

Electromagnetic Fields are Transduced Like Other Stimuli

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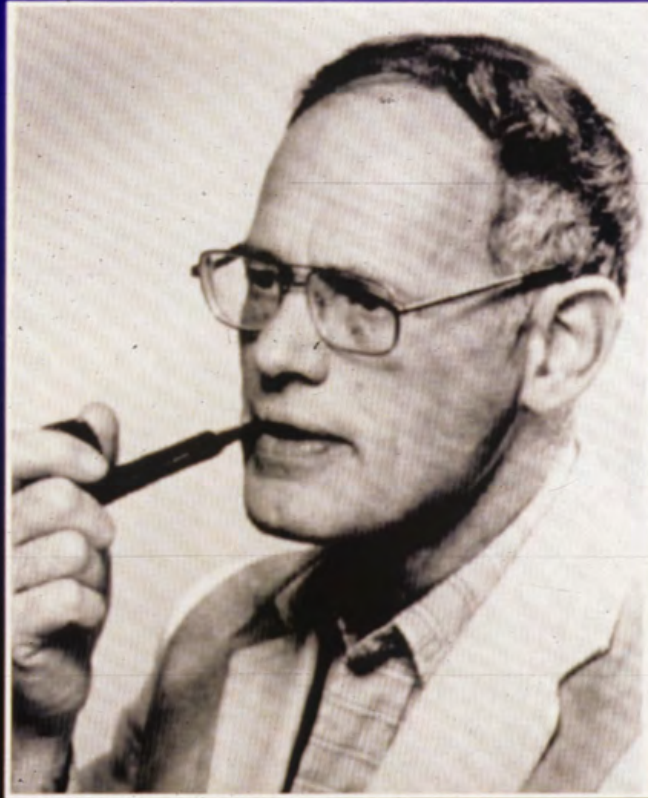
Shreveport, Louisiana, U.S.A.

Citations to sources given here.

Overview

- EMF origins
- Issues raised
- Hypothesis (ΔV_m)
- Data (EEG, Immune system, Bone)
- Statistics

Origins of EMF Bioeffects (U.S.)



- JBJS 43A:643-656, 1961
- Technology Review (MIT)
32-38 (Dec.), 1972

Origins of EMF Bioeffects (Russia)

- Kholodov, Yu.A., 1966: The effect of electromagnetic and magnetic fields on the central nervous system
- Presman, A.S., 1970: Electromagnetic fields and life
- Tolgskaya, M.S. & Gordon, Z.V., 1973: Pathological effects of radio waves
- Sadcikova, M.N., Dumanskii, G.P. & Shandala, M.G., 1973: in Biologic effects and health hazards of microwave radiation

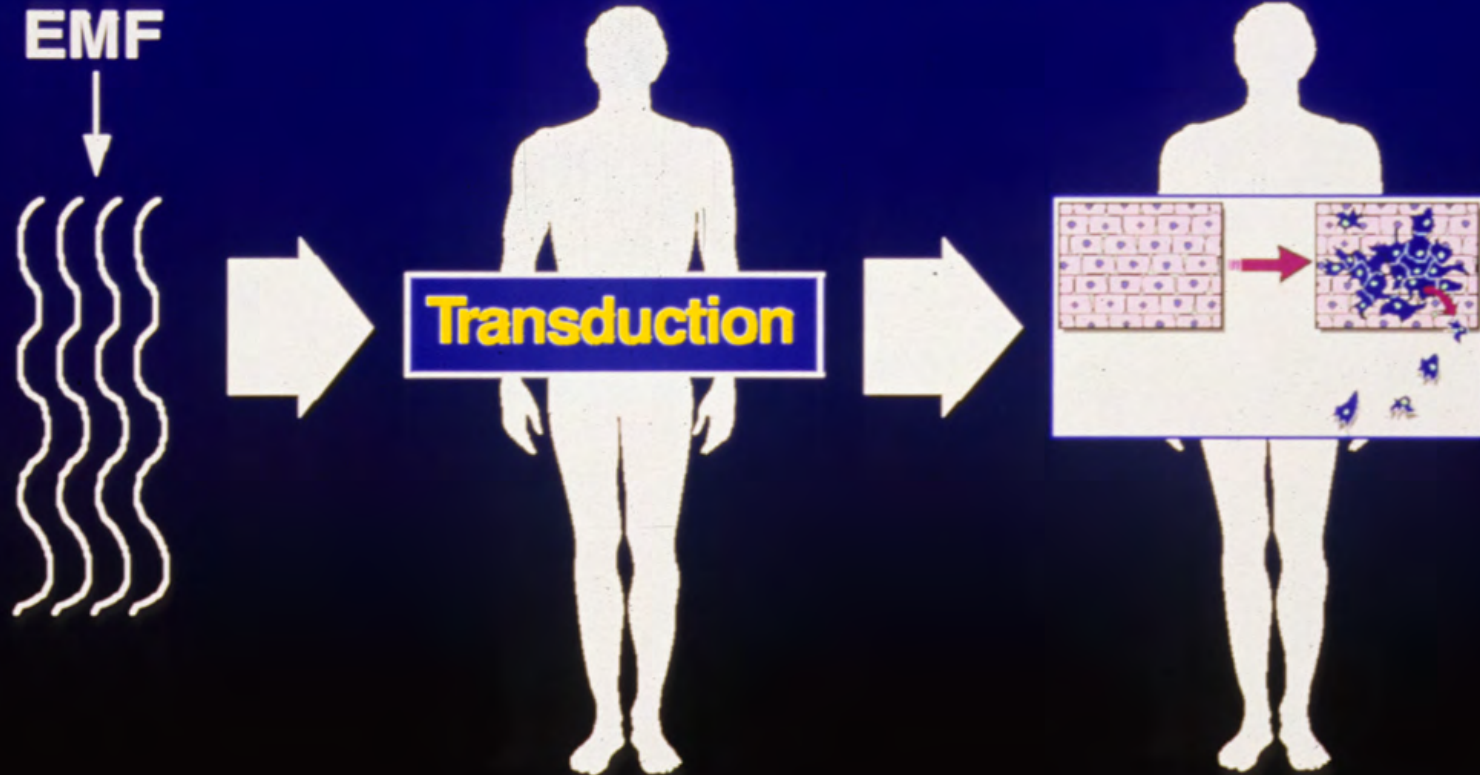
EMF Bioeffects: Areas of Interest

- Health risks (cancer)
- Medical applications (bone)



