

Cell Phones and Brain Tumors

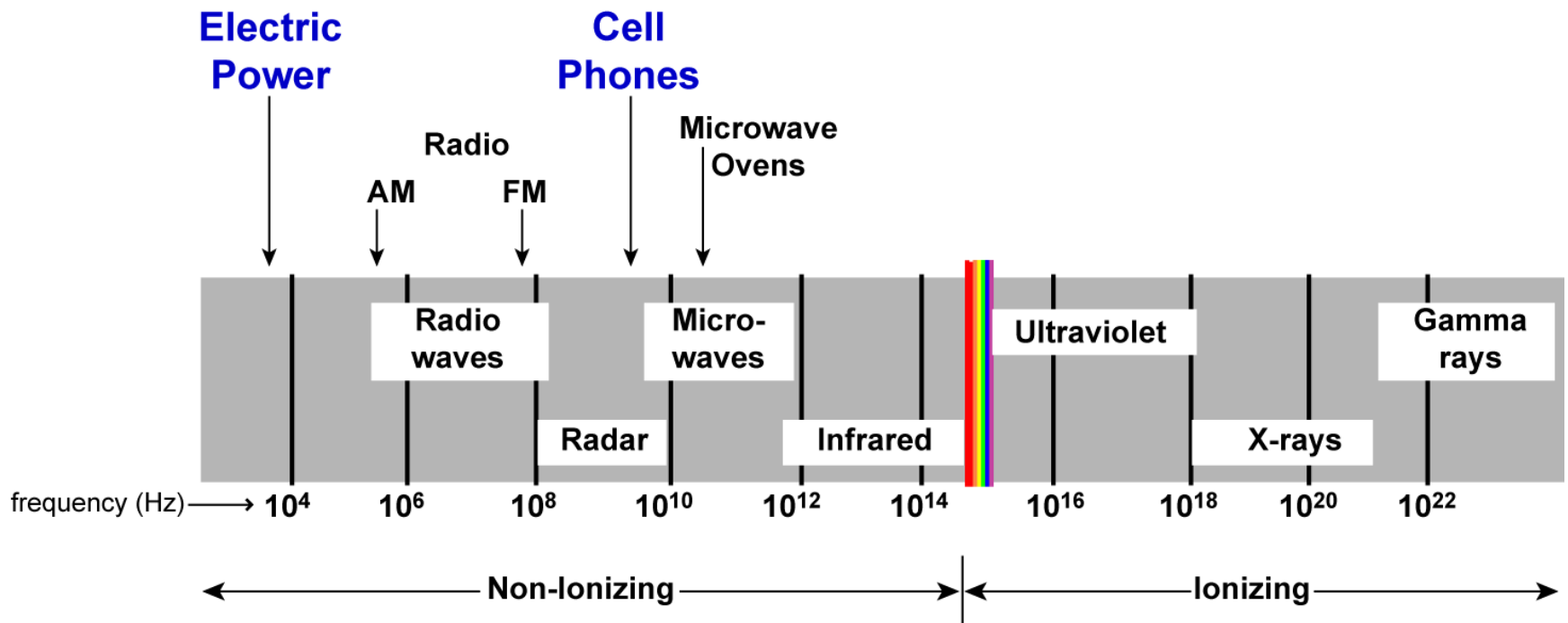
**Neurology Grand Rounds
March 23, 2012**

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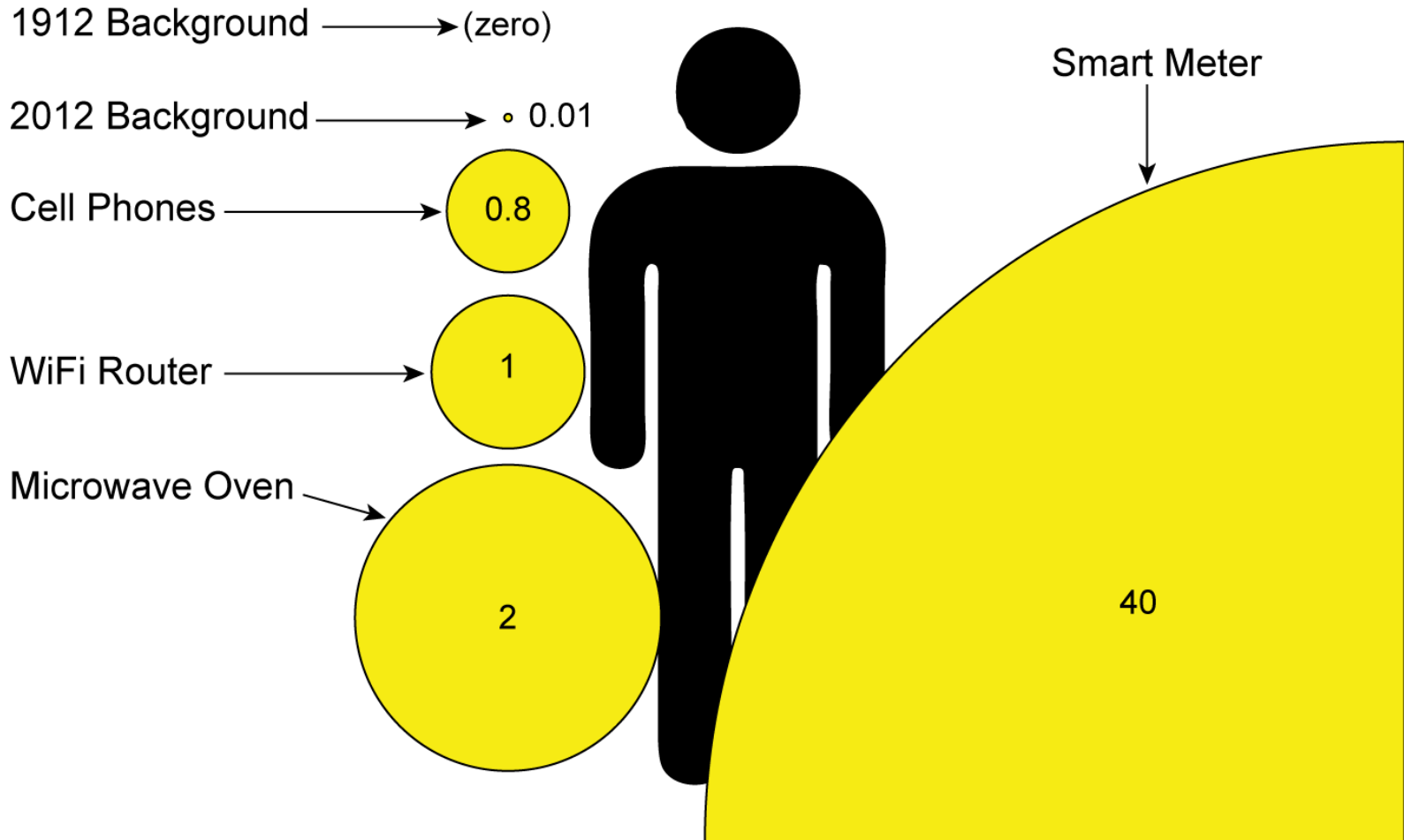
Summary

- Environmental electromagnetic fields (EMFs)
- EMFs and brain tumors
- 800-pound gorilla
- Physiological mechanisms
- Biophysical mechanisms

