Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1981 Volume IV: Writing Across the Curriculum

Perception and Sense Organs A Writing Unit for Biology

Curriculum Unit 81.04.10
by Elisabet O. Orville

Students in my biology classes are always interested in sense organs and perception. The facts that butterflies taste with their feet and most mammals see only black and white fascinate them. What would it be like if we humans were like bats and used echolocation to find our food? Can a newborn see her mother's face? Do whales talk to each other? Do all people see things in the same way?

Why does the subject of perception provoke so many questions? Perhaps it's because we humans are so visually oriented that we forget that animals often depend on other senses for survival. For instance, a male gypsy moth can detect the scent of a female who is more than 1/2 mile away; a bat locates moths at night by aiming waves of high frequency sound; and a cockroach disappears in a flash if air currents disturb the feelers on its abdomen. By studying the sense organs of various animals we can extend the limits of our own concept of reality.

This five to six week unit is designed for high school classes, but with slight modifications it would also be suitable for middle school.

This is both a science unit and a writing unit. My premise is that if students get "hooked on science" they will be willing to write about their observations and experiments, especially if they can build up their vocabulary gradually. Writing is the most important skill a student can learn in school but traditionally we have not done too much of it in science classes. The kind of writing assignments I would like to see emphasized in my biology class are daily writings based on the activities and discussions of the day. What I have done up to now is to assign copious worksheets and an occasional report. Although the worksheets are welcomed by many students, the brightest ones are not very stimulated by them. Doing the reports is always good but I have often had the feeling that I should build up to them more gradually so that students would feel more confident about using their own words instead of copying the encyclopedia.

This unit on perception and sense organs emphasizes daily writing assignments based on the activities the class has done that day. Students may complain that this is NOT an English class but once they get used to the daily writing rhythm and their scientific vocabulary starts to build up, their confidence will too, and the going will be easier.

Writing should start casually, as a group activity, with the emphasis on just words at first. There should always be a discussion before the actual writing. Gradually longer pieces can be attempted, in class if possible, culminating finally in a short research report. The important thing is that students get practice in writing every

day.

It would also be useful if the students could get used to reading their writings out loud either to another student or to you, the teacher. This feedback will help them improve the clarity of their writing as well as correcting mistakes.

When we science teachers do teach writing, how much grammar should we emphasize? I personally don't think that we should give regular lessons in grammar (*that* I would prefer leaving to the English teachers). There are two things that I would emphasize in scientific writing: correct use of scientific vocabulary and logical thinking. That is, did the student stick to the subject and did she argue convincingly using facts learned in class?

The other aim of this unit, of course, is to learn some science in particular, perception and senses of sight, hearing, touch and smell. (Taste will not be covered). Students should, as much as possible, obtain their information in the same way as scientists by observations and open ended experiments, and then use these results in their writings. The nice thing about teaching science is that so many students are careful observers and really inventive experimenters, and that these skills have little to do with intelligence or writing abilities. Everyone has something to offer when results are discussed. It's important that students feel like scientists and learn to be critical, to question authority and to try new approaches. (One student I had last year always signed her lab reports, Jane Smith, SCIENTIST, when she felt particularly inventive.)

PERCEPTION AND SENSE ORGANS: How to approach the unit.

Each sense in this unit will be covered in somewhat the same way. We will start by investigating the students' own senses and eliciting a vocabulary from them. Then we'll go on to scientific diagrams, vocabulary and experiments. Next we'll consider what it would be like to be missing that particular sense, and finally how various animals use their senses.

There are diagrams at the end of this unit which accompany various activities. In addition there is a learning package at the Yale-New Haven Teachers Institute which contains 30 copies of various readings for the unit. (telephone number: 436-3316) There are also 30 magnifying glasses and 15 penlights at the Institute which are needed for experiments.

Since so much emphasis in this unit is placed on writing, each student should ideally have a notebook to be used only for biology.

SENSES IN GENERAL AND VISION

The first WRITING ASSIGNMENTS will be group activities which develop word lists about the senses.

1. Ask your students how many of their senses they have used already this morning. Set up the five headings of *hearing* , *sight* , *touch* , *smell* and *taste* (in any order) on the board and write

down how they used them. For instance, *smell* , frying eggs or *sight* looked at the newspaper. Have them copy the lists on paper and remind them to bring notebooks the next day.
2. Have them write which sense has been the most important to them today, and why. Have as many students read their answers our loud as possible and quickly tabulate the class's results. Vision will probably be chosen by almost all students as the most vital sense.
3. This informal poll should make vision the logical starting point. Now build up a list of adjectives that are strictly visual in the following manner: put a vase of particularly colorful flowers on the desk or table and if possible have students arrange their desks in a semicircle around it. Elicit one visual adjective from each (all nonvisual adjectives are rejected) and have the students write them down as you put them on the board.
4. List all the synonyms that students can think of for seeing. (for instance, squint, peer, gaze). You could make it a contest between the two sides of the room.

What is light?

