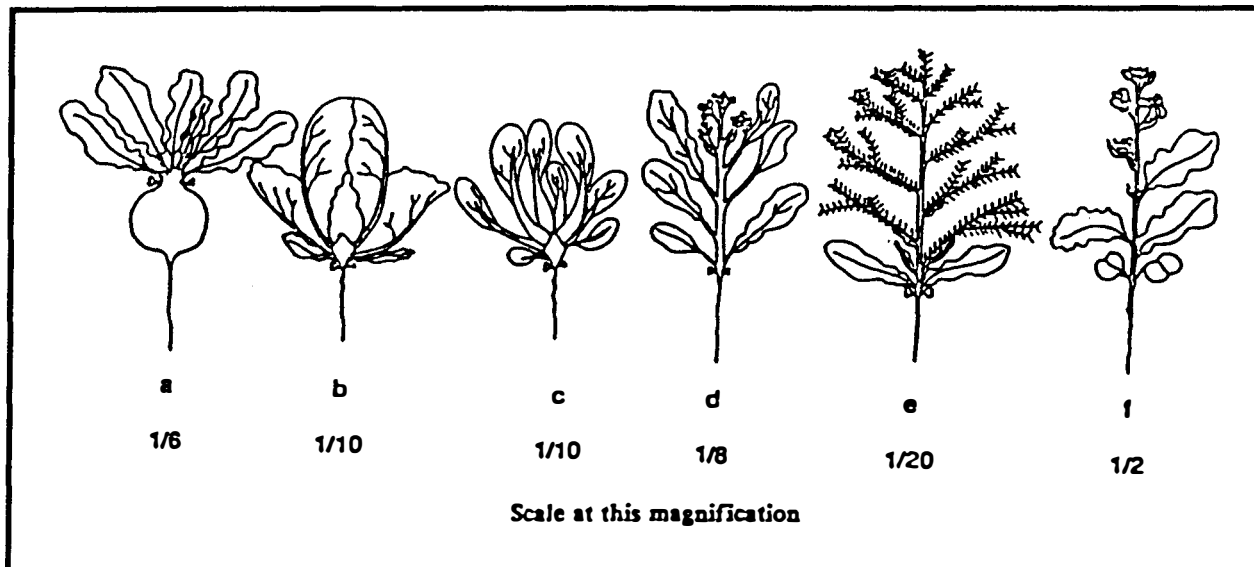


Figure 2. Forms of *Brassica rapa* representing various cultivar groups: a, turnip group; b, Chinese cabbage group; c, pak choi group; d, saichin group; e, turnip rape group; f, rapid-cycling group.

DEVELOPMENT OF THE RAPID-CYCLING VARIETIES

Brassicas normally take six months to over a year to flower. The rapid-cycling populations were developed initially by combining diverse early flowering individuals from several thousand seed collections made around the world. Early flowering plants were interpollinated. Selection of successive generations were made on each population according to the following criteria: 1) minimum time from sowing to flowering 2) rapid seed maturation 3) absence of seed dormancy 4) small plant size 5) high female fertility 6) uniformity of flower maturation. After appropriate uniformity of flowering was achieved, the resulting populations were designated as rapid-cycling base populations (RCBP's).

The rapid-cycling base population of the species *Brassica rapa*, designated as RCBBr, has the most desirable attributes for the classroom. RCBBr plants complete their entire life cycle within the course of 35-40 days when grown under continuous cool white fluorescent light. The seeds

begin germination within 12 hours of planting and progress to the flowering stage without delaying long in the vegetative, or leafy, stage. Average time to first open flower is 14 days and the average height at the first flower is 13 centimeters. Rapid maturation and compact idotype (plant form) have been achieved while maintaining sufficient seed set under high density classroom growing conditions (an average of 37 seeds per plant at densities of 472 plants per meter square). Uniformity of flower maturation enhances pollen transfer among plants. The use of the bee-stick described earlier (see Figure 5, page 12) makes controlled pollen collection and transfer accessible to students of any age.

Although RCBBr is relatively uniform with respect to flowering time and plant form, plant populations show great phenotypic plasticity in response to changing environmental parameters such as nutrient level, light intensity, soil volume, and density. More than 50 traits

under simple genetic control have been incorporated into the rapid-cycling base populations of *B. rapa*. Many of these genetic stocks have considerable educational value (see Table 1, page 7).

A simple and economical classroom growing system has been designed for the rapid-cycling varieties with a maintenance regime compatible with a teacher's demanding schedule (see Figure 3 below). Ease of cultivation and

rapid growth and development at high population densities combine to form a model plant system. This system provides students with the opportunity to design, conduct, and complete investigations of their own choosing within the time frame of most curricula. Students can gain experience in cultivating plants, pollinating, observing, maintaining accurate records, constructing and testing hypotheses, and interpreting data.

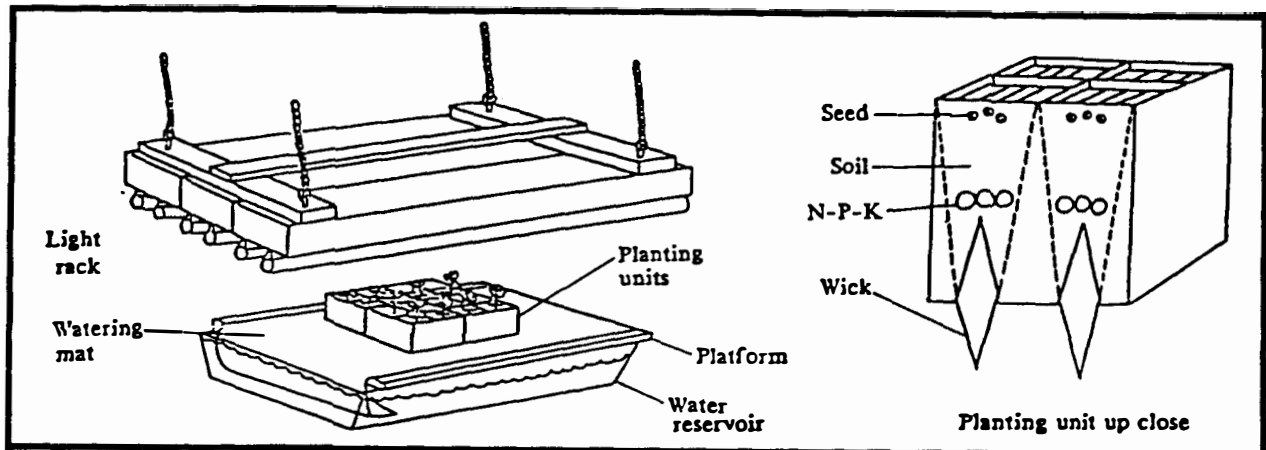


Figure 3. The growing system. The standard light rack consists of three 2-bulb fluorescent light strips mounted side by side, with a total of six 40 watt cool white bulbs. The spectral emissions from cool white fluorescent bulbs are adequate for *B. rapa* growth and development. Light bulbs should be on 24 hours per day and a distance of 8 centimeters maintained between the bulb surface and the growing point of the plant throughout the life cycle. Water is drawn by capillary action up from the reservoir water supply through the watering mat (pellon pad) to the wick and up through the soil to the growing plant. Watering of the plants throughout their life cycle requires refilling the water reservoir every 3-4 days. Controlled release fertilizer pellets are the source of major nutrients. The soil mixture is light and porous enough to complement a capillary watering system. Planting containers are reusable styrofoam. Individual cell size is 2.1 cm. square and 4.4 cm. high.

