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Bees: An Interdisciplinary Approach

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Teaching Level:

For elementary school teachers, grades 4 6, and middle school teachers, grades 7 and 8. Individual students or small groups may follow the curriculum independently.

Part I: General is for elementary school.

Part II: Specific is for middle school and students working on their own.

Part I: General

You know how important time is to us and how much attention we pay to hours, days, seasons, rhythms and cycles. Well, scientistsare finding that life is a marvelously complex pattern of rhythms and time cycles, in tune with a world made up of the rhythmic movements of the sun, moon, stars, and planets and the precision of vibrating atoms. In fact, scientists are concluding that probably all forms of life have builtin clocks of one kind or another.

Lets look at the bee (Apoldea). Bees are blessed with a very reliable twentyfourhour clock that is seldom affected by anything and does not seem to depend on events in the outside world to keep it working.

Bees also can measure very short units of time, down to mere fractions of a second. They use their internal clock sense to arrive at the right time for the opening of a flower that offered a generous serving of nectar the day before.

The biological clock is also a very important part of a bee’s directionfinding equipment. When a foraging bee leaves the hive to look for nectar or pollen, an almost unbelievable process begins. Flying at a speed of perhaps thirteen miles an hour, the bee’s eyes sense its flight speed in relation to the ground and somehow measure the direction of its flight compared to the angle of the sun.

On a heavily overcast day bees seem confused, presumably because there has been no glimpse of the

position of the sun. But on a partly cloudy day, a bee can use a small patch of blue sky as its directionfinder. This is possible because bee's eyes detect polarized light. Bees also see the entire pattern of the sky at once, for their compound eyes are made up of thousands of tiny facets.

It is interesting to note that flowers look quite different to bees from the way they look to us. This is because bees see ultraviolet as a distinct color in itself.

When it comes home to the hive, the bee does its intricate little showandtell dance accompanied by a whirring sound made by beating its wings.

This tailwagging dance done by a foraging bee involves a number of precise measurements and is rather complicated. The dance, performed on a wall of the hive, traces a sort of imaginary mathematical diagram of the direction and distance to a supply of nectar or pollen. The bees who watch the dance also examine the body of the dancer with their antennae to find out what kind of flowers have been visited. The scent of the blossoms clings to the forager's hairy coat. The quality of the food is tested by tasting the sample while the reporter bee tells its opinion of food through the energy and persistence of its dancing.

Additional information is given by the dancing bee through the whirring sounds it makes. The length of the sounds indicates the relative distance from the hive to the food supply. It is believed that the bee audience "hears" the sounds through his legs. Bees are very sensitive to slight vibrations in any material they are standing on, although they are otherwise deaf to most sounds.

The antennae of honeybees serve as their thermometers. From them, the bees receive signals telling them what needs to be done to keep the hive comfortable and safe. If the bee colony is too warm, some of the bees form living chains and fan the air with their wings. Other bees collect water, which will cool the nest as it evaporates from the surfaces of the honeycomb. At the same time, a watery substance, probably from their honey stomachs, evaporates from their mouths. When it gets too cold outside, the bees warm the nest by clustering very closely together.

Part II: Specific

Orders and families of Bees: (Refer to chart)

The place of bees in time: Fossils of all living families of the Hymenoptera are found in the Cenozoic era, tertiary period.

Bees (Apoidea)

Bees are characterized by their dense coating of plumose and the enlargement of the first or basal joint of the hind tars). In many bees this joint has rows of comblike hairs which are used for gathering pollen. Moistened pollen is packed between marginal rows of bristles on the outside of the hind tibiae and carried back to the nest. Pollen is transferred from the pollen brush to the pollen basket by rubbing the two hind legs together, scraping the grains from the tarsus of one leg, and forcing them into the basket on the tibia of the opposite leg. The scraping is done by the pollen comb, a row of stiff bristles located at the end of the tibia on the inside; the pollen is forced through a gap between the tibia and tarsus, into the concave pollen basket on the outside

of the tibia. The honey stomach at the anterior end of the alimentary tract is used to store nectar and carry it to the nest, where it is manipulated and stored in cells as honey. Flowers provide their basic food, and, for many species' a mating site and place for sleeping. The food of adult bees is largely nectar (which is mostly carbohydrate), with some pollen; the larval food is largely pollen (which is rich in protein), usually mixed with some nectar. "Constancy in the collection of pollen is a characteristic of bees in general" (Linsley). Many species consistently collect pollen from a single species or a group of related species; this is a characteristic of the great majority of solitary bees.