The Electromagnetic Spectrum



Typical Levels of Radio Frequency EMFs ($\mu\text{W}/\text{cm}^2$)

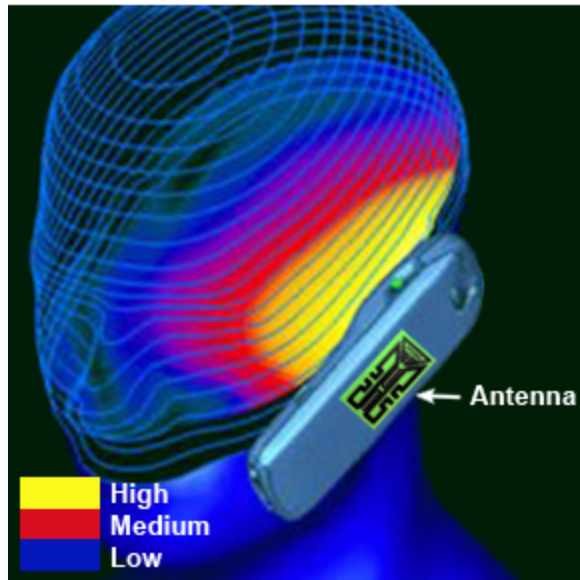


Cell Phones Produce Three Kinds of Electromagnetic Fields

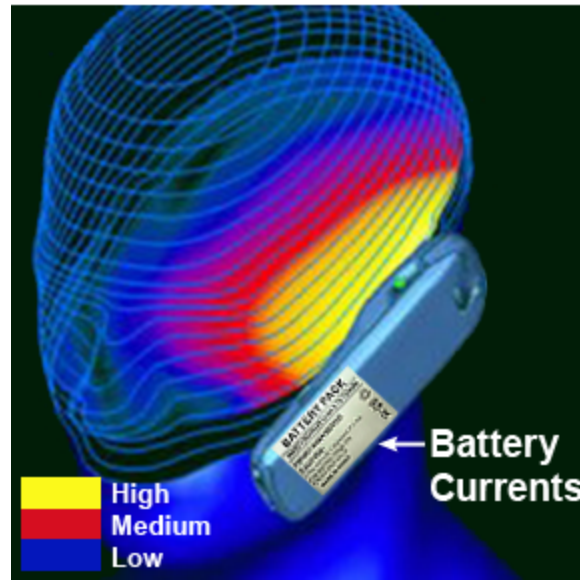
High Frequency (1 GHz)

Low Frequency (216 Hz)

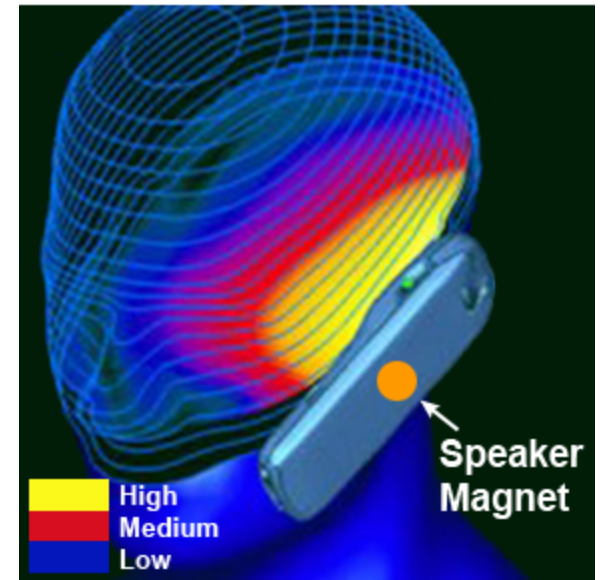
Zero Frequency (DC)



A



B



C

Central Questions

1. Do cell-phone EMFs cause brain tumors?
2. If so, how?
3. What do *cause* and *how* mean?

Types of Brain Tumors

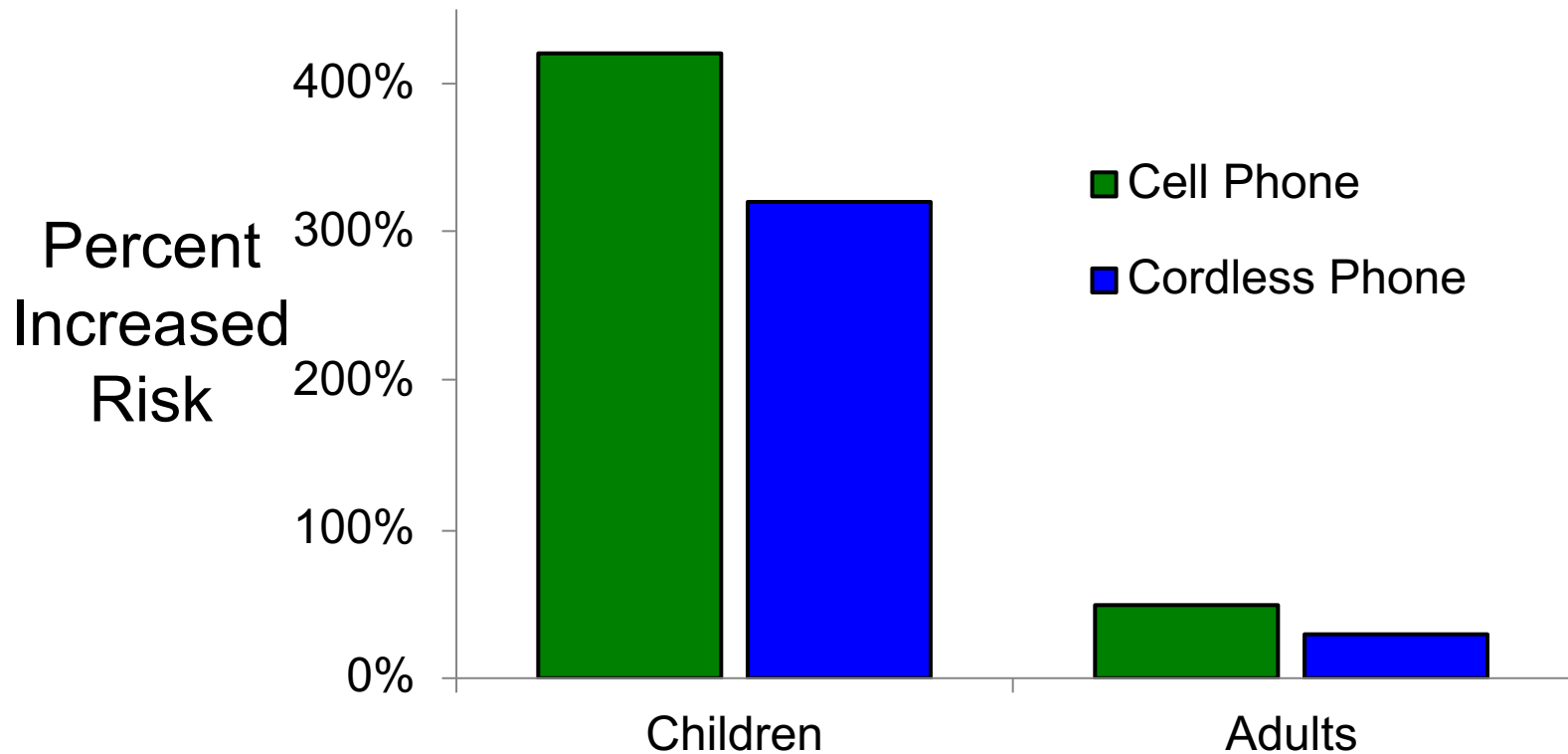
Tumors OF the brain (gliomas)