All reports erroneous
or
New physiology

First Type of Issues

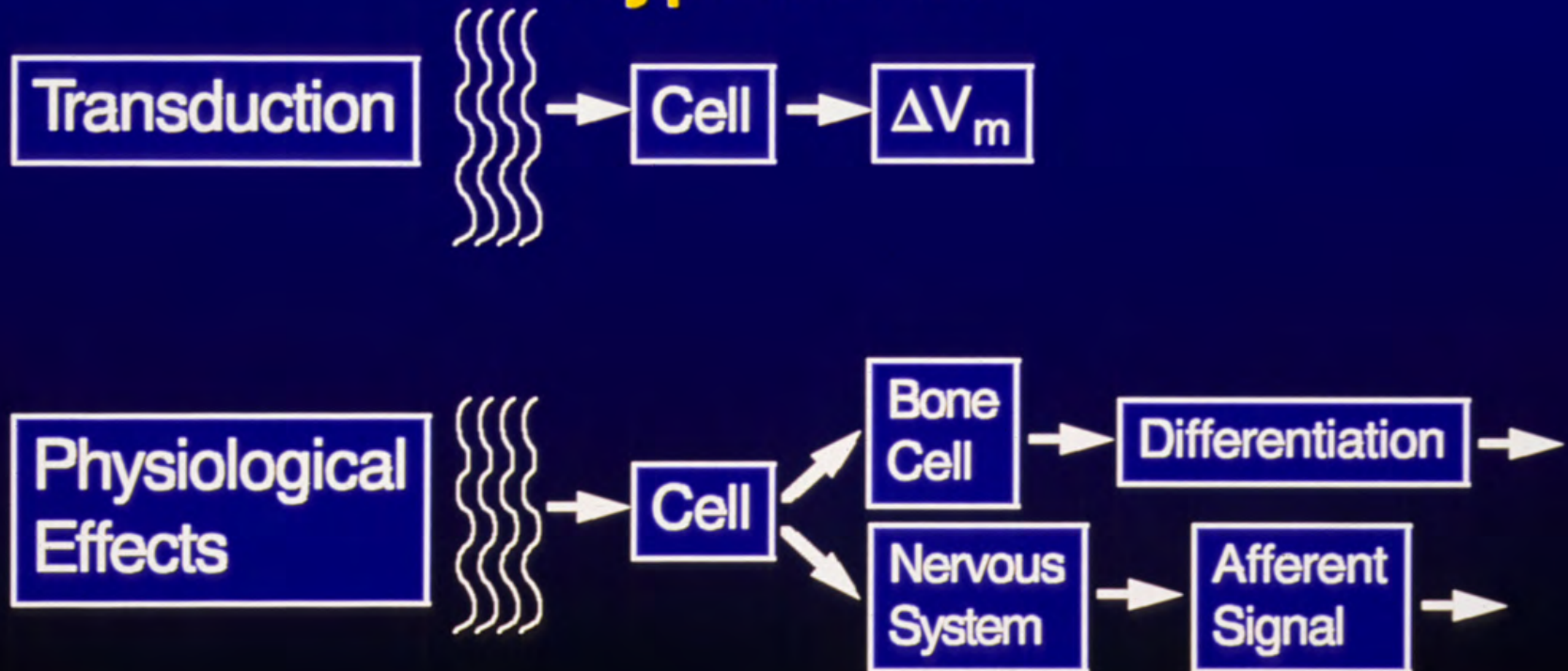


Second Type of Issues

- How should the existence of EMF effects be determined*?
- Statistics
 - Mean? Variance?
 - Non-Linear Methods?

