How-To-Do-It

Internal Temperatures— Concepts Revisited by Radiotelemetry

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Early in our exposure to living things we were taught that animals could be classified as warm-blooded or cold-blooded. Those that are warm-blooded or homeothermic maintain constant body temperature through high rates of metabolic activity, while those that are cold-blooded or poikilothermic have variable body temperatures largely dependent on their environment. These definitions are acceptable in the general sense, but closer examination reveals that some homeotherms may not maintain constant body temperatures. Poikilotherms, on the other hand, may, by behaviorial mechanisms, maintain body temperatures within relatively narrow limits.

The development of very small, short-range implantable radio transmitters in recent years has allowed students to get "inside" the temperature story. Such technology allows the acquisition of accurate body temperature data, in free-ranging or normally active animals, whether poikilothermic or endothermic. Science students of many ages could profit from the use of this method.

The use of small portable AM/FM cassette tape recorders controlled by a simple electronic timer switch allows for the monitoring of internal temperatures at preset intervals over long periods of time. Data gathering units composed of a transmitter (implanted within an organism), an electronic timer switch, a power supply, and an AM/FM cassette tape recorder can be placed in the laboratory or in the field and left to gather temperature data. The data, recorded on the tapes as a series of pulses or clicks, can be analyzed later by comparing a calibration curve which plots changing body temperature with changing pulse frequencies (Figure 1).

How such a methodology is applied by students and their teacher is limited only by the questions posed and imaginations of those involved. Almost any question dealing with body temperature and its biology can be studied.

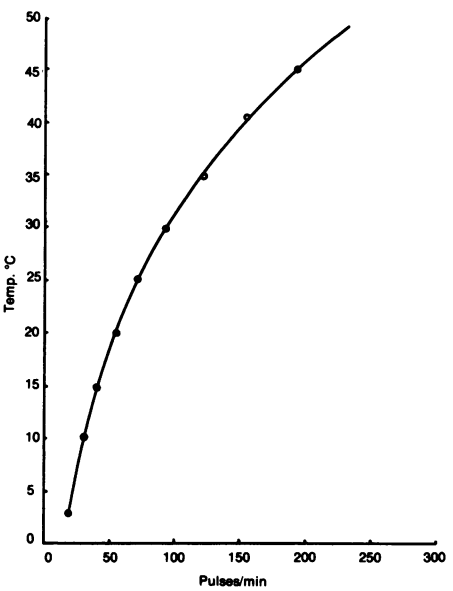

Figure 1. Typical transmitter calibration curve.

Transmitter Calibration

Transmitters sealed in plastic capsules, the finger of a rubber glove or dipped in a 50-50 paraffin beeswax mixture and coated with silicone rubber, can be calibrated in a water bath. The transmitter emits a radio signal that consists of a series of clicks. The number of clicks or pulses in a given period of time is proportional to the temperature. By suspending the sealed transmitter in a water bath containing a stirrer, thermometer, and crushed ice and counting the number of pulses per minute, a smooth curve of temperature versus pulses/min. can be made. Temperature increments of 5°C provide a sufficient number of points over a range of 0°-50° to construct a curve without an excessive investment of time (Figure 1). Students should be cautioned to allow a minute or two for the transmitter to equilibrate at each step.

Implanting Transmitters

Suitably sealed transmitters can be implanted in frogs, snakes and mud puppies. Forcing the transmitter into the esophagus followed by gentle external finger pressure will cause it to slide into the stomach (Berry 1971). Data can be gathered after the animal rests undisturbed a few minutes. Amphibians can be placed in water baths ranging from 5°C to 33°C. Rates of change of body temperature can be observed. Snakes or other reptiles can be placed in terrariums with a heat source, such as a light bulb at one end, providing a thermal gradient. Both body temperatures and behaviorial adaptations can be observed. Transmitters can be recovered by gently squeezing the transmitter up the esophagus and out the mouth.

Large animals, such as dogs, can be made to swallow the transmitter in the same way they would be given a pill. The transmitter can be recovered after passing through the digestive tract.

A freshly laid egg may be removed from the nest of birds, bearing in mind the size of transmitter to be implanted. Once removed, the egg is opened by carefully sawing through the shell without cutting the shell membrane. A very fine hacksaw works well. Once the shell has been cut completely around, the membrane can be cut with a scalpel. The contents of the egg are

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discarded and replaced by 1 g/100 g water agar-agar solution. Before the agar sets, the transmitter is suspended in the egg by a thread. After the agar has set, the two parts of the egg are joined by quick-setting epoxy (Figure 2). When the glue is dry, the egg can be returned to the nest. Using the timer and radio-cassette recorder (Figure 3), thermal events of the incubation period can be monitored.