Tumors TO the brain (metastases)

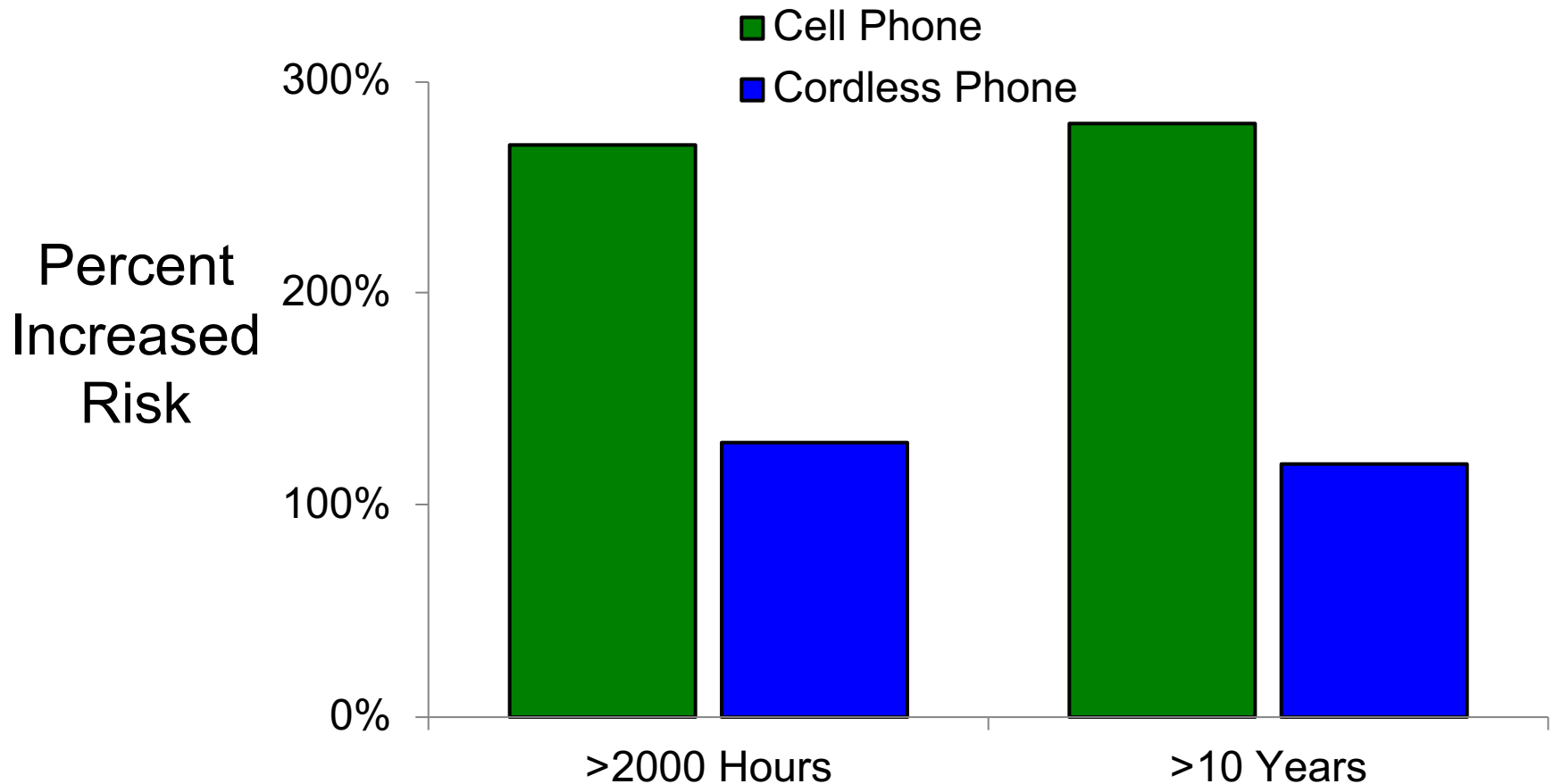
Tumors ON the brain (meningiomas, pituitary tumors, acoustic neuromas, etc.)

- >100 subtypes
- Gliomas most common
 - Causes unknown (2–3% arguably hereditary)

Cell-Phone EMF Brain-Tumor Risks Are Greater in Children (Hardell studies)



Cell-Phone EMF Brain-Tumor Risks Increase with Hours of Use and Years of Use (Hardell studies)



Major Cell-Phone Industry Study (Interphone Study)

- Case-control study (13 nations)
- Funded \$25 million
- Results reported in 2010 for 2 brain tumors
 - Meningioma
 - Glioma
- Numerous shortcomings (biased reduction in estimated tumor risk)

Interphone Study Biased Toward the Null

- Insufficient latency time (data collected in 2000–2004)
- Absurd entry criteria (1 call/week)
- Average lifetime cell use < 100 hrs
- No children included

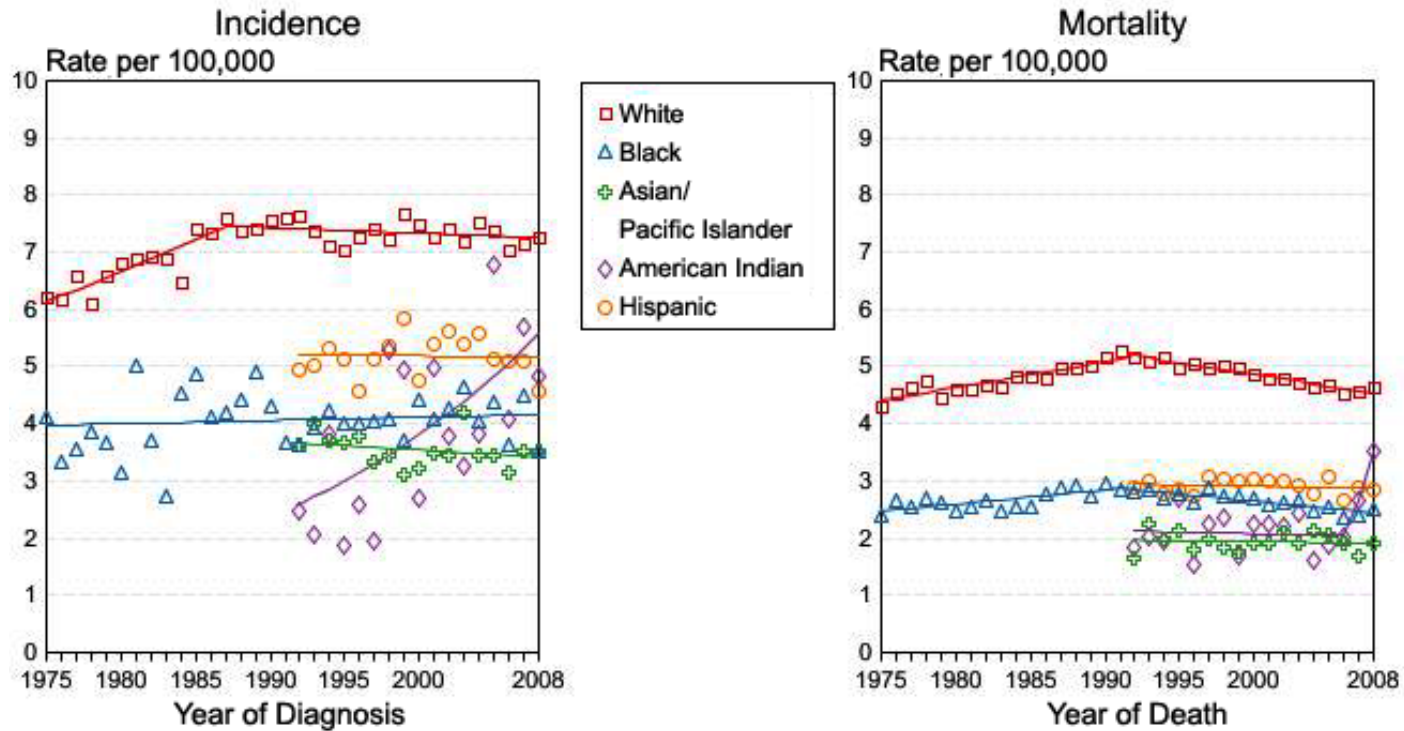
Is This a Reasonable Hypothesis?