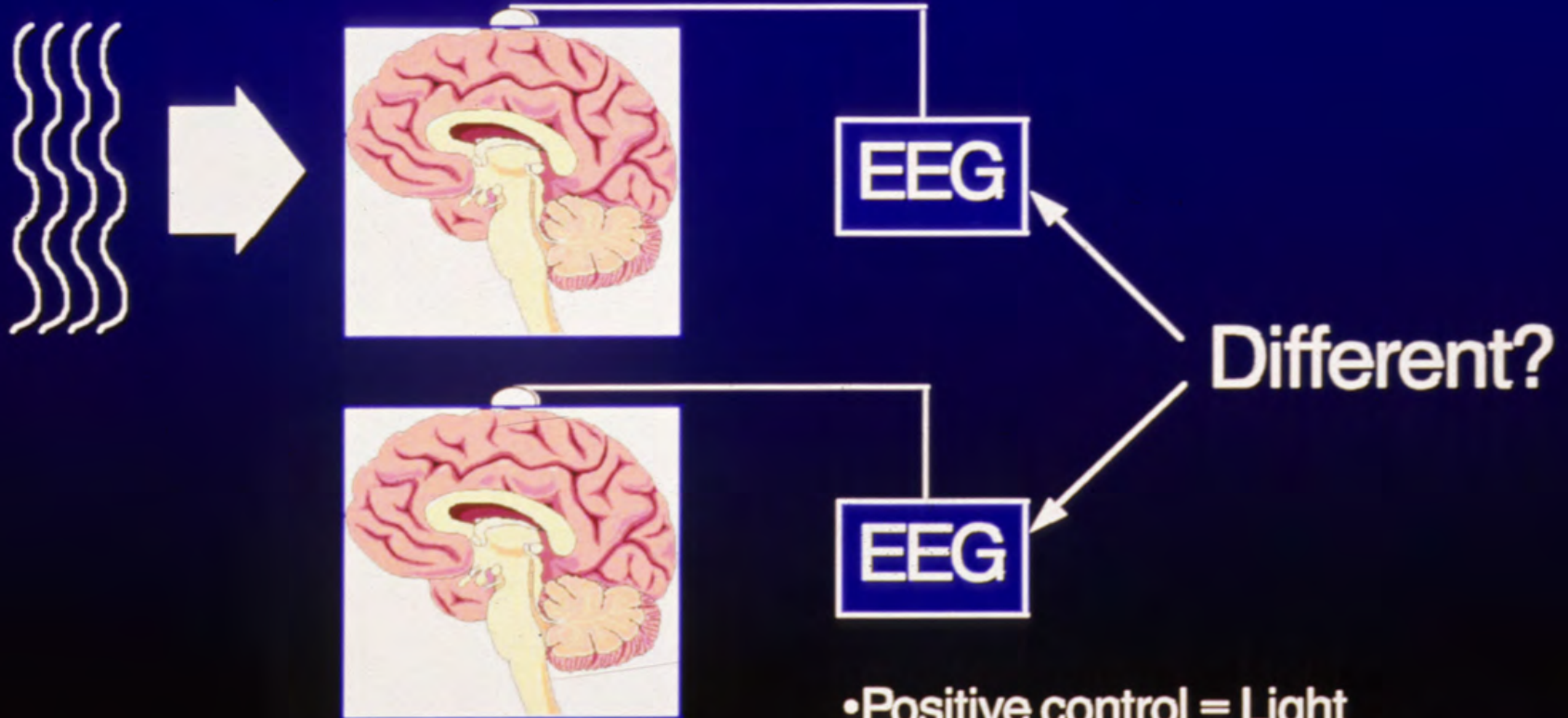
*<http://www.ortho.lsumc.edu/Faculty/marino/BEMSLink.html>

Hypotheses



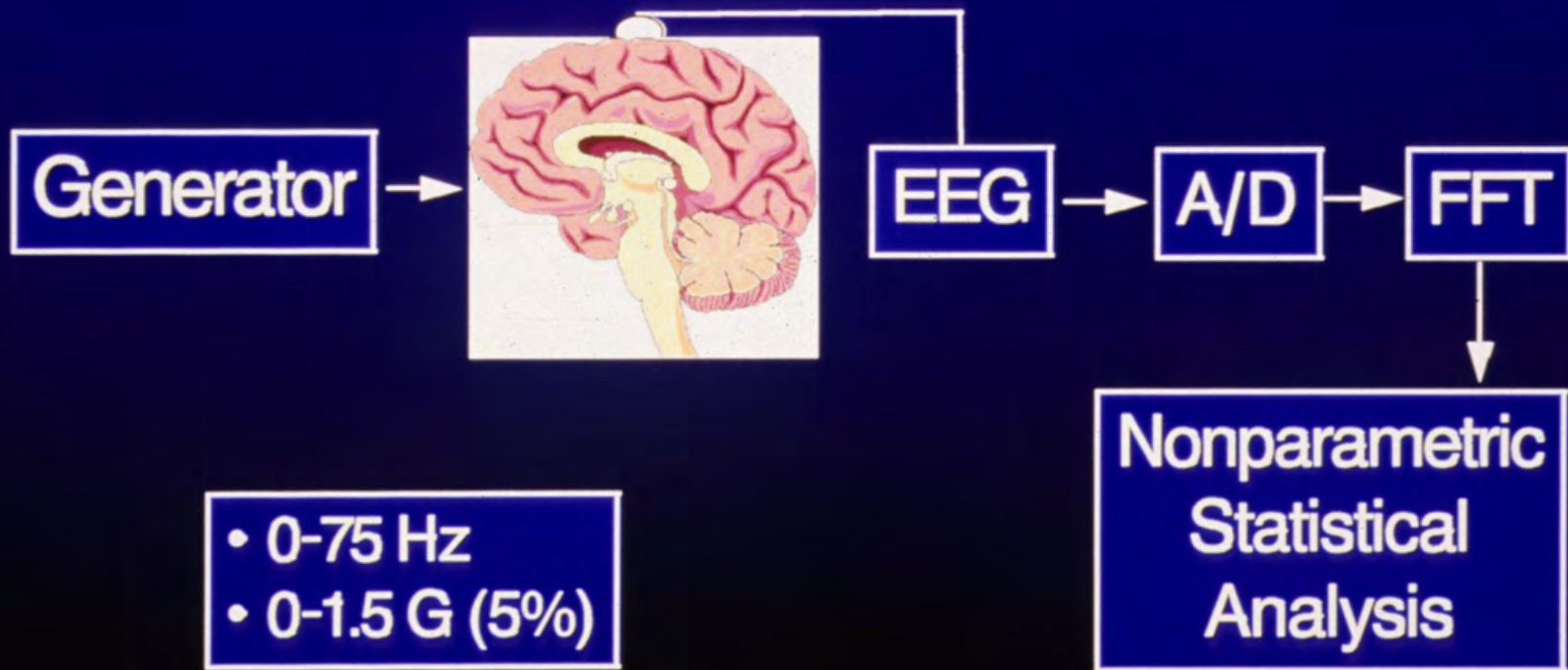
Electromagnetism & Life, Becker and Marino, SUNY Press, 1982.