The ancient Greeks thought that the eye sprayed out beams of light that lit up whatever we were looking at but of course we know now that the light source is always external and is reflected from the perceived object *into* our eyes.

The sun, which is the source of most of our visible light, also gives off radio waves, infra red, ultraviolet and X-rays. All these forms of energy travel as waves at 186,000 miles/second. The only difference between them is their wavelengths radio waves are very long and X-rays are extremely short with visible light somewhere in between. (you will probably need to explain about waves and wave lengths).

ACTIVITY: *The Electromagnetic Spectrum and Vision* Reproduce Diagram 1 at the end of this unit for your students to tape into their notebooks. They will also need colored pencils.

1. Discuss the various forms of electromagnetic energy and explain the meaning of the exponents (104 = 10x10x10x10) Emphasize that the only difference between visible light and X-rays, for instance, is the wave length.
2. Have students locate the tiny band of light visible to human eyes, and then color in the spectrum as indicated. (from left to right, red, yellow, green, blue, violet). Explain that color is determined by the wavelength of light. Red, for instance , has a longer wave length than violet.
3. Color the rest of the electromagnetic spectrum black, indicating that it is invisible to human eyes. Therefore our eyes are sensitive to only a tiny band, although we can feel infra red as heat and ultraviolet produces a sunburn.

Although human eyes are quite limited is that true of animals also? Actually bees can see ultraviolet as a

visible color. A flower that reflects ultraviolet will look quite different to a bee than a human, but on the other hand bees can't see red—it probably looks black to them. A bee's visual world is very different from a human's visual world.

Most mammals and all nocturnal animals see very little color at all. We humans (along with bees and birds) are exceptions in having color vision.

WRITING ASSIGNMENT: Describe what it would be like to go clothes shopping if you could see NO colors, only shades of black, gray and white.

The outside of the eye:

ACTIVITY: Have your students work as partners, taking turns looking carefully at each other's eyes. Have them draw each other's eye, label the parts they know and write down all observations (for instance, how many times do they blink in a minute? does the iris open and close?)

Follow up with an EYE CONFERENCE to compare results. Give them the correct scientific terms (sclera, cornea, iris, pupil) to label their drawings. (*The Life Science Library Book on Light and Vision* , page 83, has an excellent large photograph showing the exterior of the eye.).

The inside of the eye:

ACTIVITY 1: Xerox the picture of the cross section of the eye (Diagram 2 at the end of unit) and give each student a copy to tape into her notebook. Label and discuss the functions of the parts.

A. cornea—The transparent front of your eye. It bends the light entering the eye.
B. sclera—The white of your eye. It protects and holds the shape of the eyeball.
C. iris—The colored ring that determines whether your eyes are brown, blue or other colors. It controls the amount of light entering the eye.
D. pupil—This is merely the hole in the center of the iris.
E. lens—A crystalline body that changes its shape (until you age) in order to focus on near or far objects.
F. vitreous humour—This is the jelly like substance that fills most of the eyeball and helps it keep its shape. (It may contain floaters, those specks that drift).
G. retina—The all-important back layer that converts the light energy into electric energy. It contains two kinds of cells—the *cones* that see color and the *rods* see only black and white.
H. blind spot—There are no rods or cones in this part of retina.
I. optic nerve—The individual nerve fibers from the retina exit as the optic nerve. It carries the electric impulses to the brain.

Again the *Life Book on Light and Vision* , pages 84-95 has excellent drawings and photos.

ACTIVITY 2: You can have your students make cardboard models of the eye by using manila folders. Cut a large eyeshaped hole in one side of the folder and glue in white paper for the sclera, cellophane for the cornea, colored paper for the iris. They can even glue on thread for the eyelashes. Suggest that they are fourth grade teachers who are going to use the models to explain the eye to their students.

ACTIVITY 3: Compare the eye to a camera. See if students can figure out the similarities and differences. This should help sharpen thinking as to the functions of the eye parts.

Similarities : The iris and diaphragm open and close to control the amount of light. Both lenses focus light. The retina and the film record the light that strikes them to form an image.

Differences : Our iris is automatic. The diaphragm may or may not be. Our lens changes its shape to focus but the lens in a camera moves forwards or backwards to focus. Film must be developed to show an image. The retina sends impulses to the brain to get an image.

WRITING ASSIGNMENT: Comparing the eye to a camera should reinforce students' knowledge of the eye. First have them make a simple picture of each and then write down the similarities and differences.

If you bring your camera to class why not take students' pictures with very fast black and white film, discussing f-stops and times?

Simple experiments to demonstrate how our eyes work

After the students have tried each of these experiments with their partner, they should be able to WRITE very clearly a) how they did it and b) what it showed them about their eyes. Then you can have a VISION CONFERENCE to compare results.