APPLICATIONS

Table 2 (page 8) contains a list of biological topics which students from the elementary to the university level have found fruitful for investigation with RCB. We recommend that both teachers and students grow and observe the plants through an entire life cycle before carrying

out specific investigations. A familiarity with growth, development and reproduction will provide a conceptual foundation on which to base further investigation. What follows is more explicit information regarding the brassica life cycle and suggested student activities.

Table 1. *B. rapa* stocks with educational potential [() are maternally inherited; all others are single gene recessives].

<u>Trait</u>	<u>Symbol</u>	<u>Description</u>
anthocyaninless	anl	Hypocotyl and plant remains green to maturity (lack of purple pigment).
apetalous	apt	Flowers with 0-4 petals (petals are often folded into a funnel shape); variable expressivity.
folded petal	fop	Petals fold under and are curled. The bud stage has a distinctive 'Turks-cap' appearance.
elongate internode	ein	Both hypocotyl and epicotyl are greater than normal length; possible phytochrome deficient mutant.
glossy	glo	Plants lack a waxy blue-gray bloom covering on the stems, leaves and pods (appear "shiny" in comparison to wild type).
male sterile	mst	Small anthers completely devoid of pollen.
	[cms]	Cytoplasmically inherited male sterile; absence of pollen.
orange flower	orf	Flower color has an orange hue.
rosette	ros	Plants are compact (extremely shortened internodes), dark green, slower emerging and maturing. Following the application of gibberellic acid, internodes will elongate and plants will flower normally.
variegated	[var]	Varying amounts of chlorophyll deficient tissue (white interspersed with green) in the leaves, stems, buds, flowers and pods; maternally inherited.
yellow-green	ygr	Cotyledons and true leaves are chlorophyll deficient (yellow-green in appearance).

Table 2. Suggested areas of investigation with *B. rapa*. () represent genetic stocks (see Table 1).

1. The Life Cycle (producing seed from seed)

a. Growth and Development

1. Plant anatomy and morphology.
2. Measurement of growth -- producing a growth curve.
3. Localization and control of growth.
4. Assessment of the qualitative and quantitative variation within plant populations.

b. Reproductive Biology

1. Flower structure and development.
2. Coevolutionary relationship between the brassica flower and its pollinator, the honey bee.
3. Pollination -- use of the bee-stick.
4. Embryogenesis.

2. Genetics

1. Gene expression: dominance, recessiveness and interaction.
2. Gene assortment: independence, linkage, F1, F2 and testcross.
3. Useful markers: (ein, anl, ygr, ros, glo, orf, apt).

b. Non-Mendelian

1. Maternal inheritance: cytoplasmic variegation ([var]) -chloroplast; cytoplasmic male sterility ([cms]) -mitochondrion.
2. Quantitative inheritance: plant height, pod length, seed yield.

c. Natural and Artificial Selection

1. Selection for short or tall plant stature, high or low seed yield, etc.

3. Physiology

a. Photosynthesis

1. Photosynthetic assays.
2. Chlorophyll deficient mutants (ygr).
3. Light energy and plant growth or seed yields.

b. Growth Responses

1. Hormone responding mutants (ros).
2. Gibberellin, cytokinin and auxin responses.
3. Phototropic and geotropic responses.

c. Photomorphogenesis

1. Etiolation (ein mutant).
2. Chlorophyll and anthocyanin induction.
3. Induction of flowering; photoperiodism.

d. Nutrition

1. Major and minor element requirements for growth and development.

4. Ecology

a. Chemicals in the Plant's Environment

1. Effects of acidic rain, air pollutants, excesses of salt and herbicides on growth and development.

b. Diseases and Pests

1. Insect pests, aphids.
2. Pathogenic microbes, viruses, bacteria, fungi.
3. Use and effects of pesticides.

THE LIFE CYCLE

VEGETATIVE GROWTH AND DEVELOPMENT

Background

Vegetative growth and development in RCB_r occurs roughly as follows:

Days 1-4 following seeding: The appearance of the embryonic root (radicle); the emergence of the cotyledons and the extension of the hypocotyl; the activation of pigment systems: chlorophyll (green) and anthocyanin (purple).

Days 5-9: The appearance of true leaves and flower buds; the growth and expansion of the leaves.

Days 10-13: The elongation of the internodes and raising of the flower buds above the plant foliage; the continued expansion of leaves and the enlargement of the flower buds.

Activity

1. Each student plants a quad (4-celled planting unit) with RCB_r.

2. Beginning with germination and continuing throughout the life cycle, students observe and make daily drawings of the changes in form, size and relative location of the various plant structures (cotyledons, hypocotyl, true leaves, flower buds, nodes and internodes, flowers, pods).

3. Students measure and record plant heights (distance along the stem from the cotyledon to the growing point) each class period. This procedure should begin at approximately day 7 and extend through height stabilization. Class data may be summed, and height versus time from seeding may be graphed to produce a growth curve.

4. Students observe and record qualitative and quantitative variations

among their plants as growth ensues. Possible quantitative characters include: plant height, number of flowers, time to first open flower. With summed class data students create a population distribution by plotting plant height, number of flowers or time to first open flower (X axis) versus percentage of the population (Y axis).

REPRODUCTIVE BIOLOGY

Symbiotic relationship between the brassica flower and its pollinator, the honey bee (see Figure 4, pages 10 & 11).

Background

For approximately the last one hundred million years angiosperms and specialized groups of flower-visiting insects have been coevolving. One product of that coevolutionary process is the symbiotic relationship between the brassica flower and its pollinator, the honey bee (*Apis mellifera*). To the honey bee, the flower is a source of pollen (protein) and nectar (carbohydrates). Through cross pollination, the bee enhances the probability of genetic continuity.

The honey bee compound eye has three visual pigments which permit the bee to see hues in the ultraviolet spectrum as well as that portion of the color spectrum (except red) visible to humans. Flowers that have coevolved with bees characteristically possess showy, brightly colored petals which are usually blue or yellow as in the *Brassica* genus. The brightly colored flower petals of the brassicas, when fully extended, act as landing platforms for the foraging bees.