Effect of EMFs on EEG

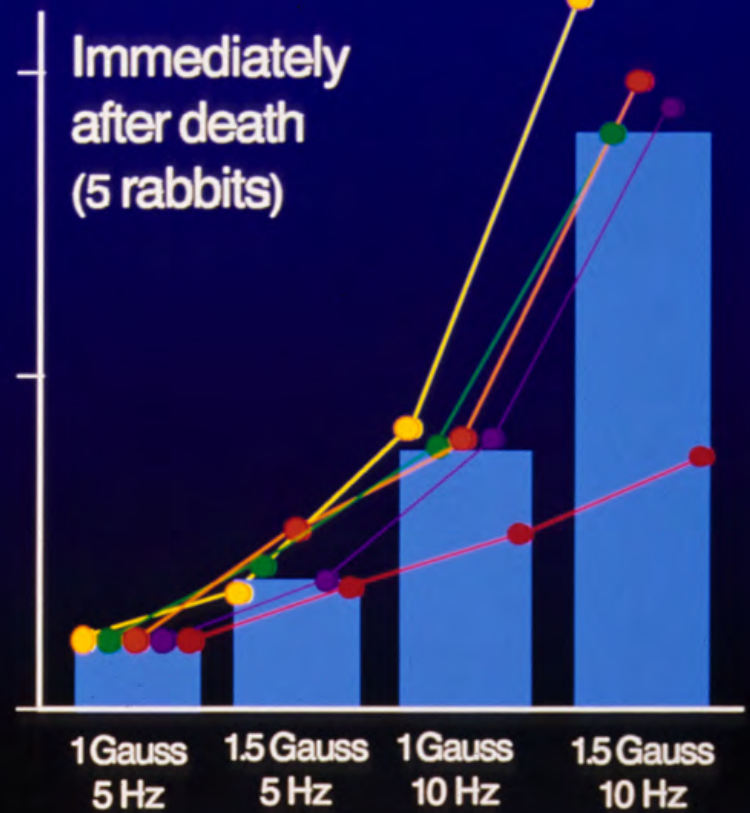
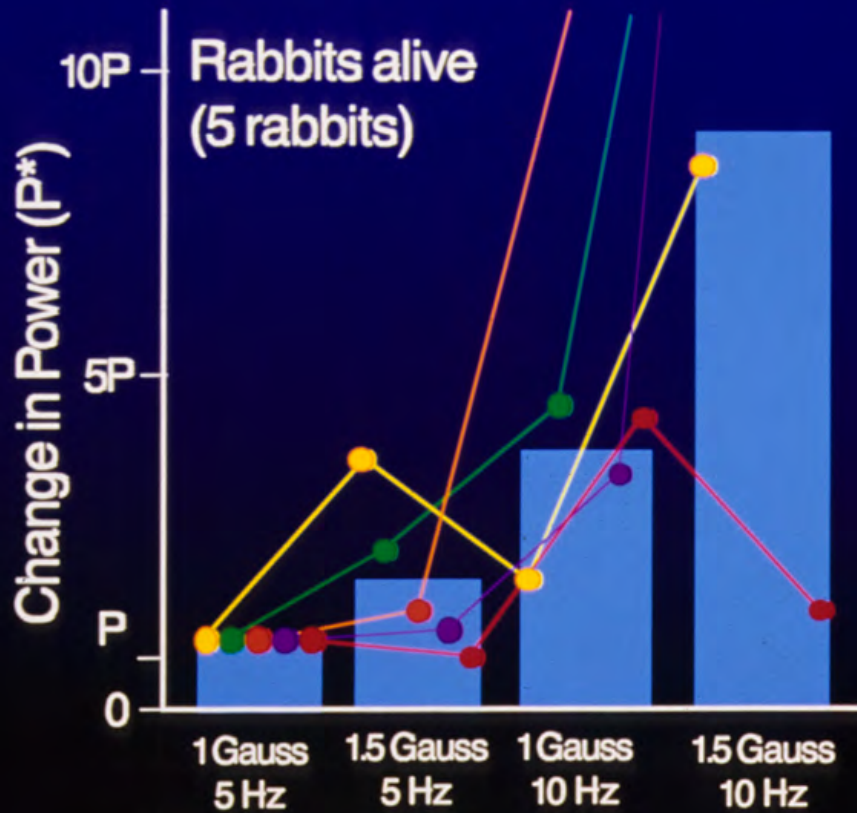


- Positive control = Light
- Negative control = Sham Exposure
- Humans and rabbits