Materials needed: magnifying glasses and penlights (available from Teachers Institute) paper and pencil.

a. *Automatic adjustment of the iris* . Put your hands tightly over your eyes for a few minutes. Then have your partner shine a penlight in your eyes the moment you remove your hands. What happens to the iris? (answer: it closes , otherwise we would be blinded by excess light)
b. *Depth perception by the lens* . Hold your finger about 12 inches in front of your face. Focus on your finger and then focus on the background. Can you focus clearly on both at the same time? (answer: no because the lens must change its shape each time).
c. *How the lens focuses light on the retina* . You will need a magnifying glass and a white sheet of paper. Face the wall on the far side of the room from a window. Put the paper against the wall and bring the magnifying glass close enough to it to form the image of the window on the paper. Is the image right side up OR upside down? (answer: upside down because the lens has turned it. The reason the whole world does not look upside down is because the brain rights the image for us.)
d. *The rods and color perception* . One student sits and stares straight ahead with both eyes. Her partner, who stands behind her, slowly brings a brightly colored object around the side of the subject's head until it can just be seen. What color is it? (answer: you can't tell because the rods which see only black and white are the only cells on the periphery of the retina.)

e. *The blind spot* . Draw two simple figures about three inches apart on a piece of paper. (for instance, a circle and a cross). Close one eye and focus on the circle as you bring the paper towards you. What happens? (answer: the cross will disappear as its image passes over the optic nerve exit where there are no rods or cones. This is called the blind spot.).
f. *Putting two images together* . Roll up a tube of paper and look through it with one eye. Place your open hand against the middle of the tube and look at it with the other eye. What do you see? (answer: your hand with a hole in it. The brain is receiving two very different images and is putting them together as best it can. Seeing is a matter of the eyes and brain working together).

Optical Illusions (or now that you know how the eye works, can you trust it?) There are a few optical illusions that students might already be familiar with. For instance, on hot summer days we can see pools of water shimmering on the highway ahead of us which always disappear as we approach. These are of course mirages, caused by light bouncing off the hot air above the road.

The moon always looks larger when it is on the horizon than when it has risen higher (Students in the city may not have notices this). The reasons for this are not clear.

Diagram 3 (at the end of the unit) contains several different kinds of optical illusions which you can make copies of for your students. In these illusions you eyes are sending the correct images to the brain, but the brain because of previous experiences becomes confused and gives us the wrong answers.

ACTIVITY. Diagram 3 is divided into three types of optical illusions, those of perspective, reversible images and impossibilities. Have your students study each type and then write about them.

1. *Optical illusions of perspective.* In most pictures the brain knows what the clues are for judging distance. Near objects are larger than close ones, the sides of a road converge in the distance and far objects are less distinct than near ones.

If possible bring in a landscape print or photograph and have the students discuss and write their reasons for thinking something is near or far. Because we have subconsciously learned these conventions of perspective we are usually fooled by optical illusions that change the clues around.

Then have the students examine the optical illusions of perspective and WRITE in notebooks (they can make a rough sketch of each) a) which line they thought was longer and b) why they were fooled (if they were). (In illusion D., ask if the lines are parallel)
2. *Optical illusions that are reversible images* . In these illusions we see one possibility at first but then suddenly another appears and so we alternate between both images, never seeing more than one at a time. The brain just doesn't seem to be able to handle more than one solution. You can have your students WRITE a) what the two configurations are as they perceive them and b) what their explanation is of the phenomenon. (It may be as good as that of scientists).

3. *Optical illusions that are impossibilities* . What is wrong with the illusions in group c. ? Have the students WRITE about each one in their notebooks.

What is it like to be blind?

WRITING ASSIGNMENT. *The New Haven Register* ran a series of articles in April, 1981 on various handicaps, including blindness. In the learning package (30 copies at the Teachers Institute) there is an article about Susan Chambers, a blind Centrex operator at Yale.

Students should read the article in class and then the following points can be discussed and written about:

a. What machines are required for a blind person to work as a telephone operator?
b. What are some of the difficulties that she must cope with in her life?
c. How do sighted people tend to treat blind people?
d. Can you think of other jobs that a blind person could do? Are there any that would be impossible for a blind person?
e. Do you know any blind people? How do they cope with life?

ACTIVITY WITH BRAILLE. A blind person must develop her sense of touch in order to read. Braille is a system of raised dots representing the letters of the alphabet which was invented by Louis Braille in the nineteenth century. A really fast reader can scan up to 2000 dots per minute with her fingertips, an equivalent of almost 100 words per minute.

The Oak Hill School for the Blind (120 Holcomb Street, Hartford, 06112) is extremely generous about sending Braille alphabet cards as a public service. It should be possible to get up to 25 of them if you write or call.

Give each student a card. Read the explanation together and then have her close her eyes. Explore the number and position of the dots for each letter by touch. (Our fingers are so insensitive it is often difficult to tell). Next work as partners. Exchange short messages in Braille by cutting out letters and gluing them onto another sheet.

LESSON 1 at the end of this unit is a Lab on Phototaxis in Invertebrates. This would be a good time to run it, before the section on Healing is started.

HEARING :

The first WRITING ASSIGNMENTS will again be group activities to develop a vocabulary of hearing.