The honey bee has a highly developed sense of smell and when a bee is close to a flower, floral nectaries

and associated aromas provide the stimulus to alight. The nectaries, which secrete an energy rich sugary fluid (nectar), are situated at the base of the corolla tube where they are accessible only to the specialized mouthparts of certain insects. In the case of the honey bee, the mouthparts have become fused into an elongate sucking tube termed the proboscis.

When a bee lands on a brassica flower, it pushes its proboscis down between the stamens to reach the nectary, and in doing so the setae (feather-like hairs) of the thorax come in contact with the anthers and thus pick up pollen. When the bee passes over the top of a flower to reach nectaries on the other side, its pollen covered thorax transfers the pollen to the stigma surface. The presence of both male and female reproductive structures in a single flower serves to make each visit by the pollinator more effective because the bee can both pick up and deliver pollen at each flower stop. Since *B. rapa* exhibits genetic self-incompatibility, pollen from a given plant cannot fertilize flowers on the same plant.

The legs of the honey bee possess adaptations which allow for both collection of pollen from the hair covered thorax and temporary storage of the pollen. The first segment of each of the three pairs of legs has a patch of bristles on its inner surface. Those of the first and second pairs are pollen brushes that gather the pollen that sticks to the bee's hairy body. On the third pair of legs, the bristles form a pollen comb that collects pollen from these brushes. To pack the pollen, the bee brings her hind legs together and moves them alternately up and down. By this action the rastellum (rake) of the descending leg scrapes pollen from the comb of the other leg. The pollen detached by the rake falls at the base of the pollen basket and is packed up into it. The pollen is subsequently mixed with small quantities of honey or nectar and packaged into cells adjacent to the brood nest where it undergoes a chemical change to a product called 'bee-bread'. This product is stored until consumed by adult bees for conversion into glandular and partially digested forms of larval food.

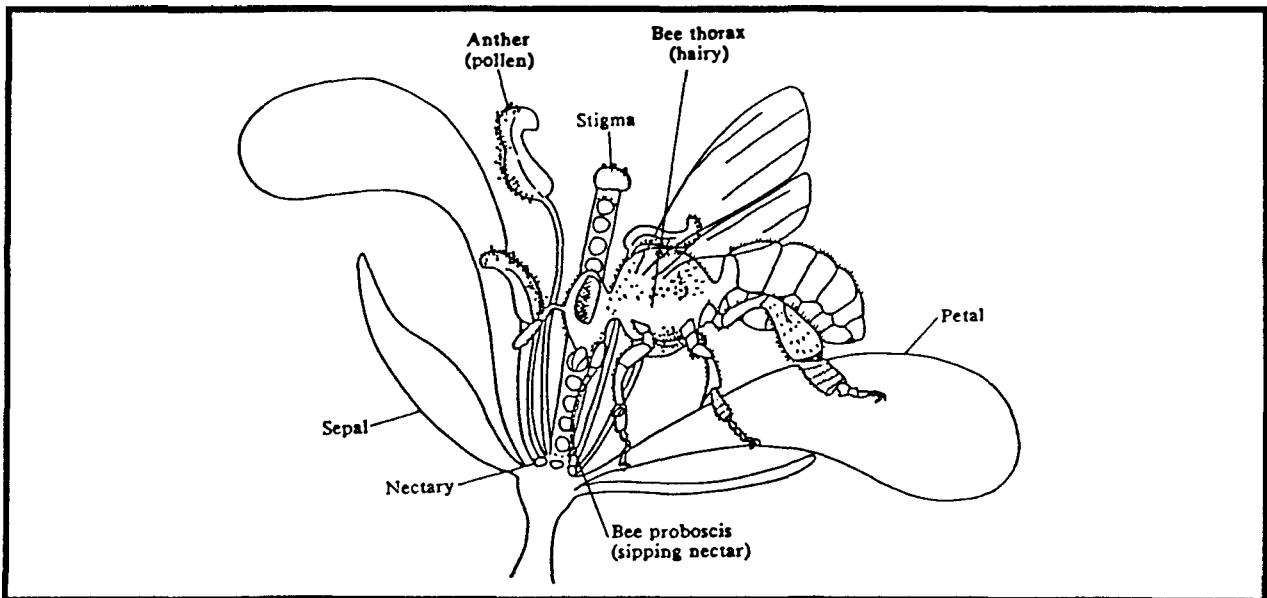


Figure 4a. Brassica flower and its pollinator, the honey bee (*Apis mellifera*).

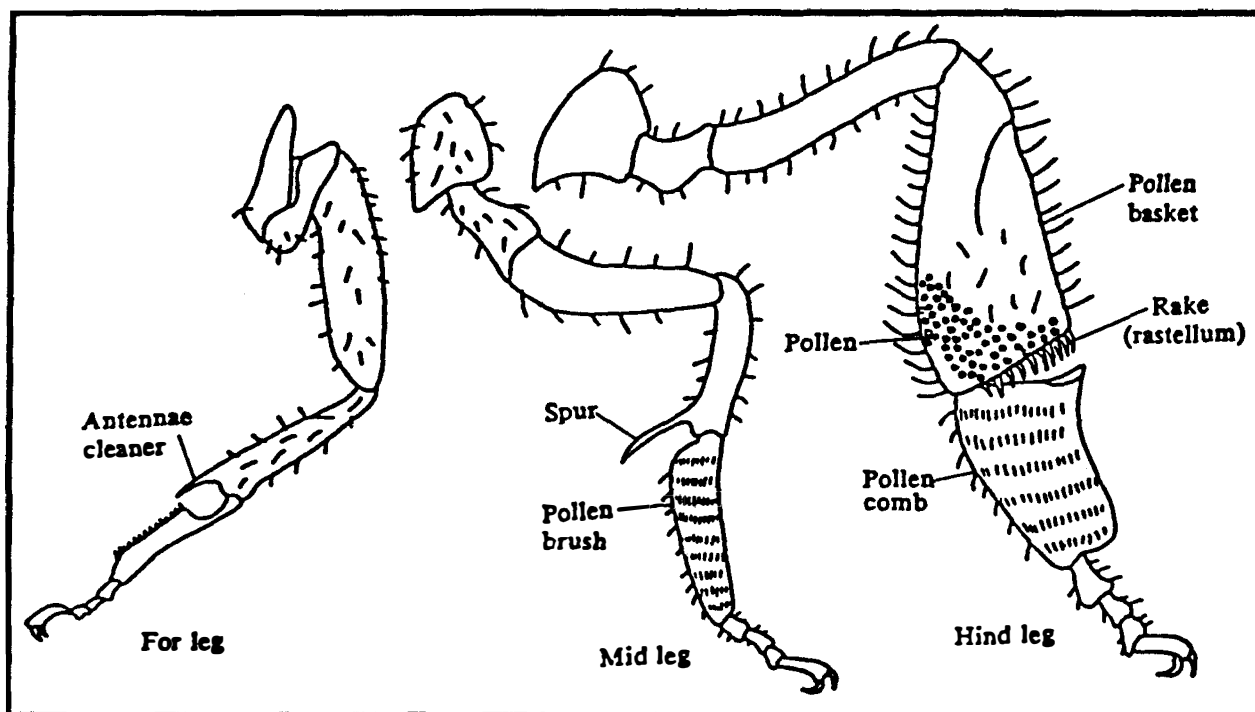


Figure 4b. The parts of a honey bee's leg.