Exposure System



Effect of EMFs on Rabbit EEG



$$*P = c (f B^2)$$

Brain Research 570:307-315, 1992

Effect of EMFs (0.25-0.5 G, 40 Hz) on Human EEG

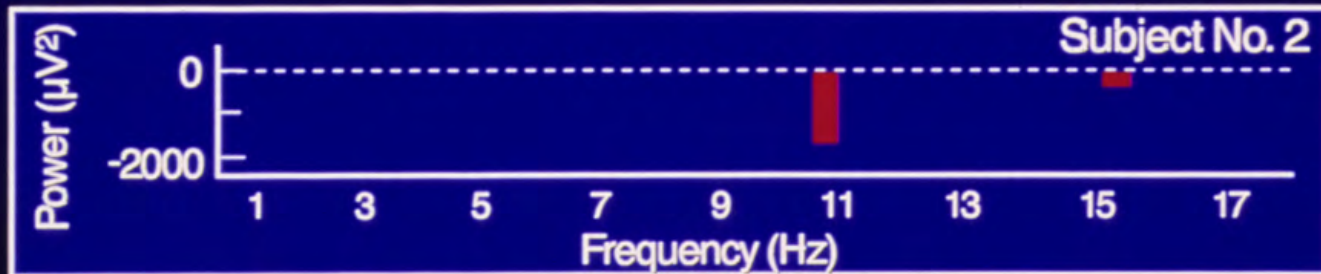
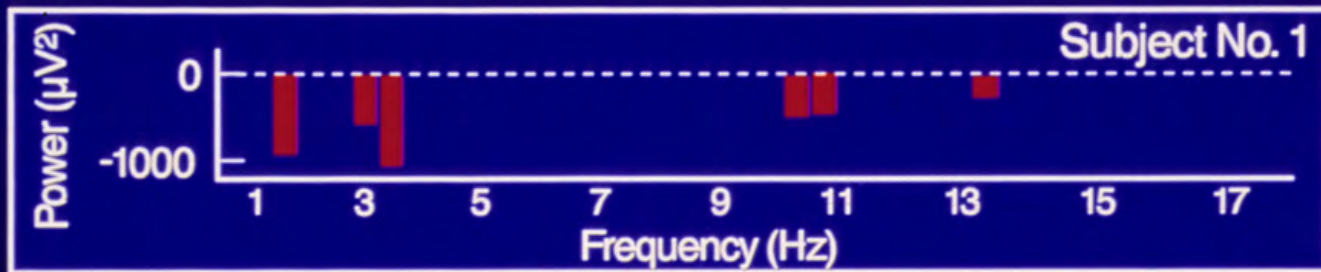
<u>Subject</u>	<u>EEG Frequency (Hz Affected)</u>
1	None
2	O-2.5, 17
3	P-11,12
4	O-5.5, 7
5	C-1.5, 3, 3.5, 10, 10.5, 13
6	None
7	C-10.5, 15

<u>Subject</u>	<u>EEG Frequency (Hz Affected)</u>
8	None
9	None
10	None
11	P-11, 12
12	None
13	None
14	C-6, 10, 12; O-1, 1.5

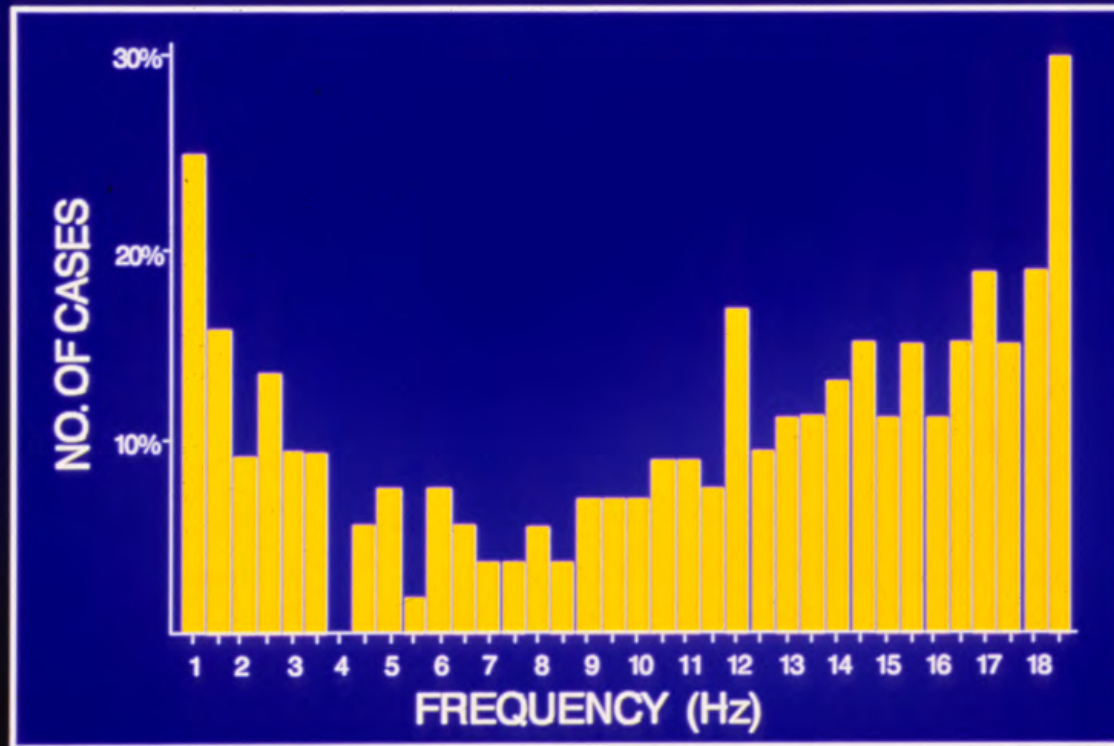
C, P, O are central, parietal, and occipital electrodes, respectively.

Lancet 338:1521, 1991.