1. Have the whole class sit as quietly as possible for a few minutes. Then in their notebooks list all the sounds they are hearing. WRITE their words on the board. Add other words for sounds (such as crash, rustle, murmur)
Are there as many synonyms for *listening* as there are for *seeing* ? List as many as possible.
2. Survival in the desert at night if you are a small rodent depends on how acute your sense of hearing is. Kangaroo rats, which are common in our western deserts, are the favorite food of predators such as snakes, lizards, hawks, owls, foxes and bobcats. *The Life Nature Library Book of the Desert* has excellent desert scenes, pages 79-93. In the daytime kangaroo rats sleep in their burrows but at night when it cools off they energy looking for seeds which they stuff into their cheek pouches. However, the predators are also out at night so the survival of the rat depends on its keen hearing and its ability to jump out of the way.

Have your students WRITE a story about the night of a kangaroo rat—all the sounds he hears, which ones mean danger and which ones don't. Make it as dramatic as possible.

What is sound?

1. ACTIVITY. (you will need a tuning fork and rulers)
Strike the prongs of a tuning fork against a desk and then hold it upright on the desk so that students can feel the vibrations. A tuning fork that sounds the A above the middle C on the piano is vibrating 440 times a second. This is its *frequency* . The greater the frequency, the higher the the pitch of the sound.

Have students hold rulers against their desks with different lengths protruding and make them vibrate. A short end vibrates with a higher pitch than a long section. They can also feel their larynxes vibrate when they talk.
2. ACTIVITY. Have your students construct a *bar graph* showing the upper frequency of sound that various animals can detect. (elephants 12,000 waves/second; humans 20,000; bats 150,000; moths 150,000; dogs 44,000; rats 72,000; frogs 10,000; porpoises 150,000; crocodiles 6000; cats 65,000). If they are artistically inclined they can put a simple figure of each animal below the bar representing it.

Which animals can detect ultrasound? (higher frequencies than humans can detect)

Structure and function of the ear:

Diagram 4 at the end of the unit is a picture of the human ear. Xerox it and have students tape it into their notebooks. Divide the ear into the Outer ear, Middle ear and Inner ear and then write in the functions of each part. A good source of large diagrams is the *Life Science Library Book of Sound and Hearing* . pages 38-51.

Outer ear

A. pinna—Helps concentrate sound waves.
B. auditory canal—Brings the sound waves to the eardrum.
Middle ear
C. eardrum—magnifies the vibrations and passes them on to the ossicles.
D. ossicles—Three tiny connected bones that magnify the vibrations and pass them on to the cochlea.
Inner ear
E. semicircular canals—Help you to maintain your balance.
F. cochlea—A tiny coiled snail-like organ filled with fluid which vibrates. Connected to the auditory nerve.
G. auditory nerve—Changes the vibrations into electric impulses which are sent to the brain

WRITING ASSIGNMENT: Explain all the things that happen to the sound waves from the time your friend asks you a question to the instant that your brain perceives the answer.

Echolocation in bats :

Bats are the only mammals that can fly; they are also totally nocturnal. Flying in the dark and catching insects on the wing has helped them evolve a special sense called echolocation. The bat has an enormous larynx which emits beams of very high frequency sound (up to 150,000 cycles/second). These beams (which we can't hear of course) bounce off obstacles and flying insects alike and the echoes return to the bat's huge ears. The obstacles are avoided and the moths are pursued, usually successfully. Interestingly enough, some moths have also developed ultrasound signals which they use to detect the presence of bats. It is almost like an arms race.

There are some excellent large photographs of bats in the *Life Nature Book of Animal Behavior* , pages 22-23, 106, 116-117.

WRITING ASSIGNMENT: Imagine that you are a bat hanging upside down by your claws in a cave. It is night and you are just waking up. You are very hungry. Describe what the next few hours will be like for you, catching moths and mosquitoes by echolocation. (also avoiding crashing into trees and rocks in the dark). Use your imagination.

Medical Ultrasound:

Although we humans can't echolocate in the dark, we have developed some instruments which emit beams of high frequency sound almost like bats. This ultrasound technology can tell us what is inside our bodies. It is especially popular in certain obstetrical situations; when the doctor suspects multiple births, breech birth or simply needs to know the due date of the mother. Ultrasound is painless and appears to be harmless, unlike X-rays.

A probe which emits ultrasound with a frequency of millions of cycles per second is moved over the abdomen of the pregnant woman. The same probe also records the reflected echoes from the fetus which are then changed to visible light signals on a screen. Often these days, a mother is carrying a picture of her baby in her wallet even before he is born!

WRITING ASSIGNMENT: In the learning package that accompanies this unit there is an article from the New Haven Register which tells exactly how ultrasound aided in the pregnancy of one young woman in New Haven. Read it out loud together (there are several technical terms in it) and then have the students WRITE on the following questions.

a. Explain the procedure when you have ultrasound.

b. Why did Mrs. Carbone have the first ultrasound?
c. Why did her doctor ask her to have a second one?
d. What are some of the other reasons why pregnant women have ultrasound?
e. In what ways is medical ultrasound like echolocation in a bat?