Activity

Flowering occurs approximately 14-17 days following seeding. Students dissect and identify major structural features of both the honey bee and the brassica flower (see Figure 4, pages 10 & 11). Bring a functional interpretation to the above identified structures by pointing out the following coevolutionary relationships:

1. Flower petal color/eye structure and color vision of the bee.
2. Position and scent production of the floral nectaries/structure of the bee mouthparts (proboscis) and antennae.
3. Positioning of the anthers and stigma/bee foraging behavior; structures for the collection (setae covered thorax) and packaging of the pollen (leg structures: pollen brushes, pollen comb, rake, and pollen basket).

[Supplies of dead honey bees should be available from local bee keepers, either in early spring when the hives are cleaned in preparation for honey flow, or

in late summer and fall when honey is being removed from the hive. Bees can be dried in brown paper bags at 60 degrees centigrade for 24 hours.]

Pollination

Background

Pollen transfer is easily accomplished in *B. rapa*. An effective and inexpensive classroom pollination aid is the 'bee-stick' (Williams 1985). The bee-stick is the thorax of a dead, dried honey bee (*Apis mellifera*) glued to the tip of a round toothpick (see Figure 5, page 12). The plumose setae of the honey bee thorax have evolved as highly efficient pollen collectors. By rotating the bee-stick over the anthers, copious quantities of pollen can be collected and deposited on stigmas. Under normal classroom conditions, *B. rapa* pollen is viable for 4-5 days (stigmas remain receptive for three days after flower opening).

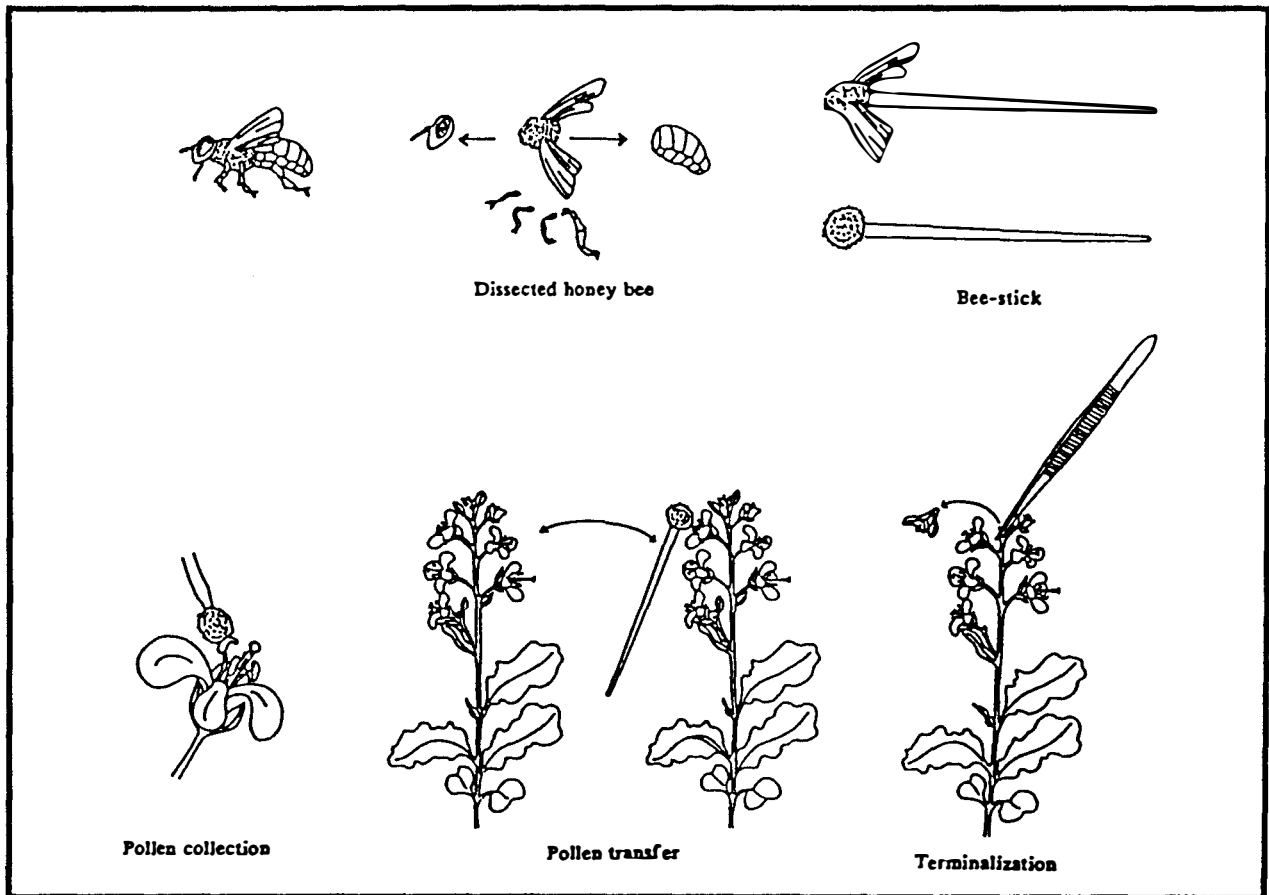


Figure 5. Preparing a bee-stick, pollination and terminalization.

Activity

Each student makes a bee-stick. Hold the honey bee by the wings and remove the abdomen, head and legs. Then, with a drop of fast drying model cement applied to the tip of the double-pointed round toothpick, glue the thorax to the toothpick by inserting the tip into a hole in the thorax left by the junction of the head or abdomen. Bee-sticks can be placed in a soft styrofoam cup or block to dry and the wings removed prior to use.

Cross pollination is accomplished by transferring pollen collected with a bee-stick from one or more plants to the stigma of another plant or plants. *B. rapa* is self-incompatible and thus pollen from a given plant cannot fertilize the flowers on that same plant. Using a bee-stick,

collect pollen by gently rotating the bee-stick over the anthers until copious amounts of yellow pollen are visible on the bee-stick. Then transfer the pollen by gently rotating the bee-stick over the stigma surfaces of the designated flowers.

When a sufficient number of pollinations have been made, the apical whorls of each plant should be snipped off with scissors or tweezers. Removing the apical whorls diverts nutrition to the developing pods. It also stimulates the production of lateral flower shoots. If successful pollination has occurred, these lateral shoots should be pruned throughout the remainder of the life cycle. Pod elongation and swelling will occur 3-5

days after successful pollination. If pollination was inadequate the first time around, the lateral shoots may be used for subsequent crosses.