Change in EEG Power

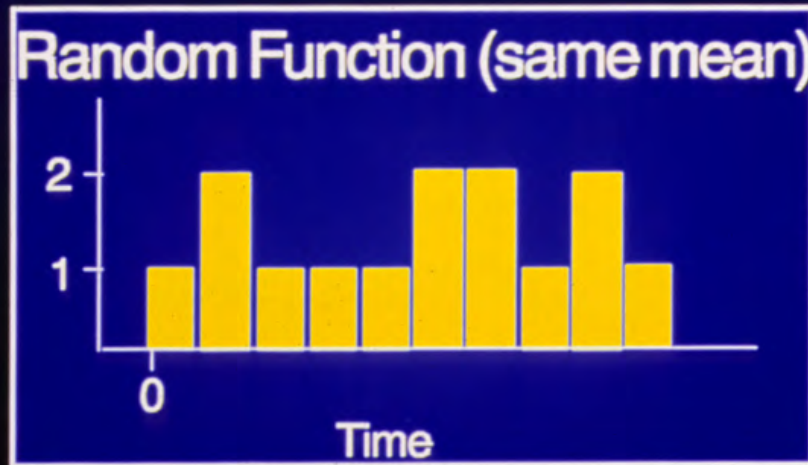
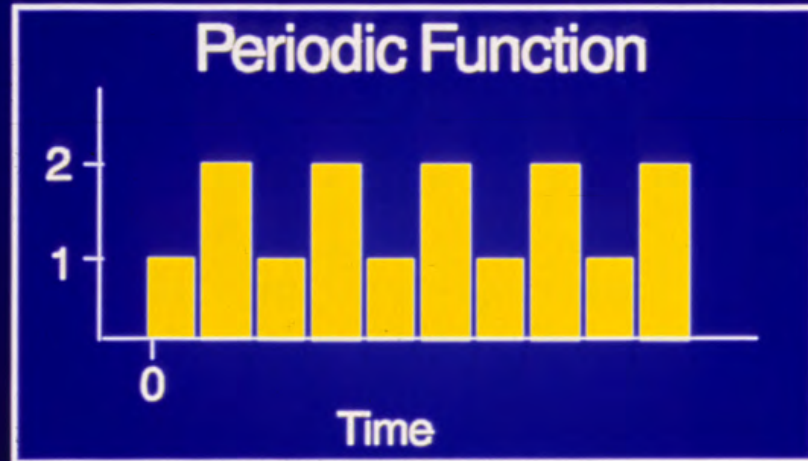


Percent of Subjects Affected by EMFs as a Function of the Response Frequency (N=53)



J. Neurol. Sci. 144:99-106, 1996

Non-Linear Data Analysis



Fourier Transform

Fourier Transform

Same Result

Non-Linear Methods of Analysis

- Record EEG
- Create phase space
- Analytical methods

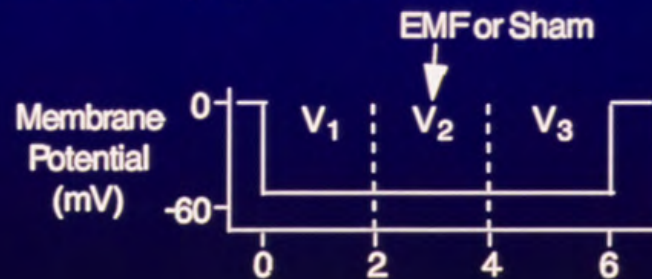
Quantifying Characteristics of Trajectories and Attractors

- Dimension (Attractor)
- Entropy (Trajectory)
- Lyapunov Exponents (Trajectory)