It has been estimated that in total species bees constitute about 25 percent of the Hymenoptera. Most wild bees are solitary and nest in the soil.

There are three kinds of social bees: The bumblebee, honeybee, and stingless bees. They are generally grouped into one family, the Apidae.

Stingless bees are strictly tropical and not found north of Mexico. Like the honeybee, they establish new colonies by swarming, but with the difference that new queens leave the nest to find a new colony rather than the mother queen. Though stingless, swarms of these bees can annoy humans, since they are sticky and can bite slightly.

The common bumblebees (balteatus) belong mostly to the genus *Bombus* and are usually black and yellow. Colonies breakup in the fall and only the young queens, now mated, remain to hibernate; all others perish. In the spring, after emerging from hibernating quarters in the soil or litter, the queen looks for a place to nest, which may be on or below the ground surface, under rocks, in a clump of grass, the abandoned nest of a mouse or bird, and makes preparations for her first brood. Egg cells are constructed, usually of pollen in the case of the first brood, and one egg is laid in each. One or more cups are fashioned of pollen and wax and filled with honey before the young arrive. There are three distinct castes among social bees: The fertile female (queen), the infertile female (worker), and the drone (male).

After the first brood arrives, commonly all workers, the queen confines herself to egglaying while her daughters forage and enlarge the nest, constructing brood cells, building and storing honey and pollen pots, caring for the young. Brood cells are not used again, but cocoons are used for storage of honey and pollen after undergoing alterations. In some colonies the second brood is all male and the third brood is female. Workers of the later broods become progressively larger. The queens and males usually leave the nest and fly off to mate. Males are often seen flying about the entrance at this time, waiting for the young queens to come out.

Bumblebee colonies are never large; probably they average less than 200 individuals and seldom contain more than a few hundred.

BumbleBee (Bombus fraternus)

Unlike the honeybee, bumblebees have one or two spurs on the hind tibia. Next to the Pennsylvanian bumblebee, this is the most common eastern species.

Black, with the thorax anterior portion above and on sides yellow. Broad black band between the wings. Abdomen with two basal segments above yellow. Wings blackviolaceous, darker toward the bases. Length is .85 1" (queens), .5.9" (males), and .5.85" (workers).

Pennsylvanian (American) BumbleBee (Bombus americanorum)

Black with front of head clothed with black pile. Males somewhat variable, with greater part of abdomen above yellow and apex reddish brown. Females with front of abdomen yellow, the remainder black. Length is .7.9” (queens), .55.9” (males), and .5.7” (workers), They visit a wide variety of flowers and are usually found in open grasslands. Easily irritated, the workers often pursue an intruder. Their sting is painful to sensitive persons.

Blackfaced BumbleBee (Bombus californicus)

Head entirely black, with front of thorax and usually dorsum of only the fourth abdominal segment yellow. Hairs moderately long and coarse. Length is .6 .9” (queens), .5.65” (males), and .35.6” (workers). A longtongued species very valuable as a pollinator of red clover.

Yellowfaced BumbleBee (Bombus vosnesenskii)

It is black, with face, top of head, pronotum, mesonotum in front of wings, and dorsum of fourth abdominal segment yellow. Hairs are dense, short and fine. Length is .4.8” long.

Yellow BumbleBee (Bombus fervidus)

Black with most of thorax and dorsum of first abdominal segments yellow. Hairs dense, coarse and medium in length. Often confused with the Pennsylvanian bumble bee. Length is .6.9” (queens), .4.6” (males), and .3 .6” (workers). A longtongued species very valuable as a pollinator of red clover.

Nevada BumbleBee (Bombus nevadensis nevadensis)

Head of female all black, face and occiput of male yellow. Tip of abdomen reddish in the male. Dorsum of thorax and first three abdominal segments of male and female yellow. Hairs dense and short. It is a prolific producer of wax. Length is .7.9” (queens), .5.7” (males), and .6.7” (workers). A longtongued species very valuable as a pollinator of red clover. *Bombus nevadensis auricomis* occurs in the eastern states.