- If exposure to cell-phone EMFs increases risk for brain tumors, then the incidence and/or death rates from brain cancer should be increasing.

Cancer of the Brain and Other Nervous System from 1975–2008*



SEER US Incidence and Death Rates



*Later data not available from NCI

IARC Press Release, 31 May 2011

International Agency for Research on Cancer



IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMANS

The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as **possibly carcinogenic to humans**, based on an increased risk for **glioma** associated with wireless phone use.

OTHER AGENTS IN THE SAME GROUP INCLUDE:

Carbon tetrachloride **Chlordane** **Chloroform** **Diesel fuel** **Dioxane**

Hexachlorobenzene **Human immunodeficiency virus** **Human papillomavirus**

Lead **Methylmercury** **Phenobarbital** **Toluene** **Welding fumes**

Cell-Phone-Funded EMF Bioeffects Studies Are Significantly Less Likely To Find Effects

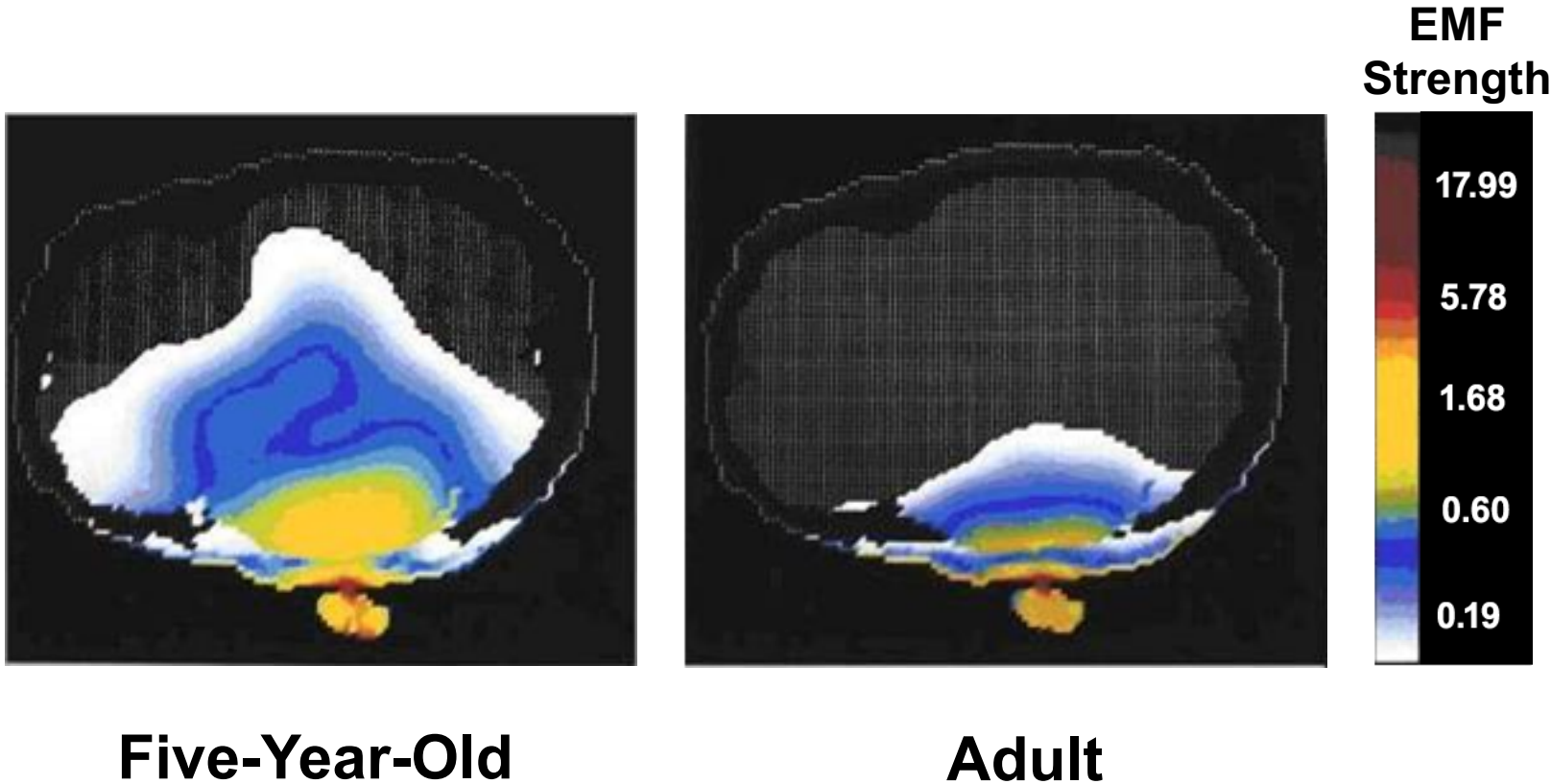
	<u>Effect</u>	<u>No Effect</u>
Industry Funded	25 (32%)	52 (68%)
Non-Industry Funded	74 (70%)	31 (30%)

$\chi^2 = 24$
($p < 0.001$)

Is the Position of the Cell-Phone Industry Ethical?



Brain Penetration of Cell-Phone EMFs Is Greater in Children



Human experiments: First, do harm

In the 1940s, US doctors deliberately infected thousands of Guatemalans with venereal diseases.



EVOLVING ETHICS

Sexually transmitted diseases (STDs) were a prime concern for health officials in the 1940s, and many medical studies—including the US experiments in Guatemala—used methods that would be considered unethical today.

Cell-Phone Use by Teenagers*

- 63% of teenagers age 12–17 have cell phones.
- Girls age 15–17 most likely (79%).
- 55% of teens with cell phones use them daily to talk (60% send text messages daily).
- By 2011 54% of kids age 8–12 will have a cell phone.

*Pew Internet & American Life Project report “Teens and Social Media” and the Center on Media and Child Health, 2008

What Does the Government Say?



U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

Radiation-Emitting Products

Current Research Results

Is there a connection between certain health problems and exposure to radiofrequency fields via cell phone use?

The results of most studies conducted to date indicate that there is not. In addition, attempts to replicate and confirm the few studies that did show a connection have failed.