What is it like to be deaf?

We all know people who are hard of hearing and who are leading normal lives, but what is it like to live in a world of total silence? There is another article in the learning package from the New Haven Register which describes a 20 year old local woman who has been deaf from infancy. Again have your students read the accompanying article. Discuss her feelings and adjustments to her handicap and then WRITE on the following questions.

a. Why do you think Jackie says that she would prefer being deaf to being blind or crippled?
b. What are some of the ways in which hearing people react to deaf people?
c. Jackie can't hear doorbells, alarm clocks or telephones, but she can see them. Explain.

d. What is Jackie's job? Is it a good one for a deaf person? Think of some other professions suited for deaf people. Think of some that would not be good.

TOUCH:

The sense of touch is a less obvious one than either vision or hearing. There is no specialized visible organ of touch such as the eye and the ear; it is a generalized sense with individual cells scattered all over the skin. You realize how important it is to you when your foot falls asleep and you have no idea whether it is touching the floor or not.

WRITING ASSIGNMENT: Again build up a basic vocabulary of touch as you have done with the other senses. Have a cardboard box with two holes on opposite sides large enough to admit a pair of hands. In this box have an object which has good tactile qualities such as a small branch, a shell or a stuffed toy. Let a student feel the object with both hands and describe it to the class. See if they can guess what it is from his adjectives of touch. It's a good game which should elicit many tactile words, which they can record in notebooks.

Response of Sensitive Plant to touch :

We have discussed only humans and animals so far; plants should get their turn. Sensitive plant is well known for its ability to move when touched. It makes a good lab subject.

It is easily grown from seeds which you can purchase from the Connecticut Valley Biological Supply Co. Inc., PO Box 326, Southampton MA, 01073. Seeds are also available at local nurseries. It will take a few months before the plants are large enough to be used, though. We usually have several plants growing at the McCabe Center which you are welcome to borrow. (call 787-8758).

ACTIVITY: Tell your students that they are going to test the sensitive plant's responses to touch. They should be as observant as possible and write down all their lab notes in the notebook. Have them work in groups of four or five, each with a magnifying glass, (available at the Teachers Institute). They must be very careful not to jar the plants or the leaves will fold up. (A wonderful book to show them is *Mimosa, The Sensitive Plant* , by Selsam and Wexler. It has marvellous large color photos. See Student Bibliography.)

First have them draw the plant in their notebooks. Each compound leaf is made of several sprays with leaflets. If they look carefully at base of each leaf they will see a tiny swelling called a *pulvinus* . At the base of each leaf stalk there is a larger pulvinus.

Touch a leaflet pulvinus gently with a needle. What happens? (The pair of leaflets fold up immediately, and all the other leaflets on that spray may close up too if the impulse is strong enough. Now touch the large pulvinus at the base of the leaf stalk and the whole compound leaf will move down. If you touch it hard enough all the leaves will collapse. Why? The pulvinus is a water filled swelling which when touched loses some of its water and no longer props up the leaflet or leaf.

Finally bang the whole pot on the table and everything will collapse. Have a SENSITIVE PLANT CONFERENCE bringing everyone's observations together. Ask for guesses as to why sensitive plant moves when touched. (By the way, its scientific name is *Mimosa pudica* means mimic and shy.)

At the end of lab have your students plant their own seeds.

SMELL :

The sense of smell is even harder to discuss than any of the preceding senses. We humans can detect odors clearly but it may be hard to find words to describe what we are smelling. We often have to resort to saying that a certain odor smells "like something else". We do have a surprisingly good memory for smells though. A whiff of rotting seaweed can bring back hidden memories of a childhood summer at the ocean.

WRITING ASSIGNMENT: Describe the following things by smells alone: springtime, a dentist's office, your kitchen at suppertime. Name a smell that brings back a definite childhood memory for you. What is the memory? Is it easy or hard to describe smells by words?

Odor is a chemical sense in contrast to the preceding physical senses. In order to smell a substance it must be volatile (ammonia). The molecules enter the nose as we breathe and dissolve in the two olfactory organs high up in the nasal passages. The chemical sense is changed to an electric impulse which is sent via olfactory nerves to a very primitive part of the brain(which also has to do with sex and emotions).

We humans do not depend on our sense of smell for survival usually (unless the gas is on), but lower animals often do. Whereas the two olfactory patches in our nose are an inch square with about 5 million sensory cells, in a dog they are the size of a small handkerchief with hundreds of millions of cells. The olfactory region of a dog's brain is also much larger than in humans. We know that smell plays a large role in the life of a dog when a female dog comes into heat and attracts males from miles around.

The animal that has the most developed sense of smell is probably the moth. In this year of the gypsy moth we have seen males coming from all over to mate with the flightless females clinging everywhere. The female releases a sex attractant from her abdomen which drifts downwind. Any male in the right area, up to half a mile away, can detect minute amounts of this substance with his large antennae and immediately starts flying upwind.