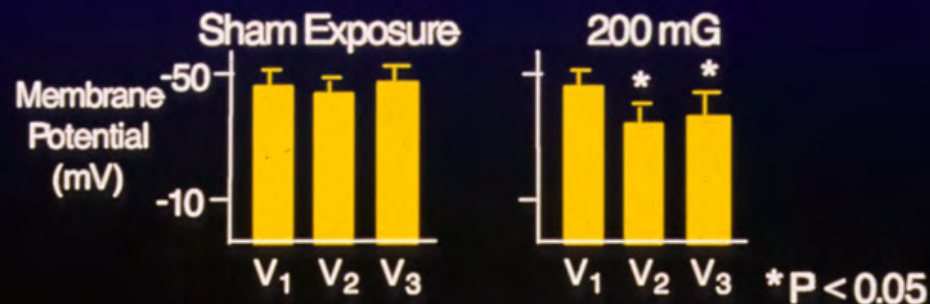
Initial Membrane Potential Measurements

Application of 60-Hz Magnetic Fields

- Sharp electrodes* (Epithelial cells)
- Procedure



- Results



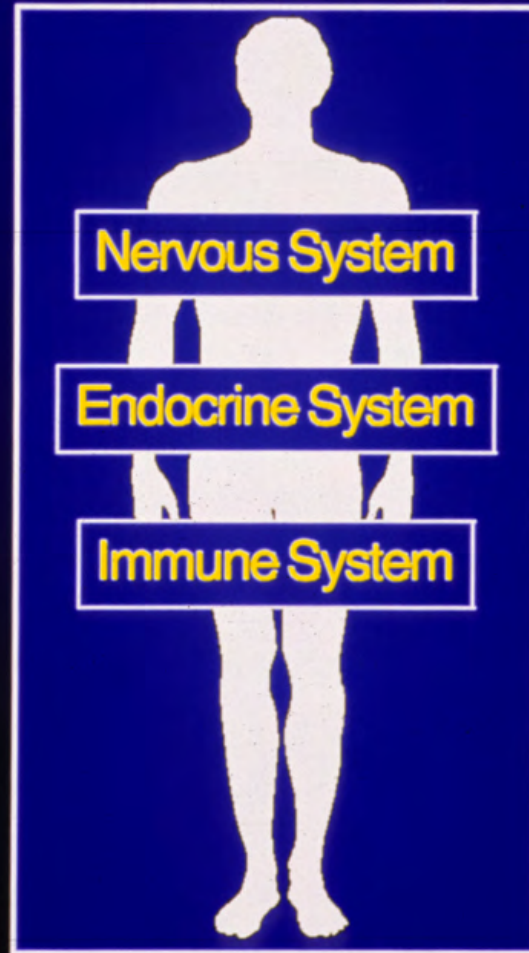
*Tumor Biol. 15:147-152, 1994

Membrane Potential Measurements

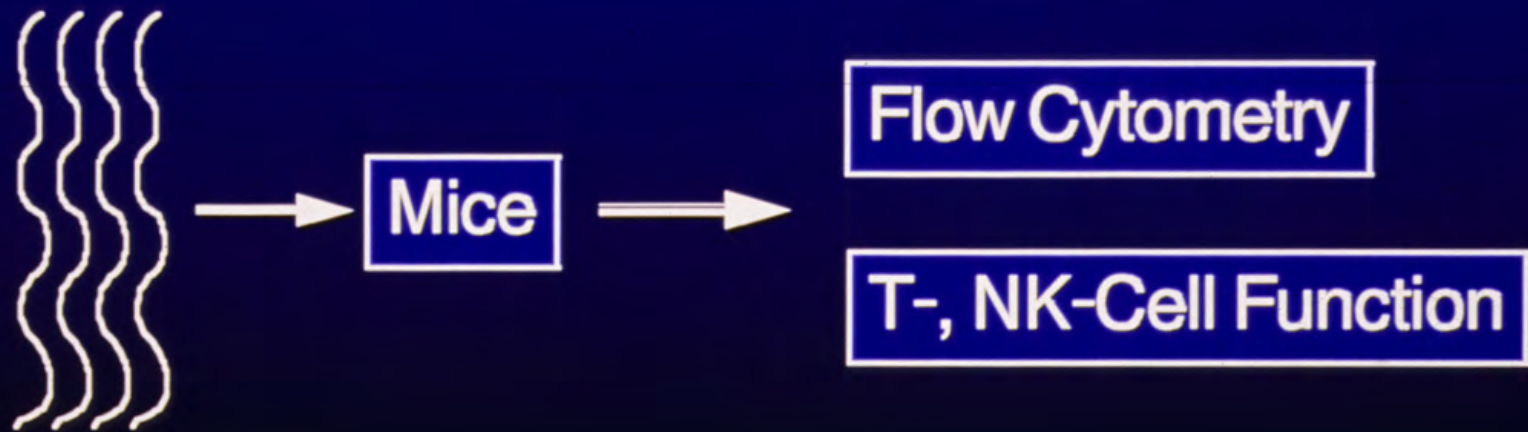
Present Studies

- Patch-clamp method
- Nystatin
- Neuroblastoma cells (SY5Y)
- Hypothesis

EMF Effects on the Immune System



Effects of 60-Hz Magnetic Fields on Lymphoid Phenotype



- 50-5000 mG (1000-5000 mG)
- 1-175 days (1-49 days)





Lymphoid Phenotype Results

Spleen

*B (E + F)
Immature *B (E)
Mature *B (F)
T (CD90⁺CD3⁺)
NK

Thymus

CD90⁺CD3⁺
CD4⁺CD8⁻
CD4⁻CD8⁺
CD4⁺CD8⁺

Marrow

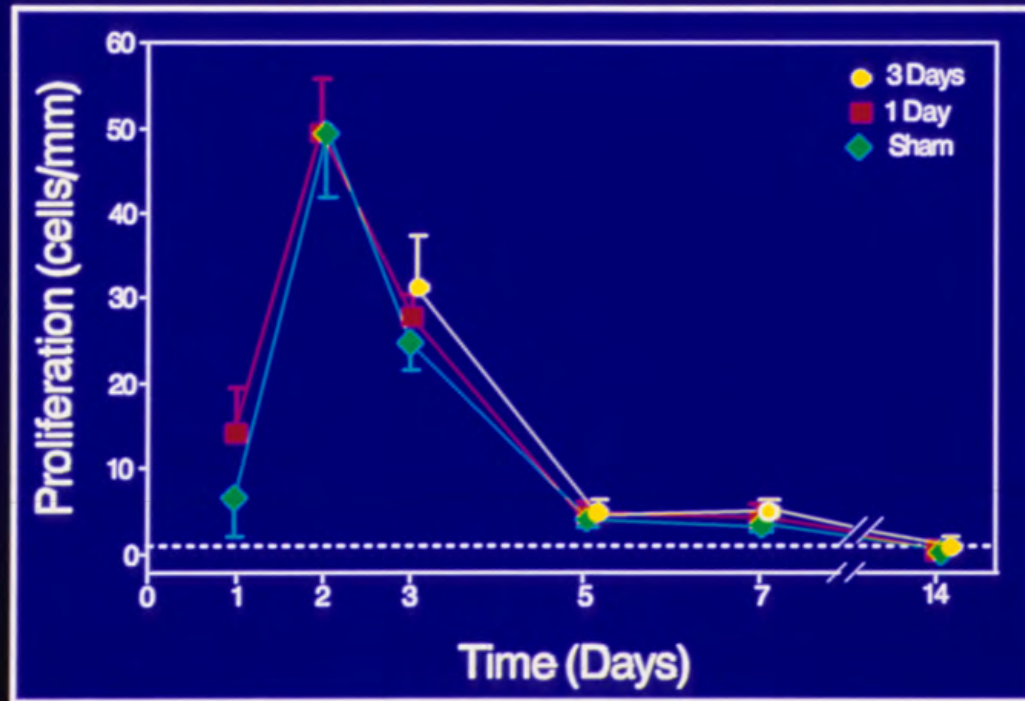
Pre-*B (A-D)
Immature *B (E)
Mature *B (F)