Honeybee (Apis mellifera)

Generally some shade of black, gray, or brown, intermixed with yellow. Thorax with dense coat of fine short hairs usually black or paler in color. Abdomen has a thin coat of hairs and often banded with yellow. Unlike bumble bees, the hind tibia is without spurs. Length is .6.8”. There are now several races of Apis *mellifera* in use in North America. The most popular has been the Italian bee, partly because of its brighter color and the greater ease in finding the queen. The queen is black, with scattered yellowish hairs, three to five yellow bands on the abdomen. This is a gentle bee and fairly easy to handle.

The Caucasian bee is mildmannered, though a persistent stinger when aroused, black in color and banded with gray. It has a longer tongue than the other honeybees, and is a heavy producer of propolis (bee glue), a brown resinous substance which serves as a wax cement.

The Carniolan bee is gray and otherwise closely resembles the Caucasian. It is the most gentle of the three races. Carniolans are good combbuilders.

Colonies of honeybees (Apis mellifera) are maintained throughout the winter by their habit of storing honey

and clustering. The population of workers in a hive of honeybees may be 20,000 to several times this number. By continued movement of wings, legs, and bodies and the normal process of metabolism, enough heat is generated to keep the compact cluster of individuals alive. They draw closer together as the temperature drops and shift their position to gain access to more stores of honey.

The queen remains within the cluster and by early February begins laying eggs. As the days grow longer and warmer, the cluster expands and drones are produced in preparation for the division of the colony.

The worker broods are kept in the lower central part of the comb, and the pollen stored around them in cells of the same size. The larger cells of the drones are usually in the lower corners of the comb. Honey is stored in cells of the same size toward the back of the hive. Queen cells are large thimbleshaped cells which hang down vertically from the brood comb.

Brood cells are kept open and the larvae fed daily. All get royal jelly, a secretion of the workers, for two days. Workers and drones are then given honey and pollen; white queens remain on the royal jelly diet.

The white grublike larva is full grown and fills its cell in about six days. The cell is capped and the larva pupates after spinning a cocoon. Pupation requires about seven and onehalf days for queens, twelve days for workers, and fourteen and onehalf days for drones.

Swarming by honeybees occurs when new queens appear in the hive, prompting the mother queen to leave and half the colony to follow her. They cluster on a limb or other overhang and remain until the scouting bees find a new home.

In the parent colony the new queens fight one another until only one remains alive. The survivor flies out to mate and returns as the new queen mother.

Young workers first serve as nurses, later produce wax, and after about three weeks of various chores in the hive become foragers. Workers live about six weeks during the peak of activity. The queen is fed royal jelly throughout her life, which lasts a year or more. Drones are fed honey as long as it is plentiful but are ousted from the hive when they become a burden. Their life span is about eight weeks.

The true honeybee, Apis mellifera, a native of Europe, Asia, and Africa, was brought to North America by the early settlers sometime before 1638. For many decades it was important only as a source of honey and beeswax. Because honeybees are proficient pollinators, it has been estimated that 80 percent of our commercial crops today are pollinated by honeybees.

The principal insect enemies of bees among the predatory species are robber flies, assassin bugs, ambush bugs, ants, and sphecid wasps.

Some other families of bees:

Sweat Bee (Halictus farinosus)

Black, with yellow legs, reddish yellow markings on abdomen. Head and thorax with covering of long dense hairs. The tongue is short and pointed. Length is about .45”. They are important pollinators of agricultural crops. *H . rubicundis* and *H . confusus* are important pollinators of lowbush blueberries and buckwheat.

Alkali Bee (Nomia melanderi)

Black with abdominal segments two to four with broad light emeraldgreen apical bands. Anterior part of mesothorax with pale yellowish brown hairs and black bristles intermixed. It nests in sandy or alkali soil, for which it gets the name “alkali bee”. Length is .5”. They are gregarious and often form huge aggregations of individual nests. It is an important pollinator of alfalfa grown for seed, but has “a rather broad host range for a wild bee,” according to Ribble. *N . howardi* is now considered a separate species.

Mining Bee (Andrena carlini)

Black, with dense covering of long hairs on head, thorax, and legs. The tongue is short, pointed. Length is .6”. It is an important pollinator of blueberry, as is *A . regularis* .