Embryogenesis

Background

Fertilization occurs within 24 hours of pollination. With double fertilization [(n)

sperm and (n) egg to form a (2n) zygote; (n) & (n) polar nuclei and (n) sperm to form (3n) endosperm], many processes are initiated. The primary endosperm nucleus divides to form the endosperm; the zygote develops into an embryo; the integuments develop into a seed coat; and the ovary wall and related structures develop into a fruit (see Figure 6 below).

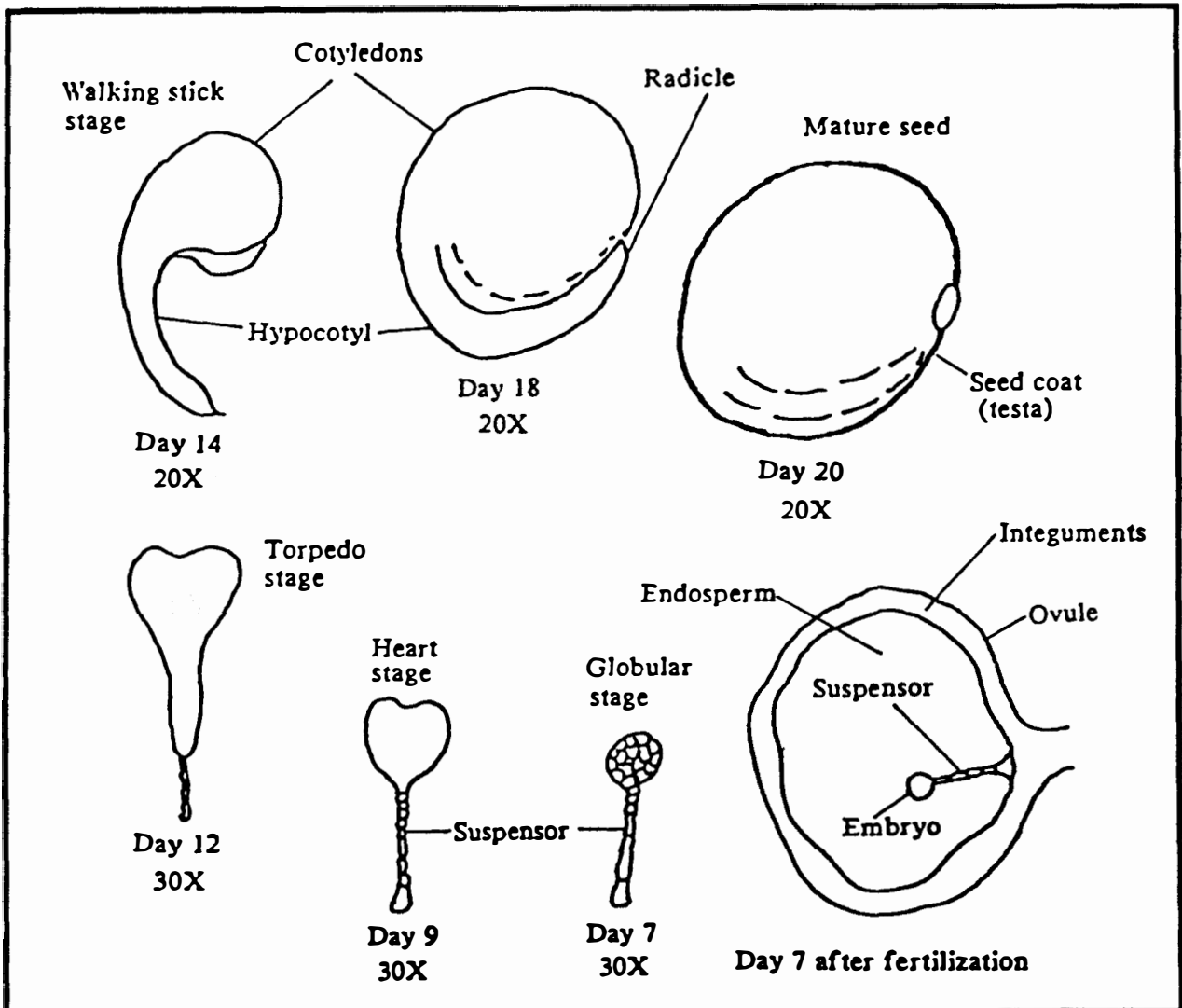


Figure 6. Embryogenesis in *B. rapa*. Formation of the embryo begins with the division of the fertilized egg within the embryo sack of the ovule. Through a progression of divisions, the embryo differentiates into a nearly spherical structure, the embryo proper, and a stalk-like structure, the suspensor (globular stage). With the initiation of the cotyledons, the spherical embryo gradually assumes a bilobed shape (heart stage). As embryo development continues, the cotyledons and the axis of the embryo elongate (torpedo stage) and the primary meristems extend along with them.

Activity

Observation and investigation of embryonic development requires a dissecting microscope with 20-40 X magnification. Students can easily observe embryonic stages by removing green pods from plants at various times after pollination, cutting open the silique (pod) to expose the ovules and cutting open or puncturing the enlarged ovules (immature seed). By placing the ovules in a small drop of water on a glass slide under the dissecting microscope and rupturing the ovary with a sharp needle, the young embryo can be squeezed or teased from the ovule and observed in the water drop. The fine granular liquid that comes out of the ovule with the embryo is the endosperm and is rich in starch and other nutrients.

THE WISCONSIN FAST PLANTS PROGRAM

The Wisconsin Fast Plants Program has initiated a Fast Plant Cooperative Network for educators interested in the development and sharing of instructional material using rapid-cycling plants. The program distributes a regular newsletter to teachers. Information regarding seed availability, growing supplies and procedures and curricular material may be obtained from:

**Wisconsin Fast Plants
University of Wisconsin-Madison
Department of Plant Pathology
1630 Linden Drive
Madison, Wisconsin 53706
(608) 263-2634**

ACKNOWLEDGEMENTS

Hafner, R.S. Cover and Figure 6.

Williams, P.H., ed. (1989). Figure 2, 3, 4a, 4b, 5. Wisconsin Fast Plants Manual. Carolina Biological.

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RECOGNIZING THE DILEMMA OF STRUCTURED LABS

Using Paper Strips to Teach the Value of Unexpected Results

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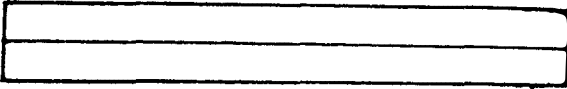
student reaction to unexpected results? Why not head off this situation during that early scientific method lecture?

The simple exercise that follows is one I have used with fourth graders, seventh graders, freshmen, non-biology majors, and even "honor students" in college. In all instances the attention and the "aha" were optimal during a lecture that some consider rather predictable.