EMF Effect
No Effect

*A-F Hardy development scheme

Effects of EMFs on Bone Cells

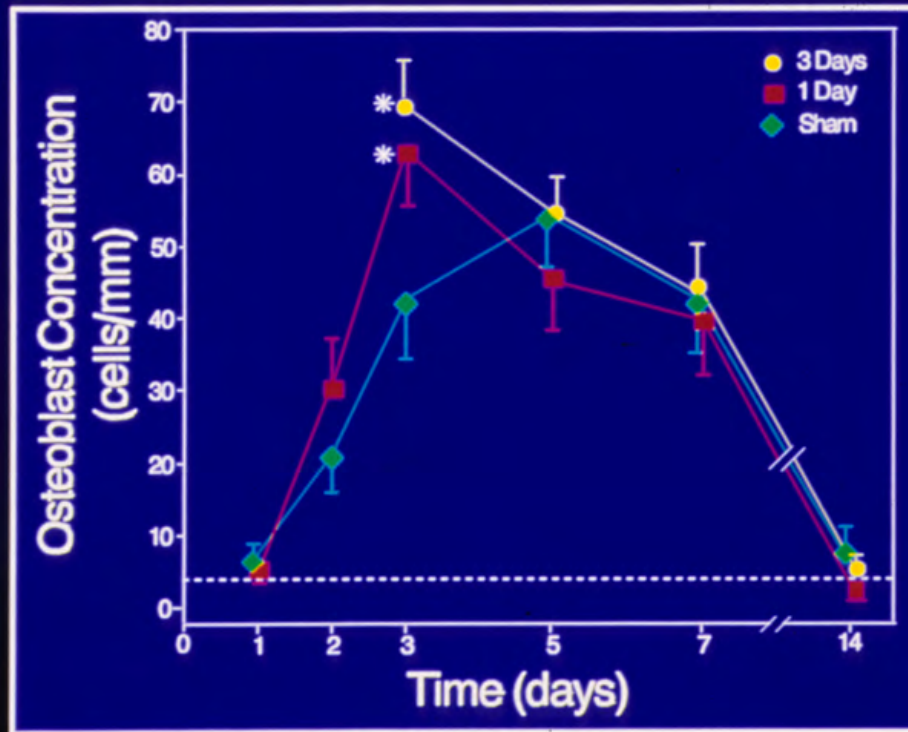
Proliferation of Osteoprogenitor Cells



• N=5/treatment/time

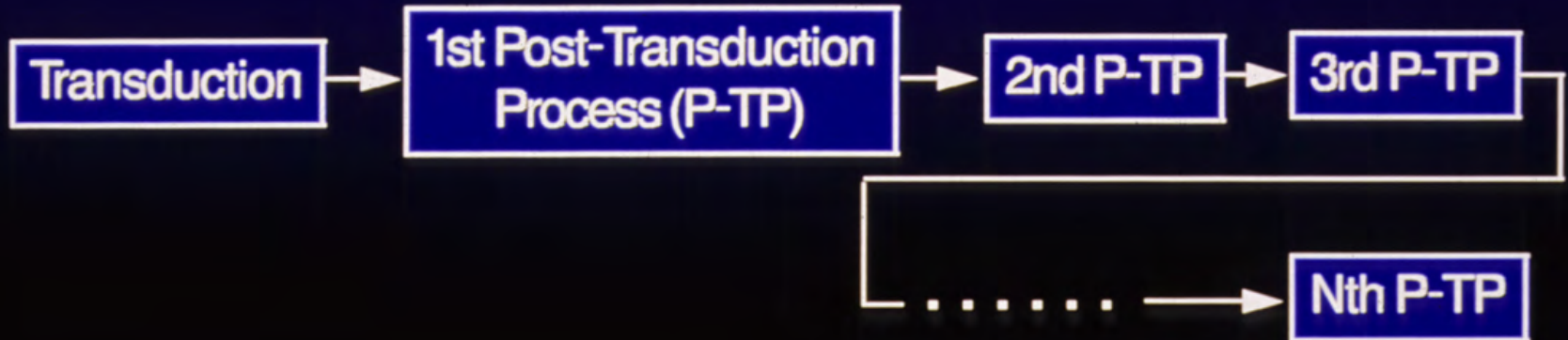
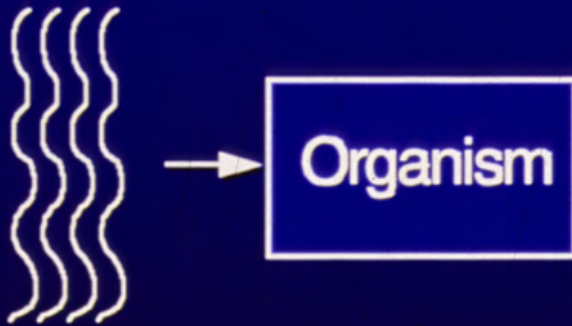
Effects of EMFs on Bone Cells

Osteoblast Concentration



• N=5/treatment/time

Chaos in the Future



Effects of EMFs on Body Weights

		<u>Mean</u>	<u>Variance</u>
Pigs	30 kV/m	No	Yes
Monkeys	20 V/m, 2G	Yes	No
Rats	150 kV/m	No	Yes
Rats	80 kV/m	No	Yes
Rats	100 V/m	Yes	Yes
Mice	500 V/m	No	Yes

AJP 37:R1013, 1995

The L Test

A New Statistic for EMF Studies

$$H_0: \mu_1, \sigma_1^2 = \mu_2, \sigma_2^2$$

$$\text{Alternative: } \mu_1, \sigma_1^2 \neq \mu_2, \sigma_2^2$$

Distribution: χ^2 or Randomization

www.ortho.lsumc.edu/Faculty/Marino/SR.html

Conclusion

- **EMF Transduction**
 - Environmental EMFs
 - Medical applications
- **Scientific Reasoning**
 - Thought-style
 - Statistics

Collaborators

- **Cell studies**

- Dr. Oleg Kolomytkin
- Dolly Smith

- **EEG studies**

- Dr. Andrew Chesson
- Dr. Glenn Bell
- Erik Nilsen

- **Immune studies**

- Dr. Mike Wolcott
- Dr. Rob Chervenak
- Frances Johnston

- **Bone studies**

- Dr. Patty Landry
- Robert Routh
- Shelia Rogers