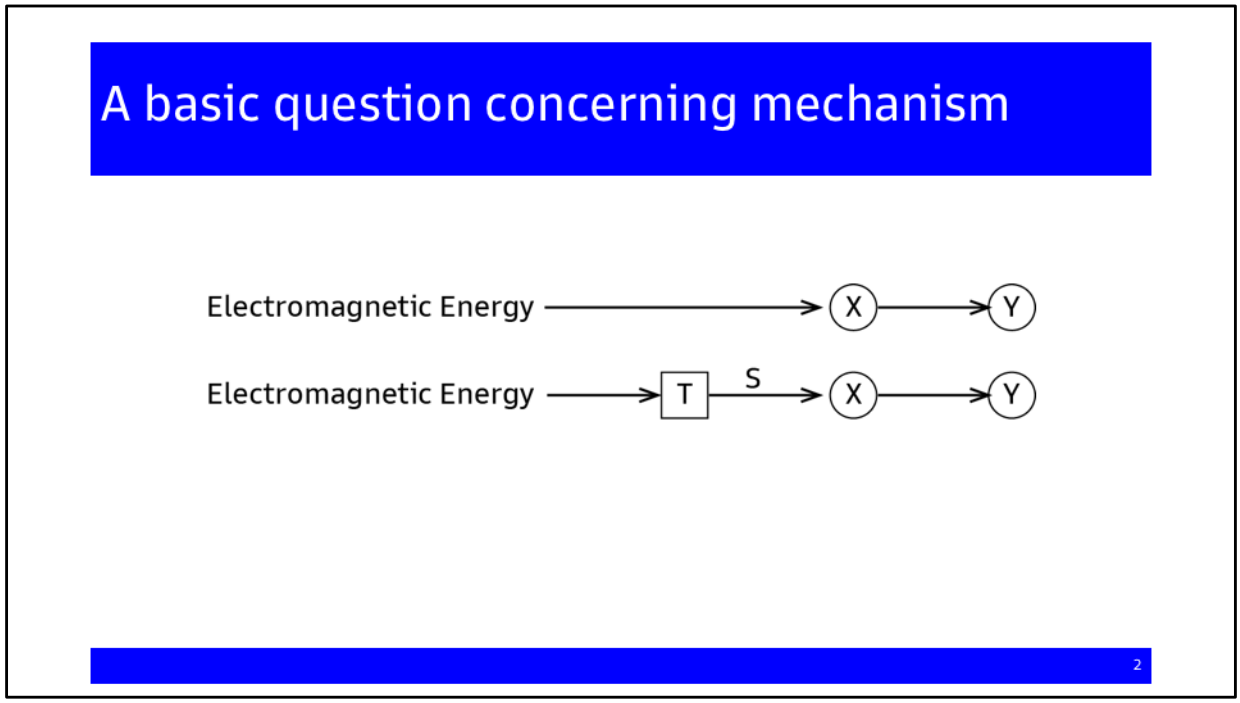
Microenvironmental Changes Due to Electromagnetic Energy

Andrew A. Marino
Veterans Administration Hospital
Syracuse, New York
March 1979

1



We can think of biological effects due to electromagnetic energy (EE) in two general ways. Either the energy interacts at a location in the body, call it X, and produces a physiological effect at or near X, call the effect Y; or the energy is transduced, call the transducer T, into a biological signal called S, which then interacts with X resulting in Y. The essential difference between the two models is that T and S are universal, irrespective of the nature or electrical properties of the electromagnetic energy. For example, T could be a free nerve ending , S could be an afferent electrical signal, X could be the brain, and Y could be a physiological change orchestrated by the brain. An example of the simpler model is a typical *in vitro* study where X is a cell in which Y occurs. In that model X can be any cell, Y can be any effect, and the S-T process can be highly sensitive to the electrical characteristics of the EE. Studying the X-Y relationships is a task that could keep investigators busy for a very long time because of the great number of possibilities. The T-S-X-Y model is far less complex because X and Y are evolutionary conditioned processes not directly dependent on the EE.

Incontrovertible effects of electromagnetic energy

	Current Density
Thermal	100 μA/cm^2
Neural Stimulation	100 μA/cm^2

3

There are only two incontrovertibly established effects due to electromagnetic energy. The effects occur when the induced current density is above about 100 μA/cm^2.

