In 1969 Helen Conlon and I, who are faculty members of the biology department at Wright College, began helping students investigate the Des Plaines River and its drainage system (Chicago and northeastern Illinois). As ecologic theory says, a river is a natural ecologic unit. It is also a natural laboratory. Rivers and drainage systems are excellent units for studying the impact of man and urbanization. The Des Plaines River "laboratory" is especially significant, because it flows through the densely populated environs of Chicago. By moving our students out of the classrooms and shifting their studies north and south along the river, we had a natural, and almost priceless, investigative opportunity.

Initially, Biology 201 students and Conlon's bacteriology students did individual investigations that included surveys of coliform bacteria, sludge worms, and other indicator organisms (those revealing the degree of water pollution). Chemistry students have since developed information as to where specific chemical pollutants enter and upset the natural balance of the Des Plaines River. Mathematics students have set up statistical models and worked in Wright's computer laboratory. Perhaps of even greater significance: students of music, art, anthropology, and the social sciences at Wright College have begun doing investigative studies of other parameters of man and his environment. Papers prepared by the nonbiology majors add a cross-disciplinary component to our course.

In retrospect, we feel The River is a unique educational experience, because in this course both traditional classroom walls and the rigidity of narrow and arbitrary curricular boundaries are disappearing. In Biology 201 each student investigator selects his own study project. In a "contract agreement" with the supporting faculty member, students first design a data-generating experiment. The students then survey pertinent textbooks and research journals and analyze their sampling data in light of current research. There are no traditional "tests" or "curves." Students prepare seminar talks, and each student writes a final report. Help from the faculty adviser centers on assistance in sampling techniques, statistical models, scientific writing style, editing, and presenting an oral report.

To date, 14 students associated with the course have presented papers at national scientific conventions or other meetings; these have included the Chicago convention of the National Association of Biology Teachers and the National Earth Science Convention, also held in Chicago. Helping to assess the Broadview, Ill., police department's community-relations program became part of a project of one of our students. Other students have appeared on educational television (WTTW, Chicago) or have presented programs at churches and at ecology meetings, including those of the Prairie Club and the University of Illinois Graduate Institute in Urban Ecology. Altogether, 60 students have participated directly in such studies. One group of honors students in Wright's River course received the first-place award from Phi Theta Kappa for community involvement and environmental concern, as part of that fraternity's national convention (Denver, 1970).

Other Biology 201 students have studied environment and social science in an investigative "laboratory" setting. One such student project surveyed residents' attitudes, community involvement, and environmental awareness in different places, including the town of Riverside, Ill., and Chicago's Lincoln Park neighborhood.

Some of our students are currently part of a conservation-action group called Save the Valley. We feel that community commitments—in this case, to help guard a state park against commercial pollution—are one measure of the course's success.

What does all this mean academically? Primarily, we feel our students can best learn about Chicago through participation. One afternoon our class was observing how the highly polluted Silver Creek flows into and fouls the Des Plaines River near Melrose Park, Ill. A student asked, "Are you trying to tell us there is some connection between the quality of our rivers and the quality of our living?"

Actually we *do not* attempt to "tell" the Biology 201 students what or how to think. Learning while standing on the bank of a polluted stream, however, is a kind of learning that surpasses listening to a teacher's lecture. We feel that experiential learning, in combination with quantitative and qualitative thinking (for example, thinking about the degree of pollution and the quality of life), has a valid role in education. At Wright College it is obvious that we are not teaching students who will all seek doctorates in ecology; but educated non-Ph.D.s are important too. We do think, though, that personal involvement and individual participation are the key factors and are important in getting our Biology 201 students to accomplish what they have done.

Other colleges, too, could study river pollution and urban sprawl. These could become central matters for the attention of their students. We advocate investigative courses like The River and feel such courses help make "community" an increasingly important part of the community-college concept.

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TEMPERATURE STUDIES IN MAN

Many courses in the life sciences consider briefly the difference between homoiothermic (warm-blooded) and poikilothermic (cold-blooded) animals. Unfortunately, the consideration often is restricted to the assertion that (i) poikilotherms do not regulate their temperatures but, within limits, adapt to the temperature of the environment and (ii) homoiotherms maintain a constant temperature, in spite of a varying environmental temperature.

These phenomena may prove difficult to demonstrate in the laboratory. Glass thermometers and electric thermometers have been used, but they have their limitations. Major limitations are (i) the fragility of glass thermometers and (ii) the wires leading from the temperature-sensitive end of the electric thermometers. These limitations can be avoided by the use of radio telemetry. Small radio transmitters, capable of measuring temperature to within 0.5 °C, can be constructed or purchased for approximately $15.00. A major advantage is their size (approximately 1 by 2 cm). Their effective range of transmission is 0.75–1 m. The size of these instruments allows them to be fed to large frogs and retrieved after an exercise is completed.

It is also possible to demonstrate the subtle changes in body temperature of humans with these instruments. The following is a typical exercise.

Man belongs to a general group of animals referred to as homoiothermic animals; that is, they maintain a constant body temperature.

Temperature regulation in homoiotherms involves (i) detecting the outside (environmental) temperature and (ii) responding by making the proper adjustment so as to maintain a constant temperature. Detection of outside temperature is performed by skin receptors that respond to heat or cold; these receptors are a part of the body's nervous system. A body's response to this detection system is to seek another environment if the body is uncomfortable. The skin receptors cannot regulate internal body temperature accurately. The internal (core) body temperature is measured and regulated by the hypothalamus, a part of the brain.

Regulation may include moving to another environment. In cold, we may increase our muscular activity; that is, we may shiver. In heat, we may perspire, and the surface blood vessels may become dilated, to release more of the blood's heat. And there are other methods.

