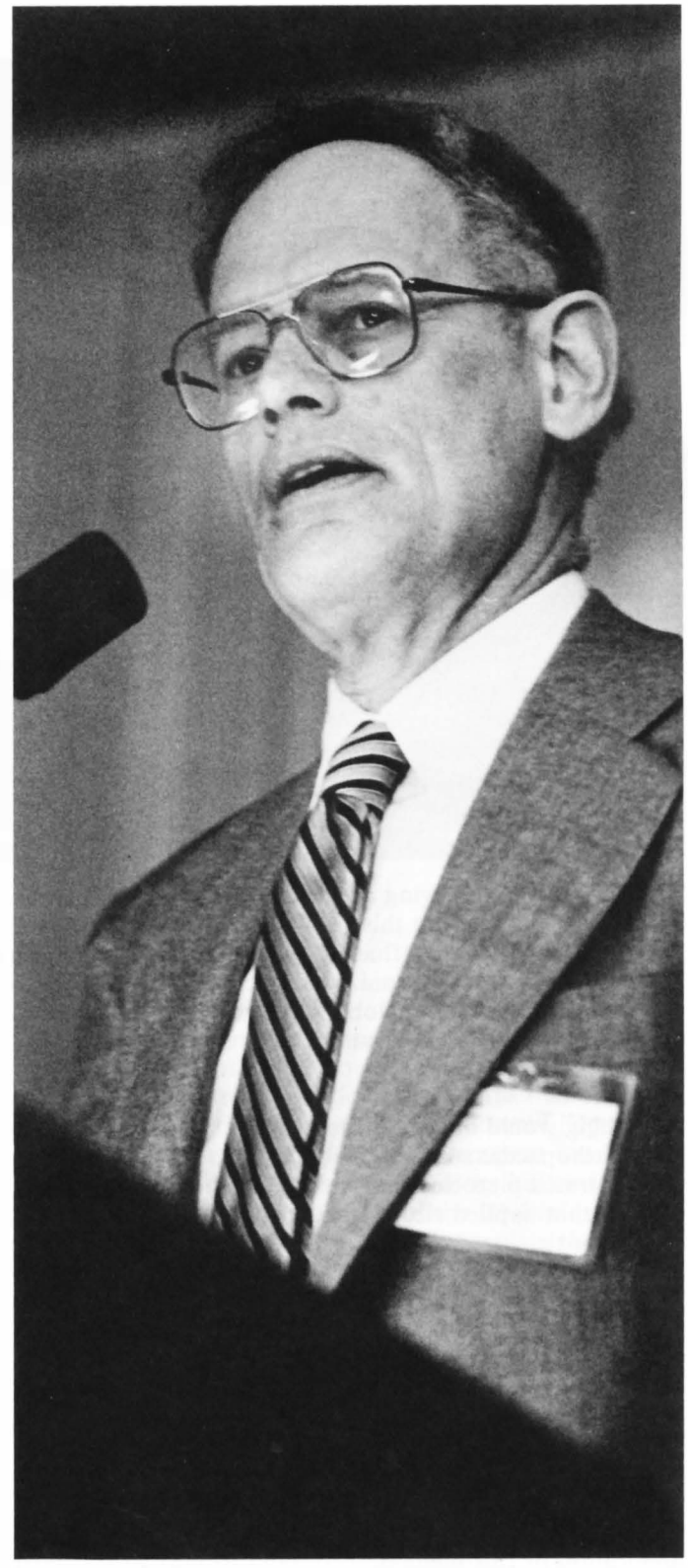
Orthopaedics and the Coming Scientific Revolution

Robert O. Becker, MD, who retired from his position as chief of orthopaedics at the Veterans Administration Medical Center in Syracuse, New York, is now working as an educator and researcher in the biomedical sciences. His particular area of interest is the relationship between electricity and biology. Speaking before his fellow orthopaedists at the Academy's Annual Meeting, Dr. Becker said that the investigation of electricity and life could lead to a "complete revolution in the concepts of biology" and a "revolution in medical practice." Following are his remarks.



As orthopaedic surgeons we tend to think very provincially, with our specialty being the most important aspect of our intellectual lives. As a result, the recent use of electrical currents and electromagnetic fields for the stimulation of bone growth has been assumed to be a relatively minor phenomenon, based upon the piezoelectric property unique to bone, and of no greater import.

The truth is far more than this. What has actually happened is a complete revolution in the basic concepts of biology. What may result is a revolution in medical practice in many areas far removed from orthopaedic surgery.

I should like to review this important development and indicate the central role played by our specialty.

Historical Background

The story goes back to the late 1700's when Galvani thought he had identified electricity as the "vital spirit," that imponderable something postulated by many great thinkers since Hippocrates that gave life to the organism.