Materials for a class of 15:

5 rolls of scotch tape
5 pairs of scissors (small is better)
20 paper strips lined on one side only
(1 inch wide by 8 inches long)

Figure 1.



Method: Xerox one side of lined paper. Cut strips so that a middle line is showing. See Figure 1.

Initial Procedure:

Pass out supplies and 1 paper strip to each group of three students. Have each group tape the ends of the paper strip to form a circle.

In any introduction to science, a

mandated lecture on scientific method

occurs early in the course. There are

diligent students who memorize the steps,

delve into the differentiation of inductive

and deductive reasoning, and can, when

requested, model the method for a

specified problem. When these same

students get to the actual laboratory

"experiments," they see little resemblance

between the process of completing their

assignment and the scientific method.

They find that the end results are only

achieved by following the instructor's

steps to the letter. When methods fail,

students feel a real sense of

disappointment and anxiety about

unexpected results. Students tend to

conclude that nothing is worse than not

duplicating the desired results.

Is this the attitude about results that

we want to develop in our students?

While it is true that structured

experiments allow the instructor to focus

investigations and develop methods, the

emphasis must remain on science. We

need to address the dilemma of

structured experiments early. Students

must learn to be careful when repeating

an experiment, but they must be open to

the unexpected. They need to

understand the opportunity that "wrong"

results present. How can we lighten up

Begin by pointing out that due to their experience with these materials they are in an excellent position to move from past observation directly to hypothesis for the following problem:
 "What happens when I cut a paper strip circle in two?"
 Ask the students to predict results. Gather their responses. Write this or a similar specific hypothesis on the board:

If I tape the ends of the paper strip to form an 8 inch circle and then cut the width of the paper strip in half, I will end up with two circles 8 inches in circumference and 1/2" wide.

Tell the students that we will now test our hypothesis. Student A in each group will cut the circles. (Hint: Pinch the end of the circle to start the cut.) Groups will write down their results and then compare them with other groups.

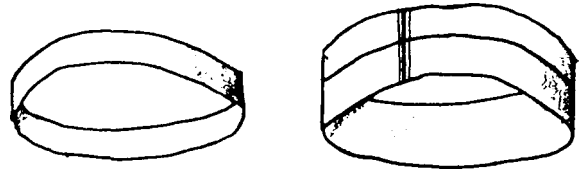


Figure 2.

Now lead a discussion of the acceptance of the hypothesis. Which groups accept or which groups reject? Pass out another paper strip to each group. Tell the students that you want them to repeat the process. (Look out for groans.)

Student B will cut this time. Step in just before they tape their papers and tell them to give a half twist to one end of the strip so that the blank side matches up with the lined side. See Figure 3. If anyone complains, point out that the procedure is allowed in terms of the hypothesis.

Repeat the procedure of writing down results and discussion. What does this do to their hypothesis? What can they do to control this?
 Suggest that they alter the original hypothesis by adding the phrase "lined side to lined side" after the word "circle." Write this on the board.
 Before they get too far in their discussion, quickly pass out the third strip of paper. Ask them to twist one end one full turn (360 degrees) so that lined side matches lined side. See Figure 5. Tape carefully.

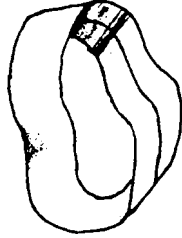


Figure 5.

Ask them to predict what will happen. Is anyone sure? Is this procedure allowed according to their hypothesis? Student C will now cut.

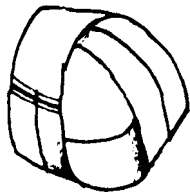


Figure 3.

Have the students cut carefully. See Figure 4. (Wait for the "aha.")

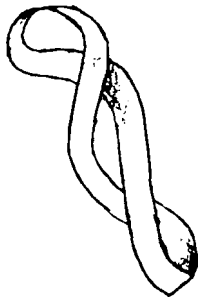
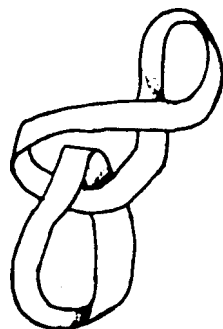


Figure 4.

Figure 6.



What does this do to the process of accepting the hypothesis? (Groups should still accept the hypothesis.)

Ask the students if there are suggestions to "improve" the hypothesis. Most students will feel that the procedure should be outlined more specifically.

They will recognize that individual interpretation led to variability.

If they desire a specific result, they need to develop specific methods. Many of the lab experiments they will complete in the course are the result of similar testing.

But what else happened? They got excited about the "wrong" results. They found the unpredicted results intriguing. If you don't believe me, try this: Pass out the fourth strip. Most groups will immediately try the one and 1/2 twist before you say a thing. (And I'm not showing you this one--you'll need to find out what happens on your own!)

This exercise stimulates students, even those who don't normally respond. They see the need to reevaluate methods. In order to do this they need to experience unexpected results. They value their "wrong" result because it surprised them.

Results that generate curiosity invariably lead to more science.

This truth is overlooked but remains a necessary part of any scientific method discussion. Students need to know the value of "wrong" results, even if the instructor does not.

THE COMMUNITY HOSPITAL AS A CLASSROOM RESOURCE

Elaine S. Chapman
Department of Biology
Illinois College
Jacksonville, Illinois 62650

When biology instructors from small, liberal arts colleges get together, usually one of the chief topics of conversation is the design and preparation of good laboratory exercises. Planning such exercises is often frustrated by a limited budget, a lack of equipment, and insufficient technical help. Although small liberal arts colleges often do not have the latest lab equipment or professional researchers in residence, they often have the advantage of small class sizes. This advantage makes possible the use of other resources which may compensate in part for technical limitations. The community hospital and local health care professionals, in particular, have been valuable instructional resources for me.

In the past five years I have used our community hospital and numerous health care professionals (e.g., physicians, nurses, medical technologists) to give my students a view of biology which was not available in the college classroom or laboratory. Because I am a pre-health professions advisor as well as a biology instructor, these field trips to area health care facilities also help me to counsel students about various career opportunities and their educational requirements. Although the health professionals who make presentations to my classes are all very busy, they usually welcome the opportunity to speak about their work to interested college students.

In turn, such tours and talks improve the public relations for the hospital and the professions. The field trips and presentations that I arrange involve no cost other than the use of college vans for transportation. These transportation costs have been met through a special course enrichment fund at Illinois College, so our departmental budget has not been affected in any way by these trips. Indeed, while expenses for the utilization of these local health care resources have been minimal, the value to my students and myself has been great.

Every year or two I have made arrangements for a cell biology class or an anatomy and physiology class to tour the clinical laboratory of our local hospital. The contact is made through the educational director of the laboratory who arranges the schedule for the group. Generally, a spokesperson for each lab specialty informs the students about the particular function of that department--chemistry, urinalysis, blood bank, microbiology, cytology, histotechnology, etc. This usually results in admonitions to the students to study more chemistry and physics! The students are exposed to the latest in equipment by the people who understand it and actually use it on a daily basis. Also, the class learns that many of the procedures they have discussed in class and perhaps attempted in lab are important in the "real" world. The

contacts I have made with the medical technologists at the hospital have yielded other, more practical results: they have often advised me on alternative lab protocols or supplied me with a particular chemical I needed on very short notice.