By means of radio telemetry it can be demonstrated that our bodies do regulate and maintain a constant temperature and that the temperature of the extremities varies just slightly from that of the trunk (chest and abdomen).

You will be given a miniature radio transmitter with a thermistor wired into the circuit. The thermistor is a very sensitive device that records the temperature by causing a certain number of "clicks" to be emitted from the transmitter. The rate of clicking depends upon the temperature of the transmitter: in general, the lower the click rate, the lower the temperature. Transmitters are sensitive to within 0.5 °C.

The transmitters are calibrated by immersing them in warm water and counting the clicks at different temperatures as the water cools. Appropriate graphs of temperature vs. click rates for each transmitter are constructed.

The other instrument needed is an inexpensive AM radio. Tune your radio to a quiet part of the dial while it is 12–15 cm from the transmitter. If you hear clicks, the radio and the transmitter are working. Determine the ambient (environmental, or room) temperature by counting the number of clicks for 30 seconds and doubling the number. This provides the number of clicks per minute. Do this three times, and record the average number of clicks. Using the graph and your click count, determine ambient temperature. Verify it with a thermometer.

Be certain to allow time for the transmitter to adjust to its different environments during the exercise. It is generally a safe assumption that the transmitter is at the temperature of the environment if it produces three successive measurements that are identical.

Having made these preparations, proceed as follows:

1. Record the air temperature at tabletop level.
2. Wrap the transmitter in a sheet of plastic, secure it with plastic adhesive-tape, and place it under your tongue. With mouth closed, determine your oral temperature.
3. Dry the plastic wrap. Then place the transmitter in an armpit, next to the skin. Record the temperature.
4. Replace the plastic wrap and retire to the bathroom. Place the transmitter against the skin of the groin, about 3 cm down the thigh. Cross your legs and record the temperature. Repeat with legs uncrossed. Remove the transmitter and return to the classroom.
5. Replace the plastic wrap. Place 10 sheets of paper on your chair, place the transmitter on the paper, sit on the transmitter, and record the temperature.
6. Place the transmitter on top of the arch of your left foot. Hold it there—covering it well—with the instep of your right foot. Record the temperature.
7. Replace the plastic wrap. Put the transmitter in your mouth and tape your mouth shut with masking tape. (First attach the plastic wrap to the tape to be put over your mouth, so you don't swallow the transmitter.) Go outside and walk slowly around the building for 5 minutes. Remaining outside, stand next to a classroom window, so that your classmates, inside the room, may record your oral temperature. Then circle the building five times at a fast jog. Again, stand at the window, so that your temperature may be recorded. Come back into the room, but do not remove the tape. Sit quietly for 5 minutes; then record your oral temperature.

Record your data and be prepared to discuss it in class.

A number of questions about your body should come to mind; only a few will be raised here. We hope they stimulate your thinking.

How can you explain the slight differences, if any, in body temperature? How does the human body use these differences?

What is the optimum temperature for the development and maturation of an ovum? How is this regulated? What is the optimum temperature for the development and maturation of spermatozoa? How is this regulated?

The above constitutes the presentation to the class. I will conclude with remarks addressed to the present reader.

Exercises of this nature have several advantages. They provide the students with an opportunity to perform "hands on" science. The students handle and manipulate the instruments and materials, and they experience what occurs in actual laboratory situations. The students collect data and evaluate them. Within limits, this exercise allows the student to construct his own experiments for further study; this may be the most valuable aspect of the exercise.

The equipment used in this exercise is reliable, inexpensive, and reusable. Transmitters made in the lab (Mackay 1968) should be coated with epoxy, then paraffin, then silicone, to keep body fluids away from the components. Commercially made transmitters (I have used those of the Mini-Mitter Co., P.O. Box 88210-G, Indianapolis, Ind. 46208) usually come embedded in epoxy and inserted in a plastic capsule, ready for paraffin–silicone coating and use.

The batteries used in the transmitter are small hearing-aid batteries. In transmitters such as those described above, battery life is several months in continuous use. When not in use, transmitters may be stored in a refrigerator or a freezer; this extends the life of the battery considerably.

References

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For Trail Riders

If you can't persuade trail-bikers to become hikers, you might at least get them to read *Trail Riders' Guide to the Environment,* by Shaun Bennett, a consultant to the American Motorcycle Association. The booklet, which the National Wildlife Federation says is "responsibly written," can be ordered from the Motorcycle Industry Council, Inc., 1001 Connecticut Ave., N.W., Washington, D.C. 20036.

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After about 96 hours, 5-mm sections from the coleoptiles (1–1.5 cm long) are isolated 3 mm below the tips in yellowish-green light (a fluorescent lamp covered with one sheet, each, of green and amber Plexiglas "G" or other suitable plastic sheet). All sections are collected in distilled water before an experiment is started. 20 coleoptile sections are floated in a 5-cm Petri dish containing 15 ml of the test solution and are incubated at 23 °C in the dark. Length of the coleoptile sections is measured to the nearest 1 mm with a ruler.

Summary

These investigations illustrate induction of growth by gibberellic acid. The students gain a keener insight into the nature of the growth process and how it is regulated by a hormone and by sugar. They develop skill in experimenting with the plant tissue in vivo—observing and measuring the growth of the segments or sections and interpreting the data.

This investigation can be extended to the study of the hormonal regulation of growth by hormone interaction, the requirement of key metabolites for hormone-induced growth, and the regulation of growth by protein synthesis.

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The Educated Man

That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with knowledge of the great and fundamental truths of Nature, and of the laws of her operations; and who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself.

Thomas Henry Huxley (1825–95),
"A Liberal Education and Where to Find It"