Biocommunications: One-way Street

The marriage of cybernetics and biology is revealing message pathways to researchers in rein control.

by Barbara J. Culliton

Words are as essential to man's physical life as they are to his mental life, though the vocabulary the body uses to communicate with itself is still largely undeciphered.

The body's language is being decoded by a new breed of scientists who have joined biology and engineering, leading both down wholly uncharted paths.

Their science is biocybernetics—the study of control and communication in living systems. Their goal is to find out how the body processes all the bits of information it receives from external and internal stimuli.

In 1960 a New York physical scientist turned physiologist observed a curious phenomenon: the eye contracts in response to a flash of darkness just as it does to a flash of light. Experiments showed two kinds of light-sensitive receptors in the pupil: One responds rapidly to increases in light only, another, slower kind reacts to decreases. Contraction following a darkness flash, the scientist found, is really a positive response to the return of light after a brief interval of darkness; the slower-reacting decrease receptors don't get a chance to react.

From this initial data and other observations about sensory responses to which it led, Dr. Manfred Clynes of Rockland State Hospital, Orangeburg, N.Y., formulated the first law of biocybernetics, called "dynamic asymmetry" or "rein control." By looking at a dynamic physiological event with the eye of a cybernetician, Dr. Clynes saw that certain kinds of information can be transmitted only in one direction, through one channel. "Rein control" comes simply from the similarity of biological communication channels to the reins of a horse. A pull on the left rein is the same pull as a pull on the right. The horse understands what it means from its location. Furthermore, it is unidirectional; you can pull on a rein, but you can't push.

The language that regulates biological control systems, Dr. Clynes says, is similarly unidirectional. It's like traveling down a one-way street. If you decide to go the other way, you have to go around the block and take another, parallel street back to the starting point. Dr. Clynes' observation that this kind of unidirectional sensitivity operates in living systems seems to apply to most forms of biological talk and explains previously poorly understood functions.

Dr. Clynes, seven years ago, designed 12 computer models for testing his proposition and threw down the gauntlet to the rest of the scientific world.

The challenge was taken. Last month, men from England, France, Holland, Germany, Canada and the U.S. gathered under the auspices of the New York Academy of Sciences to confirm the validity of rein control and usher in the new physiology.

The men were engineers and biologists who blended engineering theory with physiological fact, and observed that auditory, visual and tactile senses do operate according to Clynes' principle in many respects. For example, a person can touch a row of pin points and tell how many pins there are. But if some are withdrawn very slowly from his touch, he is not able to tell how many pins are left. The act of removal does not communicate any tactile information. In other words, there is a response to the presence of a stimulus, but no response to its withdrawal. Sensitivity here is a one-way street.

Dr. F. Eugene Yates of Stanford University, in explaining the applications of rein control theory to clinical medicine, pointed out that the brain sends and receives messages in two ways. It can speak electrically by transmitting nerve impulses at specific frequences to specific receptors, and it can dictate the manufacture and release of chemicals or hormones to carry information to specific organs. Because there is no such thing as a negative chemical to correspond to negative charges in electrical systems, the only way the body can alter the action of a particular chemical is to subject it to the influence of a second chemical. The brain, therefore, is both a chemical and electrical center of communication and control. As such, engineers are finding it more and more interesting as a subject for analysis.

Computer designers, Dr. Yates says, must design a system to carry out a certain activity. Biologists face a similar challenge in reverse. For them, the system is already there and they have to figure out how it works. The prospect of using the design of biological control systems, which are far more complex than any digital computer, to build new computers is so intriguing, Dr. Yates says, that at Stanford engineering students are turning to research in biology instead of problem-solving in industry as a career.

"Biology is getting some of its best people from engineering these days," he says. He believes the next generation of physicians is going to have to know engineering as well as medical language for he finds that engineering provides a new, more precise language for identifying specific disease processes that will pay off with better medicine.

Dr. Yates has applied engineering systems analysis to the adrenocortical system which regulates the body's supply and use of blood sugar and plays an important role in its ability to fight disease. He set out to find whether the adrenal cortical system, which is essential to life, functions by way of a single communication channel, and if so, whether it has a parallel, corresponding system for balance. In both cases, the answer is yes. The parallel system is the insulin channel.

By studying the dynamics of the adrenal cortical system—the way it works in motion—Dr. Yates found that the real source of biological control lies in the hypothalamus in the brain, and not in the adrenal gland. This means that a doctor hoping to correct an imbalance in the amount of adrenalin being secreted by the gland should look to the hypothalamus rather than the gland itself. In practice, this means the amount and potency of a drug being administered a patient should be determined by the target organ at which the drug is aimed. If an adrenocortical deficiency stems from the hypothalamus, the body will need many times more chemicals than it otherwise would to achieve normality.

The major difficulty in studying biological controls such as the adrenocortical or even cardiovascular systems is a lack of sophisticated techniques for assessing hormonal activity or blood-pressure responses in motion.

But much of the work by Dr. Yates and others is still in its infancy. Out of the present research by biocyberneticians should come the sensitive equipment that will enable scientists to study rein control, or the dynamics of communication in living biological systems.