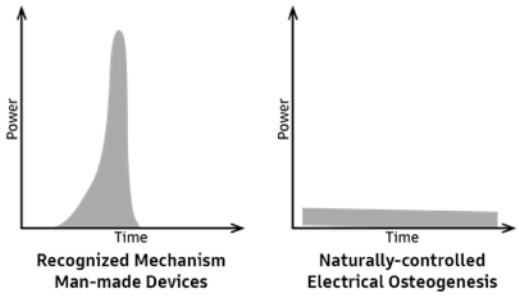
Methods of energy-induced osteogenesis by present devices

	Current Density (μA/cm²)
Direct Current	10
Inductive Coupling	10
Capacitive Coupling	0.1
Other	<0.000001

4

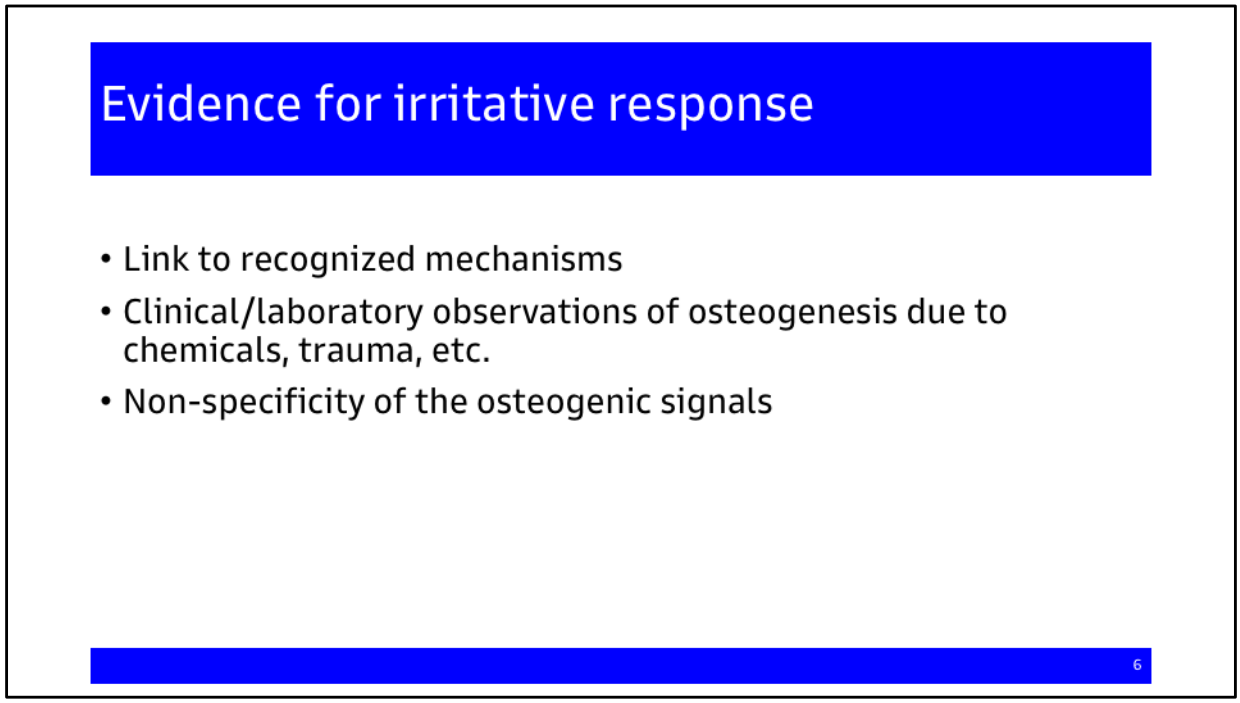
The three presently available devices for growing bone all employ current densities that are below the thermal level. Other devices that are currently under study employ even lower levels of current density.

Application of electromagnetic energy to biological systems



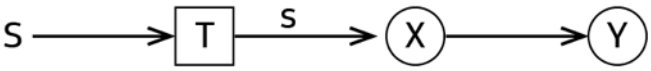
5

Not only is the energy supplied to bone by man-made electrical devices far greater than the energy associated with natural electrical control of growth, the time course of the energy supplied by mechanical devices differs strikingly from the time course used by nature.



I propose that the effects of man-made devices on bone growth are quite unrelated to natural bone healing and actually constitute nothing more than an irritative response of bone to electrical energy. It is well known that numerous factors including chemicals, acid, foreign bodies, and mechanical pressure can trigger an osteogenic response. All of these diverse factors produce a signal, S, which triggers osteoblastic activity. There is nothing "natural" or "biological" about the present devices on the market. The devices are nothing more than a way of producing a controlled injury in bone that is capable of eliciting an injury response. Claims that the devices simulate natural bone healing are misleading.

Summary



Where S represents a wide range of applied stimuli, but s is internally generated and may be the same in each instance.

7

In terms of the model mentioned initially, we can think of the transducer T as the body's basic injury response which can be triggered by numerous stimuli, S, which result in the known biochemical responses to injury leading ultimately to bone growth.

Piezoelectricity and the internal stimulus

"Other" electrical osteogenic stimuli:	1. Electrets 2. Bi-metallic elements
Proposed experiments:	1. Implanted electrets 2. Surface-charged dielectrics

8

The possibility remains that sources of electrical energy that are comparable in magnitude to the known levels of electrical energy in the body could prove to be useful for stimulating bone growth via its natural system for growth.