According to current data, the FDA believes that the weight of scientific evidence does not show an association between exposure to radiofrequency from cell phones and adverse health outcomes.

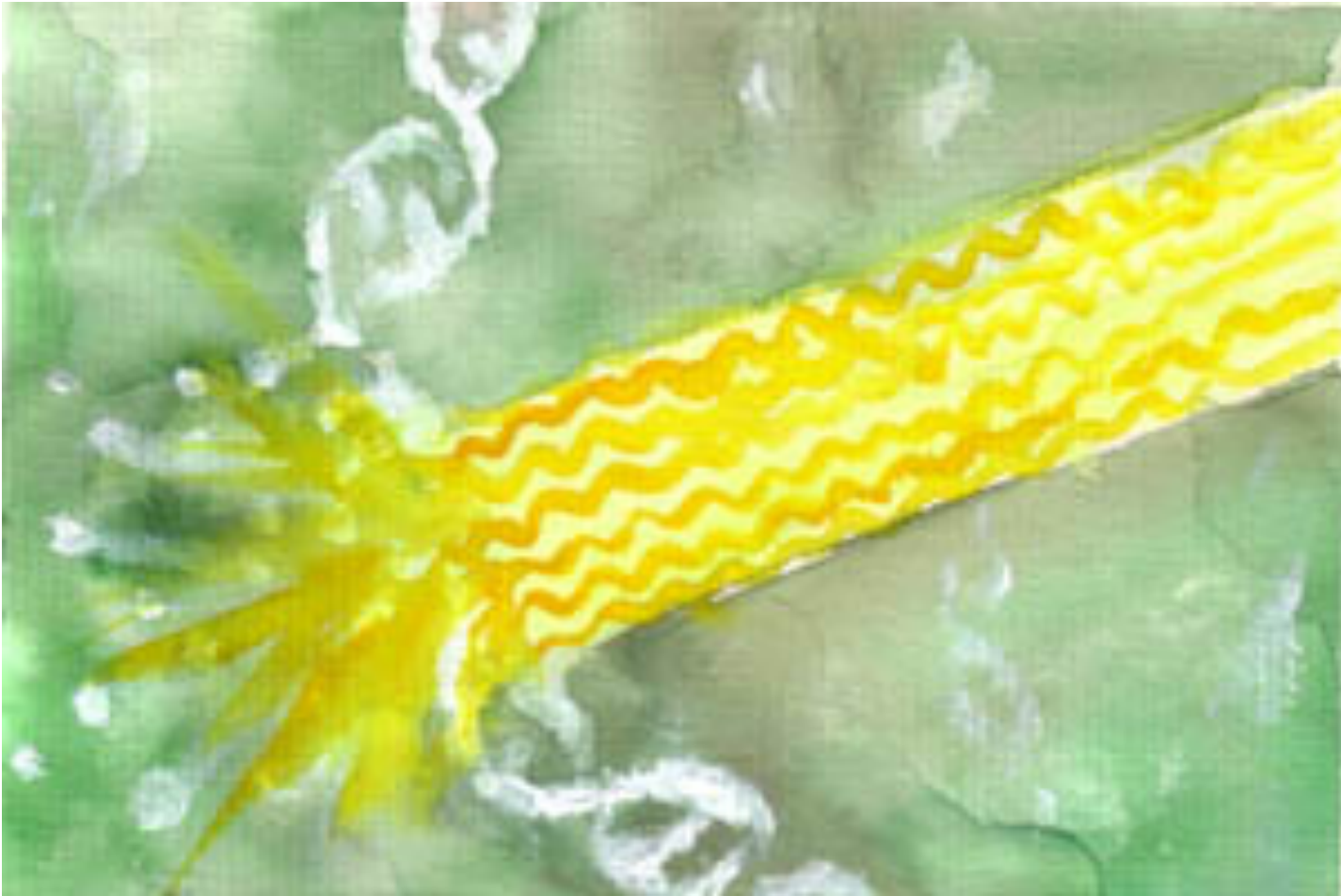
Last updated June, 2011

What is the Response from Academia?

Current Research Paradigm at Most Academic Cancer Centers

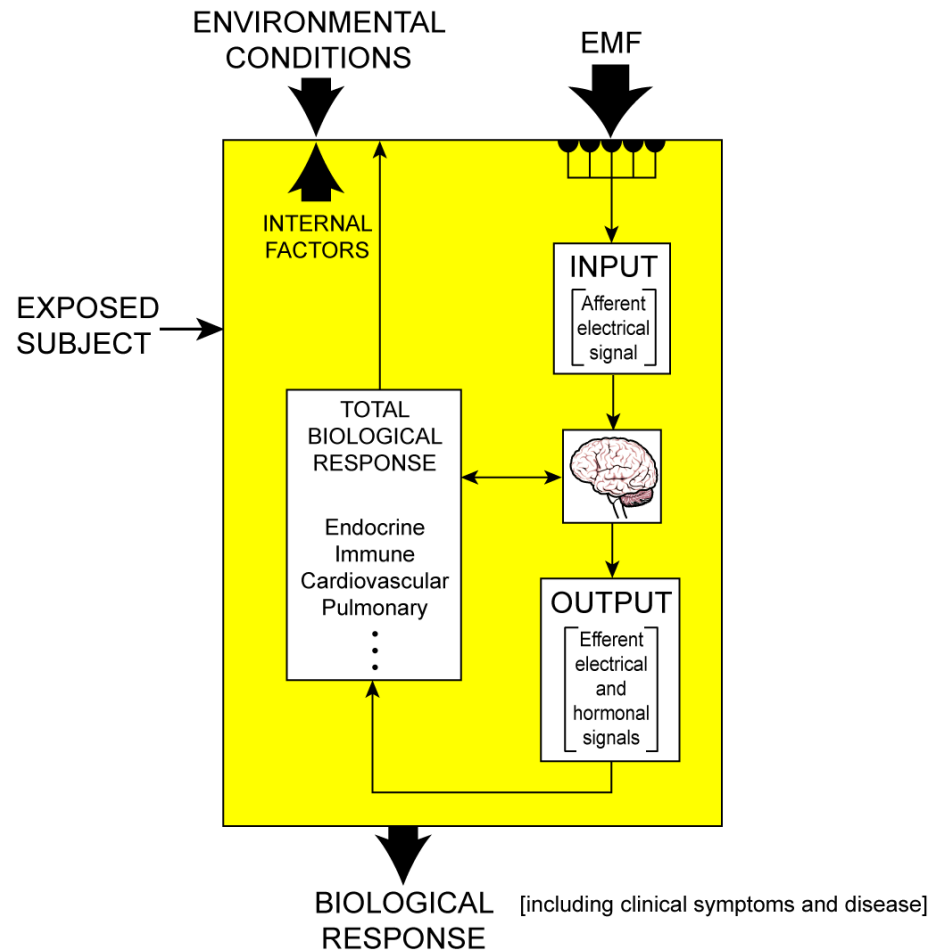
- Main focus on
 - Developing & improving cancer therapies
 - Carcinogenesis
 - Early detection
- Little attention to
 - Cancer prevention
 - Risk reduction

How Does the Body Detect a Nonionizing EMF?