Mining Bee (Anthophora occidentalis)

Black, clothed with a dense, short yellow pubescence. The tip of abdomen is dusky. Wings are clear with apexes dusky. Male with face on each side lemon yellow and tarsi brownish yellow. Length is .65” *A . abrupta* is similar to occidentalis.

Anthophora is a fairly large genus of “mining bees, which usually occur in large colonies and show a decided preference for sand or clay banks. Adults visit many different kinds of flowers.

Andrenid Bee (Perdita zebrata)

Head and thorax dark metallic blue with white pubescence. Abdomen yellow, segments two to four with brown margins. Legs yellow, marked with black. Wings clear, iridescent, with brownish venation. Length is .2 .25”.

The genus *Perdita* is a large group of small bees confined largely to the western states. Close to 750 species have thus far been described, according to Timberlake. They are remarkable in often restricting their choice of flowers to one or a few closely related species. They are gregarious, nest in the ground, usually in groups with one female to a nest.

Colletid Bee (Colletes compactus)

Black, with dense covering of long hairs on head, thorax, and legs. It has a short, slightly bilobed tongue. Length is .45”. They like asters, goldenrod, sneezeweed, sunflower and closelyrelated composites.

Colletid Bee (Hylaeus modestus)

Black, side of face lemon yellow in the male, with triangular yellow patch in the female. Wings clear, tinged with brown, venation reddish brown and tibiae yellow basally. Tarsi reddish brown in the female, yellow in the male. Apical margins of abdominal segments brownish. Length is .2.25”. *H . affinis* is the same size, black, with yellow markings similar to those of *modestus* .

Mason Bee (Hoplitis producta)

Black, with marginal bands of short white hairs along either side of abdomen. It lacks pollen baskets on the tibiae, carries pollen in “pollen brush” on underside of abdomen. Length is .3”.

Leafcutting Bee (Megachile latimanus)

Black, densely clothed with pale brownish yellow pubescence, faint white apical bands on abdominal

segments two to five. Pollen brush of female on underside of abdominal segments two to five pale red. Length is .5 .6”. _. *perihirta* is very similar, but i6 slightly smaller; pollen brush of female brighter red. The pollen brush of *M* . *dentitarsus* , on segments five and six, is red on apical half only. These above species are the most important pollinators of alfalfa. They are more active than bumblebees and honeybees, and unlike them, consistently trip flowers, which is essential to pollination.

M. *rotundata* , black, with yellowgreen abdominal bands, whitish yellow pollen brush is Eurasian in origin, was accidentally introduced into the eastern states in the 1930’s.

Little Carpenter Bee (Ceratina dupla)

Metallic blue and length is .25”. Lives in sumac and other pithy plants. Adults visit many kinds of flowers in various families. *C* . *acantha* is similar to C. dupla.

Carpenter Bee (Xylocopa virginica)

Black, resembling a bumblebee, except that the abdomen is bare and without conspicuous yellow markings. It lacks pollen baskets on the hind tibiae, a dense brush of hairs serving the purpose. In *Xylocopa* females the antennae have 12 segments, and the hind tibiae have two spurs. The males have 13 segments on their antennae and one spur. Length is .91”. Adults visit a number of flowers.

Mountain Carpenter Bee (Xylocopa tabaniformis orpifex)

Black, male with white or yellow and black hairs on head and prothorax. Length is .5.7”. The Valley Carpenter Bee (X. brasilianorum varipuncta) is larger, iridescent blueblack (female) or yellowish (male).

ORDER AND FAMILIES OF BEES

Order	Hymenoptera (Bees, Ants, Wasps, Sawflies, Horntails)				
Suborder		Apocrita (Wasps, Ants, Bees)			
Superfamily			Apoidea (Bees)		
Family				Hallctidae (Halictid Bees, Sweat Bees)	
					shorttongued bees, have one suture below each antenna.
Family				Andrenidae (Andrenid Bees)	
					acutetongued bees, have two suturea below each antenna.

Family	Colletidae (Colletid Bees)		
		obtusetongued bees.	
Family	Megachilidae (Leafcutting Bees)		
		longtongued bees, thickjawed, have one suture below each antenna.	
Family	Apidae		
Subfamily		Anthophorinae (Anthophorid Bees)	
			flowerloving bees.
Subfamily		Xylocopinae (Carpenter Bees)	
Subfamily		Apinae (Bumble Bees, Honeybees)	

BEHAVIORAL OBJECTIVES

The student will be able to:

describe the characteristics of the bee.

identify the parts of the bee.

demonstrate a knowledge of the function of the parts of the bee.

recognize the diversity of the order Hymenoptera.

discuss the importance of bees to man.