It has been estimated that the sex attractant is so potent that one female could theoretically attract more than one billion males. The USDA has worked for 30 years to isolate the attractant. They finally succeeded and were also able to synthesize it, resulting in the gypsy moth sex lure traps sold everywhere.

At this point assign your students LESSON 2: *Writing Science Fiction—Perception on Imaginary Planets* (at the end of the unit).

They will also be able to do LESSON 3: *Crossword Puzzle on the Senses* which is a review of the whole unit.

Experiment on Extrasensory Perception (ESP) :

Are there other senses that we are not aware of, such as ESP—the ability to read another person's mind?

Many teenagers (and adults) are convinced that psychic phenomena are real and surprisingly, a substantial percentage of scientists in a recent poll felt that the existence of ESP was a “likely possibility”. [1]

ACTIVITY: *To the teacher* : The object of this experiment in ESP is not to convince students one way or the other of the existence of mental telepathy but rather to have them think about the design of the experiment and what conclusions they can validly draw from it. By repeating the experiment and making a bar graph they should see the role that probability plays. (It would be fascinating if you *did* have a student with consistently high results).

This experiment is based on the classic one by Dr. J. Rhine at Duke University who studied ESP for many years. Students (who work in pairs) will make their own cards with special patterns. (See Diagram 5 at the end of this unit for the patterns). A total of 25 cards are made, 5 of each pattern. One student will be the tester and the other student will “read her mind” to guess the correct pattern. They then reverse roles and the results are tallied in a class bar graph.

To the students : (work in teams of two)

Do you think it is possible to read someone else’s mind? This ability is called Extrasensory Perception (ESP). Most scientists are doubtful about ESP. See what you think after you have tried the following experiment.

1. Your teacher will show you how to make 25 cards using 5 different patterns. Shuffle them well.
2. Partners sit facing each other. The tester holds the cards so that the subject cannot see them, and turns them over one by one, concentrating hard on each one.
3. The subject (who can’t see the cards) guesses what the pattern is on each one. The tester marks down right and wrong answers.
4. Count up the correct answers. Since there is a one in five chance of making a correct guess, an average score will be about five correct.
5. How did you do? Did you guess more than 5 correctly? Switch roles with your partner and repeat the experiment after reshuffling.
6. Using the results of the whole class make a bar graph of correct answers.
7. Did anyone have a very high score? Do you think it means that she has ESP? Should the experiment be repeated?

WRITING RESEARCH REPORTS ON ANIMAL SENSES

By the end of this unit students will have done a lot of writing. Some assignments were based on their own perceptions and sense organs, others were more speculative (what if—),and finally some were based on the results of various experiments.

The final writing assignment in this unit is a short research report on the senses of various animals using at least two sources. Since all teachers have their own methods of assigning such research reports I won't go into step-by-step details.

I have listed several books in the *Student Bibliography* which are available at the main branch of the New Haven Public Library (the librarians there are very helpful). Most of the books are on a 6th to 8th grade reading level but could be supplemented for more advanced readers by books from the *Teacher Bibliography* .

Some general guidelines:

1. Do much of the writing in class and have students share their works-in-progress out loud with each other.
2. Have them rewrite at least twice before you grade their papers.
3. To avoid a wholesale copying from books, ask them to compare the senses and life styles of various animals (instead of just writing about one).

Notes

1. Malcolm W. Browne, "Arguing the Existence of ESP", *The New York Times* (Jan. 29, 1980), p. C2.

STUDENT BIBLIOGRAPHY

I have not annotated the student bibliography. All the books are on a 6th to 8th grade reading level, they are all available at the Main Library and they would all be suitable for writing reports.

Cloudsly-Thompson, J.L., *Spiders and Scorpions* , New York: McGraw-Hill, 1974.

Cole, Joanna, *A Frog's Body* , New York: Wm. Morrow and Co., 1980.

Cosgrove, Margaret, *The Strange World of Animal Senses,* New York: Dodd, Mead and Co., 1961.

Hess, Lilo, *The Remarkable Chameleon* , New York: Chas. Scribner's Sons, 1968.

Hoke, Helen, and Pitt, Valerie, *Owls* , New York: Franklin Watts Inc., 1975 Hutchins, Ross E., *A Look at Ants* , New York: Dodd Mead and Co., 1978 Lavine, Sigmund, *Wonders of the Bat World,* New York: Dodd, Mead and Co., 1969.

Mason , George F., *Animal Vision* , New York: William Morrow and Co., Inc., 1968.

McClung, Robert M., *Gypsy Moth* , New York: Wm Morrow and Co., 1974.

Morrison, Sean, *The Amoeba* , New York: Coward, McCann and Geoghegan, Inc., 1971.

Patent, Dorothy, *How Insects Communicate* , New York: Holiday House, 1975.

Phillips, Mary G., *Dragonflies and Damselflies* , New York: Thom. Y. Crowell Co., 1960.

Schisgall, Oscar, *That Remarkable Creature, the Snail* , New York: Julian Messner, 1970.