The conflict between the vitalists, who proposed this idea, and the mechanists, who believed that living things were simply more complex assemblages of non-living units, had been going on for a long time. Galvani's claims only renewed the debate, but now the mechanists had a target—electricity. All that was necessary to destroy the vitalist concept was to remove electricity from living things.

A period of great scientific activity ensued. Galvani was soon proven wrong by Volta, who showed that what Galvani had observed was really the generation of a new kind of electricity—direct current—by the junction between two different metals in a conducting solution.

Volta's work became the basis for the storage battery and actually set the stage for much of the technological world we are all familiar with. Fifty years later, Matteucci showed that Galvani was not all wrong, living things did generate electrical currents, particularly at sites where they had been injured—the current of injury.

But, by now, the tide was running strong in favor of the mechanists and little attention was paid to Matteucci. Discovery followed discovery and by the beginning of the present century science was firm in its mechanistic view that living things were merely chance aggregates of complex chemical structure. Biochemistry and physiology would soon be able to explain all the functions of living things and none of them would have anything to do with electricity.

Continuing Research

However, by 1930, it became apparent that the chemical concept did not explain everything; there were many basic biological functions that remained total mysteries. These included growth and development to name only a few.

In 1938, Dr. Albert Gyorgi, a Nobel prize-winner, gave an important presentation in which he indicated these defects and suggested that the enormously complex, yet highly organized structure of biological molecules made electronic conduction possible. By this he meant semiconduction and other solid state electronic mechanisms, such as piezoelectricity.

He proposed that living organisms generated and transmitted small currents in this fashion and that these regulated life processes by influencing cell behavior.

Nothing was done, organized science reacted with complete indifference—even Nobel prize-winners are ignored when they say something that changes existent dogma.

Orthopaedic Curiosity

Nothing would have been done were it not for a few curious orthopaedic surgeons. In 1953, Dr. Yasuda not only demonstrated piezoelectric properties in bone, but he also showed that applied electrical current could stimulate bone growth.

In 1960, I presented evidence at the AAOS meeting in Miami that the current of injury in animals which regenerated was much different from that in animals which lacked that capacity. By 1962, C. Andrew Bassett, MD, and I rediscovered Yasuda's piezoelectric effect in bone and in 1964 we confirmed his observation of the electrical stimulation of bone growth.

In 1966, Bert Friedenberg, MD, and Carl T. Brighton, MD, were studying the electrical events associated with fracture healing. By 1972 they reported the first clinical application of this method.

What has happened since then in orthopaedics is, I am sure, well-known to all of you. The technique of electrical or electromagnetic osteogenesis has become an accepted part of the orthopaedist's armamentarium for the treatment of nonunion.

However, that is probably the least important event in the cascade of discoveries made since 1960.

The scientific establishment views all clinicians as fairly stupid, with orthopaedic surgeons being particularly so. Therefore, when these crude fellows began to experiment with electricity in biology, and particularly when they committed the heresy of actually using electrical currents to stimulate growth clinically, something had to be done!

Many experiments were set up and run with the firm expectation that living things were going to work exactly as the dogma predicted. What happened was that more and more members of the establishment came to say the same things we did. In addition, by the end of the 1970's, no one could really question the results of the clinical applications.

Growing Discoveries

In 1960 the scientific literature contained a bare handful of papers on the effects of small currents, or fields, on living things. During the last six months of 1982, there were more than 7,000 citations in this area.

We now know the following:

All living things are closely tied to the electromagnetic fields of the environment and very probably changes in these fields were involved in the origin and subsequent evolutionary development of life.

The central nervous system functions at the most basic level, in the fashion envisioned by Gyorgi, generating and transmitting minute currents which regulate growth and healing and establish the basic level of neural functioning.

This activity results in the generation of the recently discovered magneto-encephalogram, a magnetic field extending out in space from the brain and relatable to basic mental activity. Many species of organisms, including the higher primates and man, have been found to have actual deposits of magnetic mineral within their central nervous systems, the functions of which are just now being evaluated.

Levels of electrical currents far below those perceptable are known to profoundly alter behavior and cognitive functions, as well as influence cellular growth and regeneration.

Changing magnetic fields have been shown to alter mitotic activity in mammalian cells.

Abnormal electromagnetic fields produced by man's activities in power generation and transmission and in communications have been shown to have biological effects. This area is being actively explored at this time to determine the extent of the associated health risk.

State of Transition

You can see that biology is in a state of rapid transition, which will result in a very different view of how living things work.

This change would never have occurred had it not been for the effort, curiosity and willingness on the part of the orthopaedic community to disregard dogma.

The record of the past 25 years is one that all orthopaedic surgeons share in, clinician and researcher alike, and one that we can all be justly proud of.