LABORATORY.MATERIALS

Preserved Specimens

Bees (different types)	1 per student

Permanent Equipment

Magnifiers, low-power	1 per student
Microscopes	per student

Supplies and Materials

Cork stopper		5 per student
Dissecting needles	1 per student	
Dissecting pins	6 per student	
Forceps		1 per two students
Knife		1 per four students
Razor blades (1 edge)	1 per two students	
Rule, 12” with mm scale	1 per student	
Scissors		1 per two students
Slides, microscopes	2 per student	
Jars, widemouth with screw tops	2 per student	

Lesson I: Adaptations of a Bee

Time: One lab period
Materials: Honeybees, insect pins, cork, and handlenses

For teacher:

It will be best to provide bee specimens for the students, rather than to have them do the collecting. Bee stings are dangerous, and to persons who are sensitive to bee venom, stings can be extremely serious.

Interested students may want to remove various parts of a bee’s body and observe them, using the low power of a microscope. Parts such as antennae, wings, or legs can be removed with a forceps, and placed on a slide under a cover glass for viewing.

If the honeybee is pinned through its thorax, you can use a large cork as an observation platform. A hand lens will be helpful for examining the body parts in detail.

For student:

Note that the body is divided into three major regions: a head, a thorax, and an abdomen. The wings and legs are attached to the thorax.

Locate the paired antennae and the compound eyes on the bee’s head. These are sensory organs that aid the bee in locating food. Observe the mouth parts. They consist of several long structures that form a tube. Nectar is drawn up through this tube into the bee’s stomach.

Examine the honeybee’s legs. They are covered with hairs that collect pollen as the bee visits flowers. On the front legs are pollen brushes. These are used to sweep pollen from the body to the pollen baskets located on the hind legs. There is a notch on the front leg that is used to clean the antennae. Another part of the front leg serves as a brush for cleaning the compound eyes. The long, sharp spur on the two middle legs functions to remove pollen from the pollen baskets. The pollen is then stored in the comb of the hive.

Finally look for the stinger. It appears as a dark, needlelike part protruding from the tip of the abdomen. Other

parts of the stinging apparatus are inside the body, including a poison sac and poison glands.

Lesson II: Reflex in a Bee

Time: One period
Materials: Bee, toothpicks, quickdrying glue, cotton balls

For teacher:

It is suggested that a quickdrying cement be used for gluing a bee onto a toothpick. You can either use rubber cement or the model airplane glue used for gluing pieces of balsa wood. Bees will react very sluggishly when put in cold temperatures. As the temperature warms up, the bees become much more active. When the feet of a bee are not touching anything, its wings will flap. As soon as the feet touch something, the bee stops flapping its wings. This is a reflex action.

For student:

Dip the broad end of a toothpick into some quickdrying glue. Then touch the glue to the back of a bee which has been chilled so that it is not active.

Record your observations of the bee's behavior as it warms up.

Record your observations of the behavior of the bee as it is held in different positions, such as upside down, on its side, right side up, and head down.

Record your observations of the behavior of the bee as its feet touch a ball of cotton.

Lesson III: Interdisciplinary Ideas

Activities

- woodwork students could construct a model of a hive

- mathematicallyminded students could measure a bee's length. Weigh bees, etc.

- students who like art may draw different types of bees. (Examples of this lesson are on the next four pages.)

musicallyinclined students could record bee sounds.

- students of English may write poems, stories, and essays about bees.

figure available in print form.

figure available in print form.

figure available in print form.

figure available in print form.

ANNOTATED READING LIST FOR STUDENTS

Barker, William, *Familiar Insects of America* . Harper and Row, New York, 1960. (Describes those insects commonly seen in town, country, field, or forest.)

Callahan, Phillip, *Insect Behavior* . Four Winds Press, New York, 1970. (A highly readable account on many aspects of insect behavior with a special section on possible projects and experiments.)

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LaBerge, W. E., and Webb, M. C. *The Bumblebees of Nebraska* . Res. Bull 205, Agr. Exp. Sta., University of Nebraska, Lincoln, 1962. 38 pp., 12 figs. (Technical reading.)

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