

mals, the autonomic centers are modulated by higher centers in the neocortex of the more complex brain. To study the basic processes of cardiovascular regulation the higher centers must be eliminated from function by anesthesia. Unfortunately, such anesthesia also affects the primary, autonomic centers as well as functional components within the heart and blood vessels. By studying a more primitive vertebrate, such as a reptile, the basic autonomic control of the circulation is at hand with little influence from other centers. Development of techniques that permit humane study of the unanesthetized reptile allow unambiguous analysis of basic cardiovascular regulation.

Turtles are prepared by providing a chronic hydraulic connection to a central artery. This port provides access for direct monitoring of central arterial blood pressure as well as a convenient means for the administration of drugs and physical challenges. Arterial pressure is an important regulated parameter in itself, but also contains information in its waveform as to heart action and the activity of the terminal arterioles that provide most of the resistive load placed on the heart.

The initial phase of the study is the determination of the characteristics of arterial pressure regulation in restrained but otherwise normal animals in a controlled laboratory environment. This will provide a basis for comparison, in later studies, to arterial pressure patterns in unrestrained animals in their natural habitat monitored by radio telemetry.

#### **TEMPERATURE REGULATION IN FREE-RANGING OPOSSUMS**

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NIH Biomedical Sciences Support Grant

Behavioral and physiological strategies for temperature regulation are being compared in the native opossum, a primitive marsupial mammal, in its natural environment. An implanted, two-channel pulse modulated telemetry transmitter provides data on core temperature and heart rate. Data is acquired either manually, by tracking with a portable direction-finding receiver and digital readout equipment, or on a central data storage sys-

tem via transponding radio repeaters. All telemetry system components were developed in the Bioinstrumentation Laboratory, jointly sponsored by the Department of Electrical Engineering and the Department of Physiology and Cell Biology.

Animal heat production is estimated from heart rate and a factor determined from direct oxygen consumption measurements made prior to release of each individual. The ratio of core-environment temperature gradient to heat production provides a measure of heat conservation thermal resistance. Behavior is monitored by remote tracking of the position and movements of the animal from the telemetry signal.

In contrast to laboratory studies of restrained animals, these free-ranging studies allow the role of behavior to be related to physiological adjustments of heat production and heat conservation for various environmental conditions. The studies are aimed in part at determining organism management of energy resources and in part at understanding biological control mechanisms. In animals, behavior shows much of the characteristics of open sequence control while physiological adjustments are largely feedback mechanisms.

#### **RADIO TRACKING OF WILD ANIMALS IN THEIR NATURAL HABITAT**

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Movements of animals about their home range are being followed with the aid of attached radio transmitters. Once the unit is placed on or within the animal, it can be located at will with negligible disturbance to its natural behavior. Location of the transmitter and host animal is carried out with a portable direction-finding receiver system. Animals are identified by their individual, crystal-controlled transmitting frequencies in the 27 MHz frequency range. The present studies are extensions from techniques developed for past studies of box turtles, eastern Kansas snakes, opossums, racoons, skunks, and marmots.



Radio tracking of an animal in its natural habitat.

Snakes in southwestern Kansas are being tracked with transmitters fed to them. The silicone rubber-covered oval units of approximately prey size are retained in the snake's stomach for several weeks and apparently produce little interference with further feeding and movement. Transmission distances up to 100 yards and a useful life of about one month permit simple location of otherwise secretive animals.

Soft-shelled turtles living in the Lawrence-Eudora stretch of the Kaw River are being followed from transmitters cemented to their upper shell. Since these animals spend most of their time hidden in the muddy water, their movements are largely unknown. Fresh water does not interfere with propagation sufficiently to prevent location from distances up to at least one quarter mile. Greater reception range is being aided by use of a new, low-noise receiver of high tuning accuracy.

Mountain goat movements in the Montana Rocky Mountains are being determined from transmitters attached as rugged collars, firmly fastened around the neck. The larger size, higher elevation from ground, and larger batteries permitted by this large animal provide a detection range of up to two miles and transmitter life of several months.

Home range studies of wild animals provide an important link in understanding organism-to-organism and organism-environment interaction as well as the natural history of many infectious diseases for which they may be a prime host or significant vector.

#### MAGNETIC TAPE RECORDING OF EKG AND COMMENTARY FROM AMBULATORY PATIENTS

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It has been generally found that graded exercise in the form of walking is beneficial to patients who have recovered from heart attacks. Some patients undergo a prescribed regime of increasingly vigorous walks without any untoward symptoms while others experience some transient chest pain, shortness of breath, or fatigue. Understanding of the basic nature of cardiac infarct healing as well as improved convalescent management would result if electrocardiograms, recorded simultaneously with the patient's commentary, could be obtained during the prescribed exercise.

To achieve the needed exercise monitoring, the following program of study has begun. A common, battery-operated, cassette magnetic tape recorder, weighing less than five pounds, is carried by the patient and allows up to one hour of continuous recording. Voice commentary and the electrocardiogram are frequency multiplexed on the single recording channel. Voice commentary is limited to a band of 300 to 3000 Hz. The EKG signal is recorded as a frequency modulated subcarrier in the 6 kHz region limited to 40% deviation. These preconditioned signals are linearly added and used as recorder input in lieu of the standard microphone. On playback, the audio and EKG signals are separated by filters and presented on a speaker and oscilloscope, respectively.

It is expected that development of the monitoring system as a low-cost accessory to conventional portable magnetic tape recorders will make available an important tool to physicians for research and improved patient management.