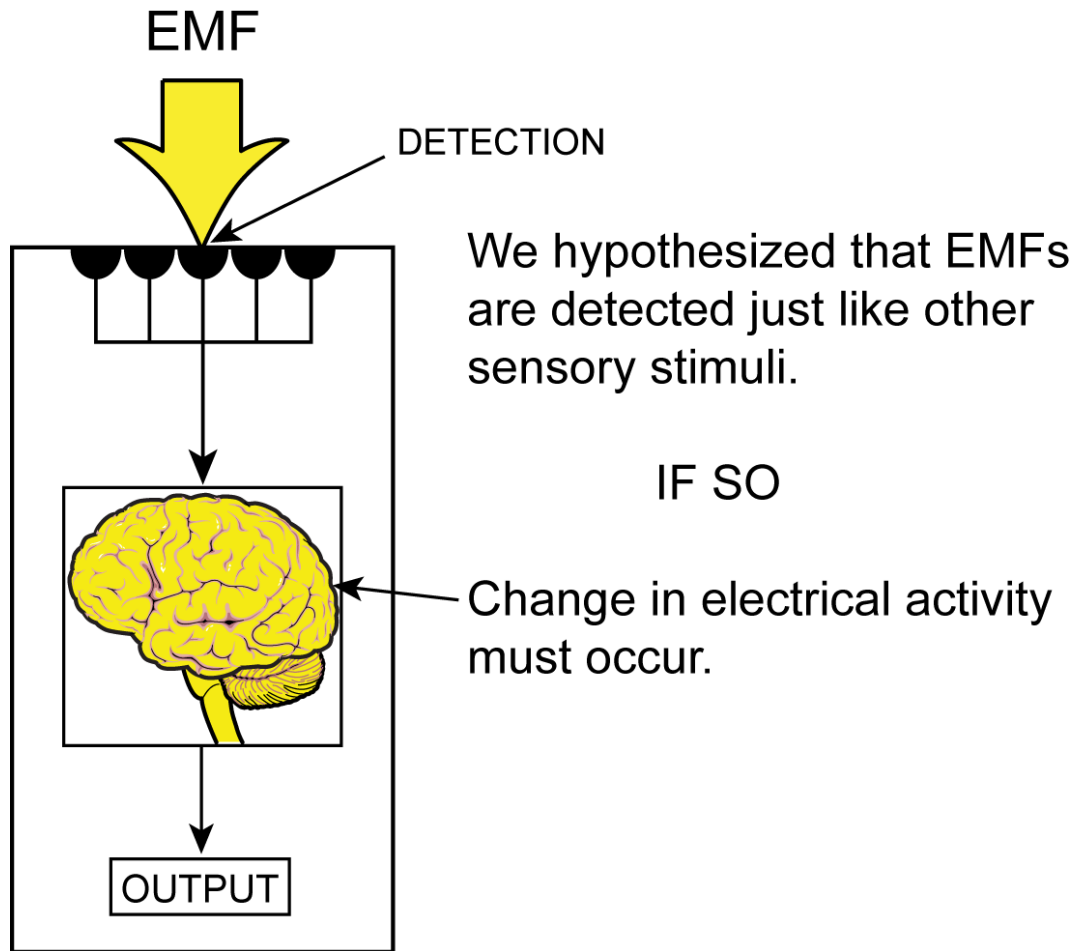
Detection process for x-rays

Hypothesized Regulatory System for EMF Sensitivity

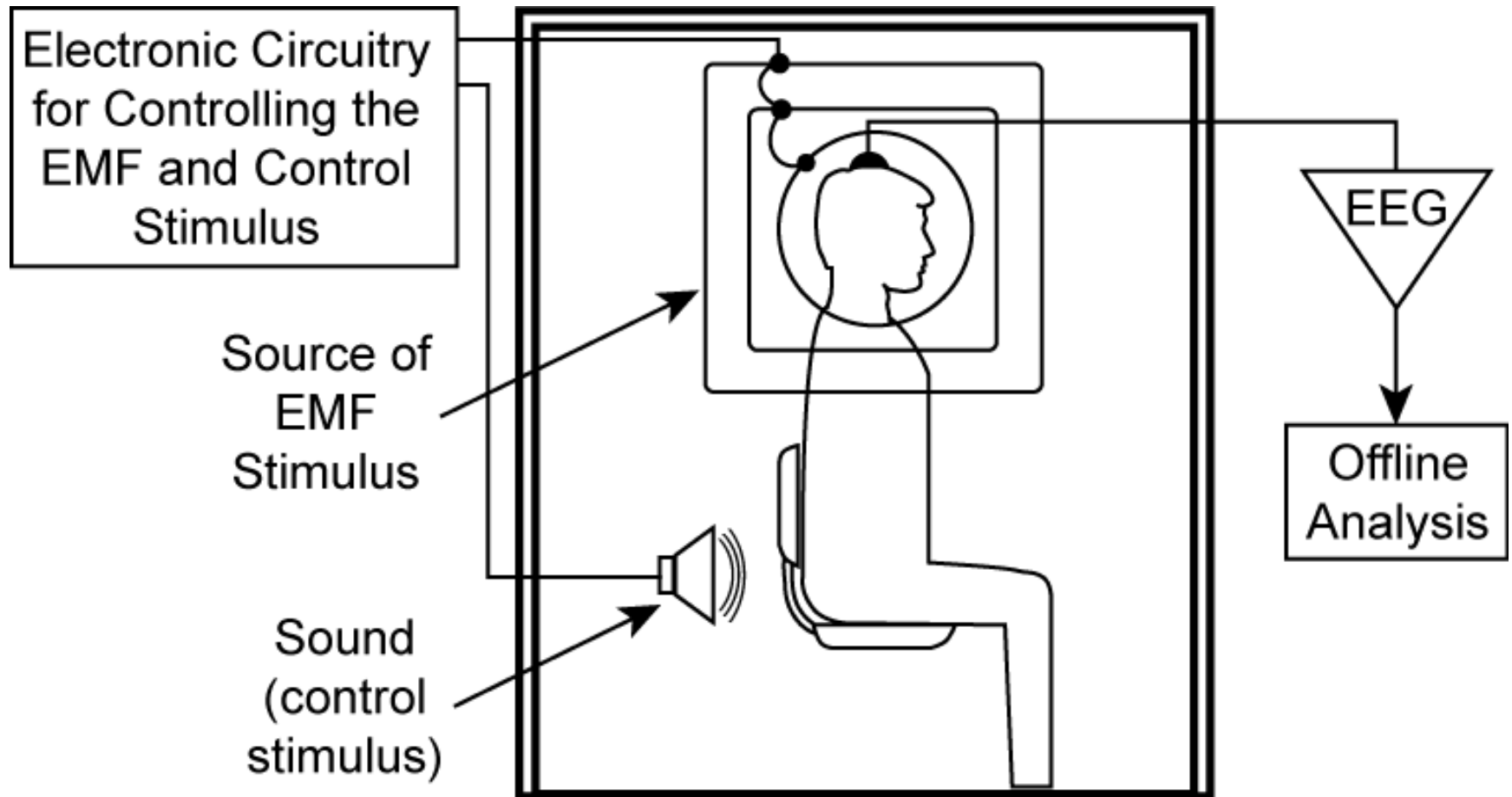


Albert St. Gyorgyi, M.D. → Hans Selye, M.D. → Robert Becker, M.D.