Often, after the students in anatomy and physiology have completed their study of the skeletal system, I ask a local physician to speak to the group about radiologic anatomy. He displays the X-rays as he describes the particular cases, and the students are called upon to identify various structures. Besides seeing anatomy in a new light, they

gain appreciation both for the difficulty involved in reading X-ray films and for the physics of X-rays.

The hospital is always willing to let us use one of their meeting rooms and the X-ray viewing lights during our laboratory period.

In our medium-sized town, professionals are often called upon to speak to various community groups. Therefore, a number of these people have illustrated lectures ready to give if their schedules permit. In the past I have asked a research veterinarian, a general dentist, and an optometrist to speak about their work. The veterinarian discussed some of his research projects with the cell biology class, and the dentist described the anatomy of the oral cavity and gave an insider's view of the dental profession when she lectured to the anatomy class. The optometrist, of course, spoke on the anatomy of the eye and problems of refraction. In each case the visiting lecturer was able to bring a slide set or a short film to illustrate the talk.

We are fortunate to be located only forty miles from a medical school, so each year I arrange a field trip for the cell biology class to visit the electron microscopy suite and hear a particular researcher describe some of his or her projects and techniques. This trip has become a tradition and is eagerly anticipated by the students; many of them return later to use the medical library for their research papers. The contact person is the public relations director of the medical school. He organizes the tour at my direction and arranges for the various professors and the electron microscopy laboratory director to speak to the group. We have a number of graduates now who work at the medical school as research technicians or who are enrolled in graduate or professional programs, so these contacts have been fruitful for the medical school as well as for our classes.

This year a philosophy professor and I developed a team-taught course on bioethics. Because many young people had never seen the sophisticated equipment used in an intensive care setting and may be unaware of the

circumstances which influence ethical decisions in a hospital on a daily basis,

I asked the administrator for patient care at our local hospital to show the students some of the equipment and discuss some cases. She arranged a panel consisting of three nurses and two physicians, each of whom gave a particular view of bioethical decisions and decision-making. In addition, the head nurse of the intensive care unit prepared a hospital bed and mannikin which was connected

to the many machines found in such a unit. These speakers in this setting with the "patient" on life support

gave a much more realistic view of bioethical problems,

and the students appreciated the opportunity to ask health professionals questions about the issues and equipment involved.

Another resource which has been provided to us through our local hospital is its library. The hospital library has a number of clinical journals which are often helpful to students writing research

papers. Although the students are not allowed to check out materials from the library, they have free access to those materials during regular library hours. The librarian and her staff have always been most helpful to the students and enjoy working with them to find resources.

I certainly do not wish to diminish the role of the laboratory experiment or exercise; these are the heart of our teaching. However, our laboratory instruction can be augmented in an inexpensive way through the use of local facilities and professionals. Perhaps my experiences with these programs will be helpful to other biology teachers as they strive to improve their instruction.

Visiting Professors for Temporary and Part-Time Teaching Positions

Often teaching positions of a temporary nature occur at the last minute, and there is considerable difficulty in filling positions with qualified individuals. Some of our retired faculty would be qualified for these positions and would be willing to serve on a temporary basis. In fact some regular faculty would welcome the opportunity to serve as a visiting professor at another school. In view of this, AMCBT is attempting to establish a teaching bureau which could be made available to any institution requesting the information, but in particular to member institutions.

If you would be willing to participate in this venture, please provide your teaching expertise, when you would be available, and the length of time you would be willing to teach. Details of salary, fringe benefits, etc. would be worked out with the particular institution.

We would appreciate your help in circulating this information to other members of your department and to recently retired faculty. Please send the information to:

**Dr. Ed Kos
Executive Secretary, AMCBT
AMCBT Central Office
Department of Biology
Rockhurst College
Kansas City, MO 64110**

The Site of Our Next AMCBT Meeting: Quincy College

Quincy College, founded by Franciscans in 1860, is an independent, coeducational, primarily undergraduate institution rooted in the Catholic tradition. It offers degree, professional and continuing education programs based on the liberal arts and humanities. The faculty of Quincy College strive for effective teaching, close student relationships, and creative achievements.

The college campus occupies three sites in the north-central section of the city. It is an urban campus with a variety of small businesses and shops within walking distance. The North Campus houses modern science facilities, general classrooms, faculty offices, a gymnasium and the varsity soccer field.

Quincy sits on limestone bluffs overlooking the Mississippi River in west central Illinois. One of the oldest cities in Illinois, Quincy is recognized as one of the three cities in the state that has architecturally and historically significant structures. Quincy is located 20 miles north of Hannibal, Missouri (Mark Twain's home town), and about 50 miles south of Nauvoo, Illinois, the historic Mormon settlement in Illinois.

The city of Quincy can be reached from the west on U.S. highways 24 and 36; from the south on U.S. highway 61; from the northwest by U.S. highways 218 in Iowa and 61 in Missouri; from the northeast by a number of roads including I-55 to Springfield, highway 36, Central Illinois Expressway to Jacksonville, and state highway 104 to Quincy; from the east on highway 36 and 104. Quincy College Main Campus begins three blocks north of Broadway or six blocks north of Main Street on 18th Street. Amtrack comes in from Chicago. Trans World has commuter service between St. Louis and Quincy, American Eagle has service between Chicago and Quincy, and Braniff may add service between Kansas City and Quincy.

**NEXT AMCBT MEETING
September 28-30, 1989
Quincy College
Quincy, Illinois 62301**

Theme: Values of Biology

PRELIMINARY AGENDA AMCBT MEETING

Thursday, September 28 Evening Sessions

6:00-8:00 p.m.

Registration/Reception

Meet your colleagues and share refreshments

8:00 p.m.

Welcome for AMCBT

Jeanene Yackey, Program Chairperson

Fontbonne College, Missouri

Welcome to Quincy College

Representative of Quincy Administration

Opening Session

Environmental Awareness: Why Save the Environment?

John Carlock

9:30 p.m.-?

Informal Social and Cash Bar

Friday, September 29 Morning Sessions

7:00 a.m.

Registration

7:30-8:30 a.m.

Buffet

Breakfast/Interest Groups

(Organized by Disciplines; price included in registration fee)

8:30-9:15 a.m.

Concurrent Sessions

Various Locations

The Compass Plant: Aldo Leopold Revisited

James Holler

University of Wisconsin-Platteville

The compass plant or cutleaf Silphium will be used to illustrate and emphasize Leopold's thoughts concerning the floristic, aesthetic and social losses that result from the removal of the native flora. Slides of the compass plant from various parts of the country will be shown.