Selsam, Millicent and Wexler, Jerome, *Mimosa, The Sensitive Plant* , New York: Wm. Morrow and Co., 1978.

Silverstein, Dr. A., *Gerbils* , New York: J.B. Lippincott and Co., 1976.

Stidworthy, John, *Snakes of the World* , New York: Grosset and Dunlap, 1978.

Sweet, Ozzie and Scott, Jack, *Canada Geese* , New York: G. P. Putnams's Sons, 1976.

Victor, Joan, *Tarantulas* , New York: Dodd Mead and Co., 1979.

Zim, Herbert, *Sharks* , New York: W, Morrow and Co., 1966.

TEACHER BIBLIOGRAPHY: (All books available at the New Haven Public Library)

Asimov, Isaac, *The Human Brain* , New York: The New American Library, 1963. No one writes better than Asinov when it comes to explaining science to the layman. Includes several chapters on human senses.

Browne, Malcolm W., "Arguing the Existence of ESP", *The New York Times* , Jan. 29, 1980, p.C1.

Devey, Gilbert B. and Wells, Peter N.T., "Ultrasound in Medical Diagnosis", *Scientific American* 238 (5) , May 1978, p. 98.

Froman Robert, *The Many Human Senses* , Boston: Little Brown and Co., 1966.

This book would also be good for students. Covers all the senses and ESP. Good bibliography.

Jonas, Doris and David, *Other Senses, Other Worlds* , New York: Stein and Day, 1976. An exciting book that speculates about senses on various imaginary planets, using the knowledge we have about animals on Earth.

Keller, Helen, *The Story of my Life* , New York: Doubleday, Page and Co., 1903.

I think students would particularly enjoy chapter 4 which describes Miss Sullivan's arrival.

Kohl Judith and Herbert, *The View from the Oak* , San Francisco: Sierra Club Books. Charles Scribner's Sons, 1977.

A very personal book on senses. Tries to imagine what it would be like to be a moth or golden retriever.

Leopold, A. Starker, *The Desert,* New York: Time-Life Books Inc., 1962.

(Mentioned in text) Excellent photos of predators and prey in desert.

Mehta, Ved, *Face to Face* , Boston: Little Brown and Co., 1957.

The autobiography of a journalist from India who lost his sight as a baby. Particularly fascinating is his description of "facial vision" which enables him to avoid obstacles without cane or seeing-eye dog.

Mueller, Conrad G. and Rudolph, Mae, *Light and Vision* , New York: Time-Life Books Inc., 1967.

(Mentioned in text) A very useful book for teaching with its large photos.

Stevens, S.S. and Warshofsky, Fred, *Sound and Hearing* , New York: Time-Life Books Inc., 1967.

(Mentioned in text) Also useful in classroom.

Tinbergen, Niko, *Animal Behavior* , New York: Time-Life Books Inc. 1965.

(Mentioned in text) Especially good on bats.

Whitfield, Philip, *The Hunters* , New York: Simon and Schuster, 1978.

This book covers predators from bats to whales. Many clear drawings showing adaptations of their sense organs. Especially interesting is the electric eel.

Winter, Ruth, *The Smell Book* , Philadelphia: J.B. Lippincott Co., 1976.

This book is fun. Covers pheromones, perfumes and how we are manipulated by ads to buy products that cover up our natural smells.

CLASSROOM MATERIALS (available at the Yale-New Haven Teachers Institute, 53 Wall St. 436-3316)

30 copies of the learning package with articles from the New Haven Register

30 small magnifying glasses

15 penlights

LESSON 1: Lab on Phototaxis in Invertebrates

To the teacher ; Phototaxis is a way of "asking" an organism whether it can perceive light or not and then respond to it. All the invertebrates used in this lab are either positively or negatively phototaxic. After students have determined the response to light, they are asked how this response might be useful to the particular animal. Then they look for the organism's eye(s) and draw it.

The lab can also serve as an informal introduction to the invertebrate kingdom. It is open ended students can delve as deeply as they wish into the structures and behavior of these animals. It should be a fun lab for them.

You will probably not want to use all the organisms from the following list. Connecticut Valley Biological Supply Co., Inc. is a good place to order the smaller organisms (address in back of unit). Sow bugs, earthworms and pond snails could be brought in by you or your students and fruit flies will magically appear if you put a rotten banana in an open jar. If the animals are too lively a short stay in the refrigerator will sedate them temporarily.

TABLE OF INVERTEBRATE PHOTOTAXIC RESPONSES

Euglena	positive
Daphnia	somewhat positive
Brine shrimp	positive (ventral surface towards light)
Sow bugs	negative
Fruit flies	positive
Pond snails	negative
Earthworms	negative

Materials needed ; (work in teams of two)

microscope and slides

magnifying glass (there are 15 at the Teachers institute)

shoebox

penlight (15 available at the Teachers Institute)

petri dish

foil

dropper

various invertebrates

To the students: You have studied eyes and vision in humans. Most invertebrates (animals without backbones) have simple eyes which can't form pictures the way our eyes do. They can perceive light though and will usually move towards it (positively phototaxic) or away from it (negatively phototaxic).