Focus on Early Process



Experimental Design: Compare the EEG in the Presence and Absence of an EMF



Discovery of Human Magnetic Sense

Rationale: Sensory perception entails evoked potentials

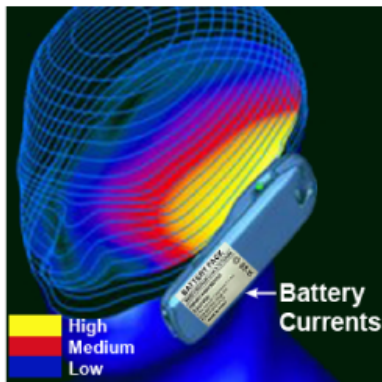
Procedure:  Analyze EEG for evoked potentials (EP) (N=17 subjects)

Summary:

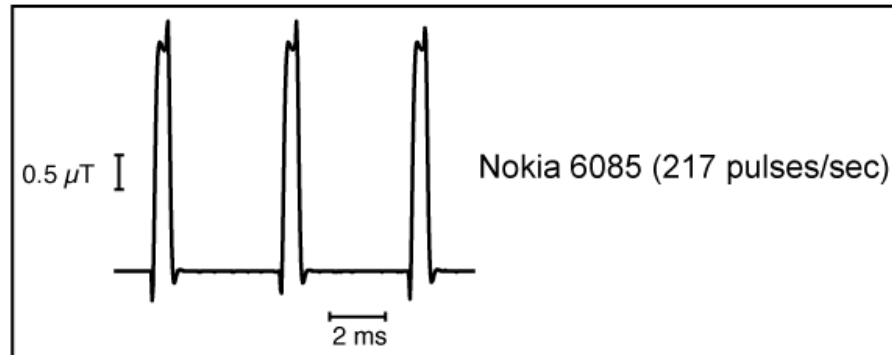
- Each subject detected the magnetic field ($P < 0.05$)
- Latency and direction of effect (relative to control) varied with subject
- Effect not bilateral

Effect of Low-Frequency Cell-Phone EMFs on Brain Electrical Activity

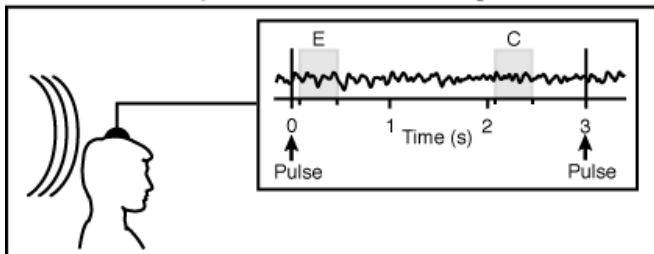
Background



Hypothesis: Human brain can detect every pulse



Experimental Design



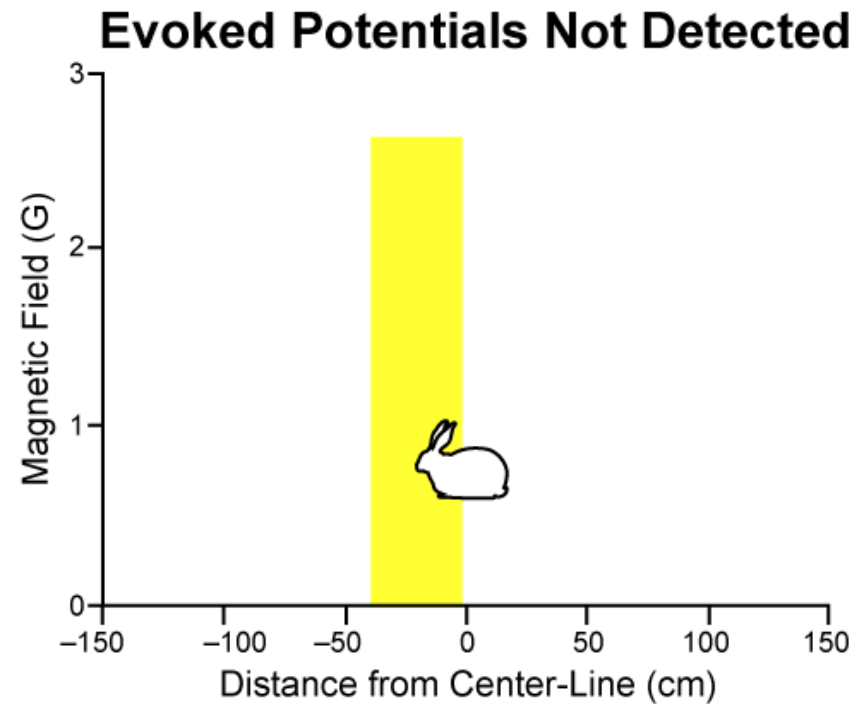
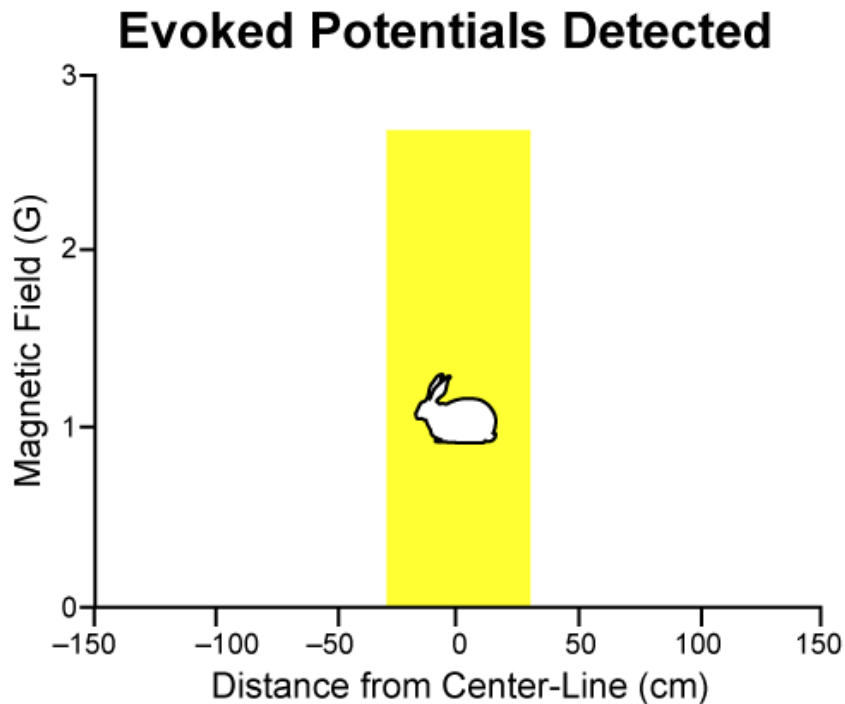
Result

18 (of 20) subjects detected the EMF, each at $P < 0.05$.

Implication

Typical cell phone triggers 216 evoked potentials per sec of use.