Many schematic diagrams are available for transmitters (Mackay 1970; Strong 1963). Suppliers, such as Mini-Mitter Co. Inc., Box 3386, Sunriver, OR 97702, also have a good selection of transmitters available. The bean-sized transmitters have an effective transmission range of one meter or less. A loop antenna effectively extends the distance over which data can be gathered to 50 meters or more. The signal can be picked up anywhere on the AM band of any radio, although some radios work better than others. Radios with a cassette recorder internally linked can be used for gathering and storing data. For gathering data over extended periods of time, the timer switching curcuit (Figure 4) works well. By adjusting the variable resistor, the cassette radio can be turned on every 15 minutes, for 15 second intervals. This provides a large enough sample of pulses for most temperature determinations.

The small battery packs of the cassette radios do not usually last long enough to follow a full incubation period. Twelve volt motorcycle batteries tapped such that only four cells function in the circuit provide long life and are rechargeable.

Students invariably enjoy obtaining data from within an organism by telemetry. The idea of remote sensing adds the flavor of "space-age" technology to the biology lab. An enduring area of study, thermal biology, revisited by modern technology results in increased awareness of the thermal plasticity of many animals, and generates considerable interest in the biology lab.

References

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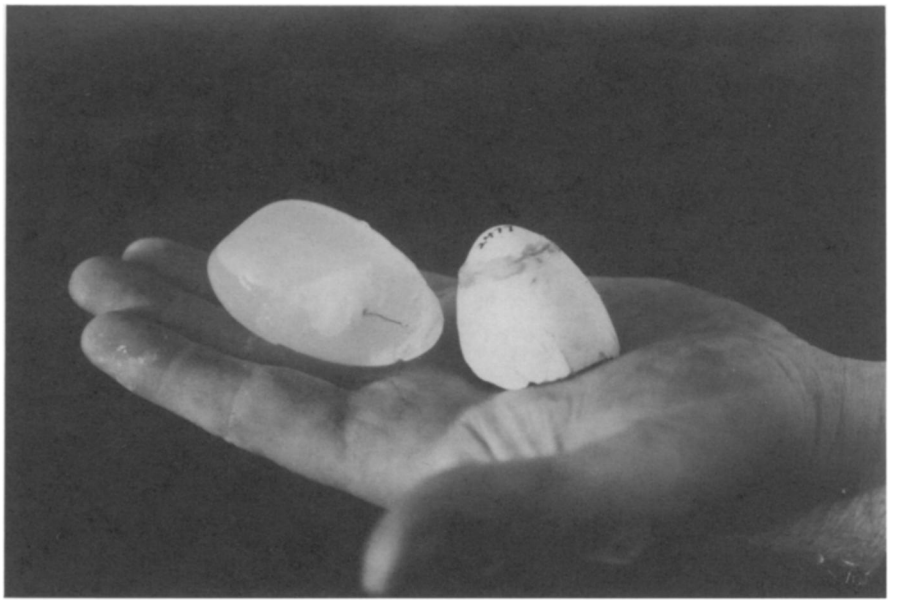

Figure 2. Transmitter suspended in agar gel. Note the egg shell with the epoxied end.

Figure 3. A complete system for gathering incubation data. The radio, timer and battery pack are placed in a moisture proof plastic cake pan.

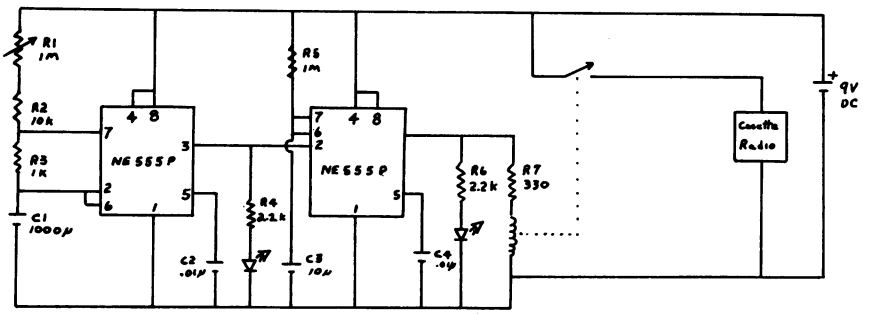

Figure 4. Schematic of timer for automatic data recording.