In this lab you will investigate the responses of various invertebrates to light and then try to answer three questions about each:

1. Is the animal positively or negatively phototaxic?
2. Make an educated guess as to how that response is useful to the animal.
3. Look for the animal's eye(s) using the microscope or magnifying glass.
4. Draw the animal and describe its behavior.

Procedure for Euglena;

1. Pour some Euglena into the petri dish and cover (water should look green).
2. Wrap the petri dish tightly in foil.
3. Cut a small hole in the middle of the foil and shine the penlight on it for a few minutes.
4. What do you notice when you remove tie foil?
5. Why do Euglena respond to light in this way?
6. Put a drop of Euglena culture on a slide and observe under a microscope.
7. Do you see a red eyespot?
8. Write down all the things that Euglena do and draw one.

Procedure for the Other Invertebrates;

1. Use only the bottom of the shoebox and turn it over. Then cut a hole in the middle of the box the same diameter as the penlight. Cut a viewing slit in the side of the box so you can watch the responses of the animals.
2. Put the invertebrates into the petri dish and place under the center of shoebox.
3. Shine the penlight through hole onto middle of petri dish and observe response of animals.
4. Why do you think it responds to light in this way?
5. Using magnifying glass or microscope find the eye(s) of the animal.
6. Write down all your observations and draw one animal.

At the end of the lab there will be an INVERTEBRATE PHOTOTAXIS CONFERENCE so we all can compare results.

LESSON 2: Writing Science Fiction—Perception on Imaginary Planets

To the teacher: In this writing exercise, which comes at the end of the unit, students are asked to write about imaginary planets whose inhabitants rely almost wholly on one sense for survival.

Remind your students that different animals on Earth rely on different senses in order to get food, escape predators and find mates. (*vision;* birds of prey and most predators: *hearing* ; bats, dolphins and nocturnal animals in general: *smell* ; sharks, salmon and moths: *touch* ; earthworms, cockroaches and spiders)

An animal that relies mainly on hearing will of course have much more developed ears than an animal that relies mainly on smell. It will also have a totally different perception of the world it lives in than an animal with highly developed olfactory organs.

Encourage your students to use their imaginations when they write their science fiction stories.

To the students: Imagine a planet where the imaginary animals rely mainly on the sense of smell (or hearing or vision or touch).

1. Draw one of these animals showing its sense organs.
2. Give your animal a scientific name.
3. Describe the environment on this planet.
4. Describe a day in the life of this imaginary animal telling how it locates food and friends and stays away from danger.

LESSON 3: Crossword Puzzle of Perception and Sense Organs

(figure available in print form)

A Review of the Unit

Across:

1. Jelly like substance that fills the eyeball.
4. Cells in retina that see black and white.
5. The _____ nerve carries impulses from ear to brain.
8. Humans can't see ultraviolet but this insect can.
9. The "white" of the eye.
10. Small, round, clear, it focuses light on the retina of the eye.
11. This plant closes its leaves when you touch it.
14. A system of raised dots that blind people can read.
15. The sense of _____ is located in our skin.
19. Most mammals can't see _____ because they have only rods in eyes.
20. A structure of the eye that controls the amount of light that enters.
21. The transparent front of the eye.
22. It is coiled like a snail and located in the inner ear.
23. Sound that is too high for human ears.
26. A membrane of skin between outer and middle ears.
27. A synonym for smell.
28. The place where the optic nerve exits from the retina is called the blind _____ .
29. Bats can hear sounds with a _____ of 150,000 vibrations/sec.
30. Light is waves of energy coming from the _____ .

Down:

1. The most important sense for humans.
2. Three little bones in the middle ear that vibrate with sound.
3. Don’t trust your eyes when you look at one of these.
4. The inner layer of the eye that contains cones and rods.
6. This is an important sense for nocturnal animals.
7. A destructive insect. The male finds the female by her smell.
8. This flying mammal catches insects at night.
12. Daphnia and Euglena have one simple _____ that responds to light.
13. Bats find insects by bouncing ultrasound off them. This is called .
16. The _____ nerve carries impulses from the nose to the brain.
17. Humans can see colors because of cells in our retina called _____ .
18. The semicircular help us keep our balance.
24. Many people have learned to communicate by sign language.
25. All our sense organs send their messages to the by nerves.

ANSWERS:

(figure available in print form)

DIAGRAM 1: THE ELECTROMAGNETIC SPECTRUM (wave length in meters)

(figure available in print form)

DIAGRAM 2: THE HUMAN EYE

(figure available in print form)

DIAGRAM 3: OPTICAL ILLUSIONS

a. Optical illustrations of perspective

(figure available in print form)

b. Optical illusions that are reversible images

(figure available in print form)

c. Optical illusions that are impossibilities

(figure available in print form)

DIAGRAM 4: THE HUMAN EAR

(figure available in print form)

DIAGRAM 5: CARD PATTERNS FOR ESP EXPERIMENT

(figure available in print form)