The Use of Cellulose Acetate Film for the Production of Epidermal Casts of Leaves

Leland Hansen
Highland College

This technique permits students to observe features of a plant's epidermis such as distribution and nature of guard cells, epidermal hairs and glands. It can also be used to assess taxonomic similarity or confirm hybridization in some instances. Stomate distribution can be correlated with ecological studies. Use of live plant material provides more interest than using prepared slides.

How Can We Stimulate Interest in the General Biology Student

Ben Dolbeare (Tentative)
Lincoln Land Community College
Moderator of Panel

10:15-11:00 a.m.

Concurrent Sessions
Various Rooms

Escherian Esthetics of Pretty Pictures in the Plane: Scale Independence in Biological Patterns

John R. Jungck
Beloit College

I will demonstrate six different techniques for studying planar patterns such as epithelial cell boundaries, fish boundaries on sandy lake bottoms, and cross-sections of leaves as well as two-dimensional projections of three dimensional patterns such as the packing of side chains in polypeptides, bird territories, and forest canopies. The famous Dutch artist, Escher, dealt with symmetrical tessellations and his art has greatly intrigued numerous biologists. The techniques that I will discuss handle asymmetric as well as symmetric patterns. These techniques range from elementary school mathematics to contemporary research in modern mathematics; however, the esthetic motivation is the primary one and I promise to show lots of pictures and biological applications. Pedagogically, multiple ways of knowing and isomorphism of various approaches will be emphasized.

Computer Generated Codons

James Waddell
University of Minnesota

Learn about a simple computer program to represent mRNA molecules. Students use the "strands" and translate the molecules. This makes a suitable review of protein synthesis and an introduction to mutations and the significance of redundancy in the genetic code.

Come and share your ideas using computer programs to illustrate concepts.

11:15-12:30 p.m.

Keynote Address

Friday, September 29 Afternoon Sessions

Concurrent Workshops and Field Trips

12:30-2:00 p.m.

Open Lunch

Exhibits

1:00-6:00 p.m. FIELD TRIPS

(Sack lunches provided??)

1:15-4:45 p.m. WORKSHOPS

BioQUEST

John R. Jungck

What is BioQUEST? BioQUEST (Quality Undergraduate Simulations and Tools in Biology) is a Biology Curriculum based upon Problem-Posing, Problem-Solving, and Persuasion. BioQUEST is committed to learning how to do modern biological research, not towards classical undergraduate textbook materials. BioQUEST is committed to cooperative, group learning rather than individualistic competition. BioQUEST is a library of Modules integrated via a Labbook not simply a collection of simulations and tools. BioQUEST is Multi-level (i.e., freshperson and upper division courses may find BioQUEST materials of considerable interest). BioQUEST is constructed by a cooperative of biology educators not authors under short-term contract. BioQUEST is Dynamic not Static. Nine Macintosh BioQUEST software applications will be moving into the Beta-test stage this fall and will be available for trial in the workshop: Genetics Construction Kit, Microbial Genetics Construction Kit, Isolated Heart Lab, Sequencelt!, Purifylt!, Systems Modelling, AXON, EVOLVE, and Environmental Decision Making. Ideas for the use of other Macintosh software and other teaching, lab, and field situations to implement the 3P's pedagogical philosophy will be explored in group discussion.

ZPG Workshop (Tentative)

Loren Denny

Southwestern Missouri State

Respiration Therapy

Albert Gordon

Southwestern Missouri State

Friday, September 29 Evening Activities

6:00-8:00 p.m.

Cash Bar Social

8:00 p.m.

Dinner

President's Address

Saturday, September 30 Morning Sessions

7:30-9:00 a.m.

Balloting
Coffee and Doughnuts

9:00-9:45 a.m.

Concurrent Sessions
Various Rooms

Biological Humor

Russell Wagner

A bit of humor can always enliven your biology course, especially when this humor is appropriate to the topic under discussion. Humor may also be used to show the lack of biological knowledge among poets, cartoonists and humorists. Example: "A bee is such a busy soul, it has not time for birth control. That is why in times like these there are so many sons of bees."

With little imagination a pun will elicit a response to indicate whether or not your students are paying attention. Some may even enjoy them and perhaps you will be more vividly remembered. Students have helped to make my test grading bearable (not bareable) by coming up with such gems as "the castrate gland" and the "respectable of a flower."

E. coli Repair of Cis-Platinum-Damaged Plasmids

Robert Muckel

Doane College

Certain types of cancer are successfully treated with cis-platinum, which destroys their DNA. Those cancers that are resistant to cis-platinum treatment are able to repair the damage to their DNA. This paper details with a preliminary study of the repair of cis-platinum damaged plasmids in *E. coli*.

Acceptable Practices Part I: Vertebrate Usage in Teaching and Research

James Rooney; Dave Erkenbrack

Lincoln University; Central College

Review of the basic regulations and guidelines acceptable in the housing and care of vertebrate animals for either teaching or research purposes. A bibliography of relevant literature will also be made available to participants.

10:00-10:45 a.m.

Concurrent Sessions
Various Rooms

Acceptable Practices Part II: The Animal Rights Issue

James Rooney; Dave Erkenbrack

Lincoln University; Central College

The ethical, moral and legal dilemmas of vertebrate usage in teaching and research will be discussed. Such issues as alternatives to live-animal research, regulation differences in livestock-industry research, and strategies of dealing with the animal rights movement will be included. Participant interaction is strongly encouraged.

Essentials of Exercise Physiology

William Buckley

St. Xavier College

Exercise Physiology is a study of the responses and adaptations that occur in the body during exercise. This science is based on theoretical foundations and also has practical applications. In exercise physiology the functions of various physiological systems are studied from the perspective of their role in physical performance. An overview of the basic concepts and current information will be presented.

11:00 a.m.-12:30 p.m.

Brunch (Price included in registration fee)

ACTION GROUPS:

Midwest Bioscience Editorial Board

Resolution Committee

Membership Chairs with President Elect New Members and Interested Members

Closing Business Meeting

12:30-2:00 p.m.

Executive Board

Application for Membership

ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS

NAME _____ DATE _____

TITLE _____

DEPARTMENT _____

INSTITUTION _____

CITY _____ STATE _____

ZIP CODE _____

ADDRESS PREFERRED FOR MAILING _____

CITY _____ STATE _____

ZIP CODE _____

PHONE NUMBER _____

MAJOR INTERESTS:

- () 1. Biology
- () 2. Botany
- () 3. Zoology
- () 4. Pre-professional
- () 5. Teacher Education
- () 6. Other

RESOURCE AREAS:

RESEARCH AREAS:

Have you been a member before? _____ If so, when? _____

Mail To:

Edward S. Kos
Executive Secretary, AMCBT

AMCBT Central Office
Department of Biology
Rockhurst College
Kansas City, MO 64110

Current Dues are \$15.00