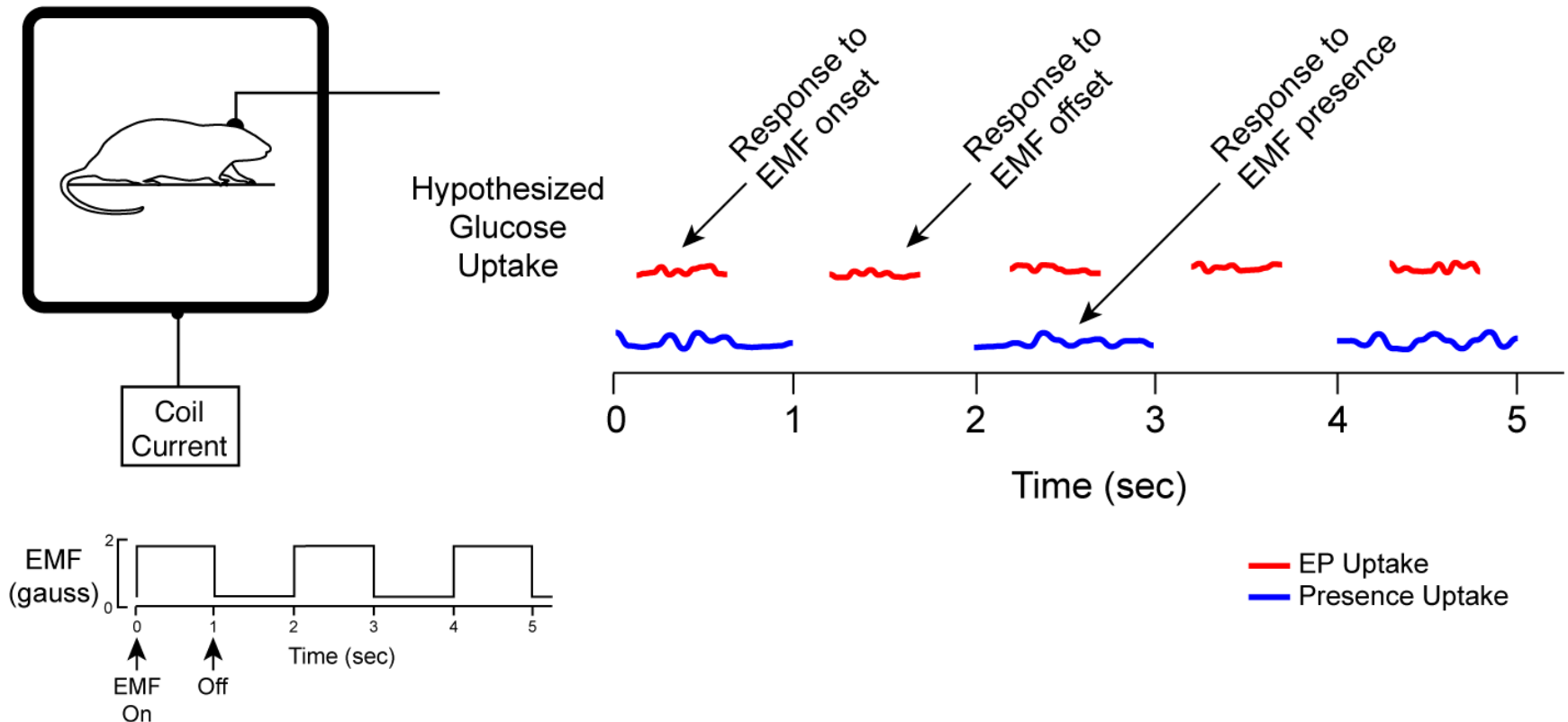
Anatomical Location of Receptor Cells



Conclusion: Electoreceptor cells are located in the head, probably the brain.

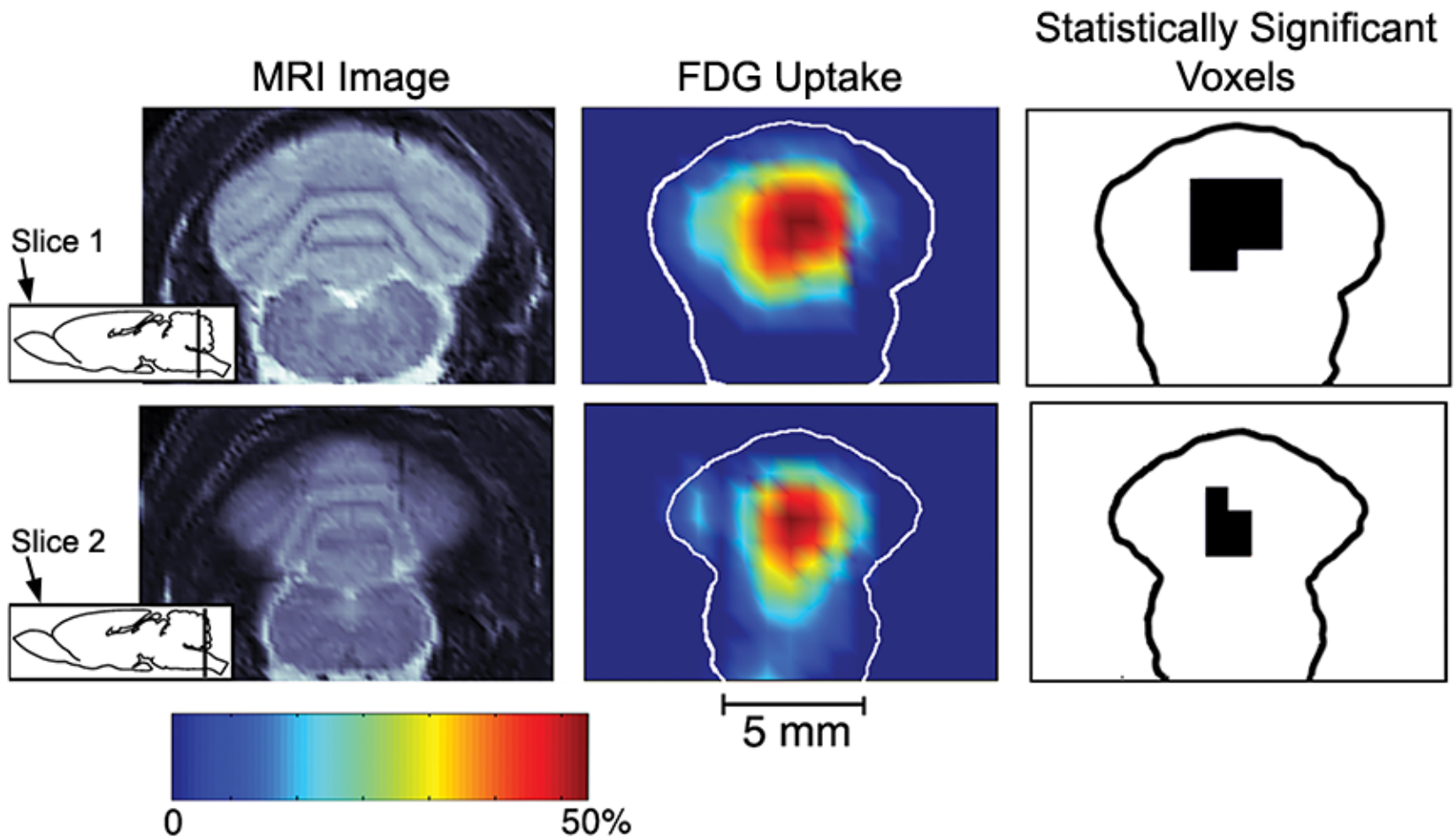
Marino, A.A., Nilsen, E. & Frilot, C. Localization of electroreceptive function in rabbits. *Phys. Behav.* 79:803–810, 2003.

EMF-Activated Brain Region Assessed Using Positron Emission Tomography

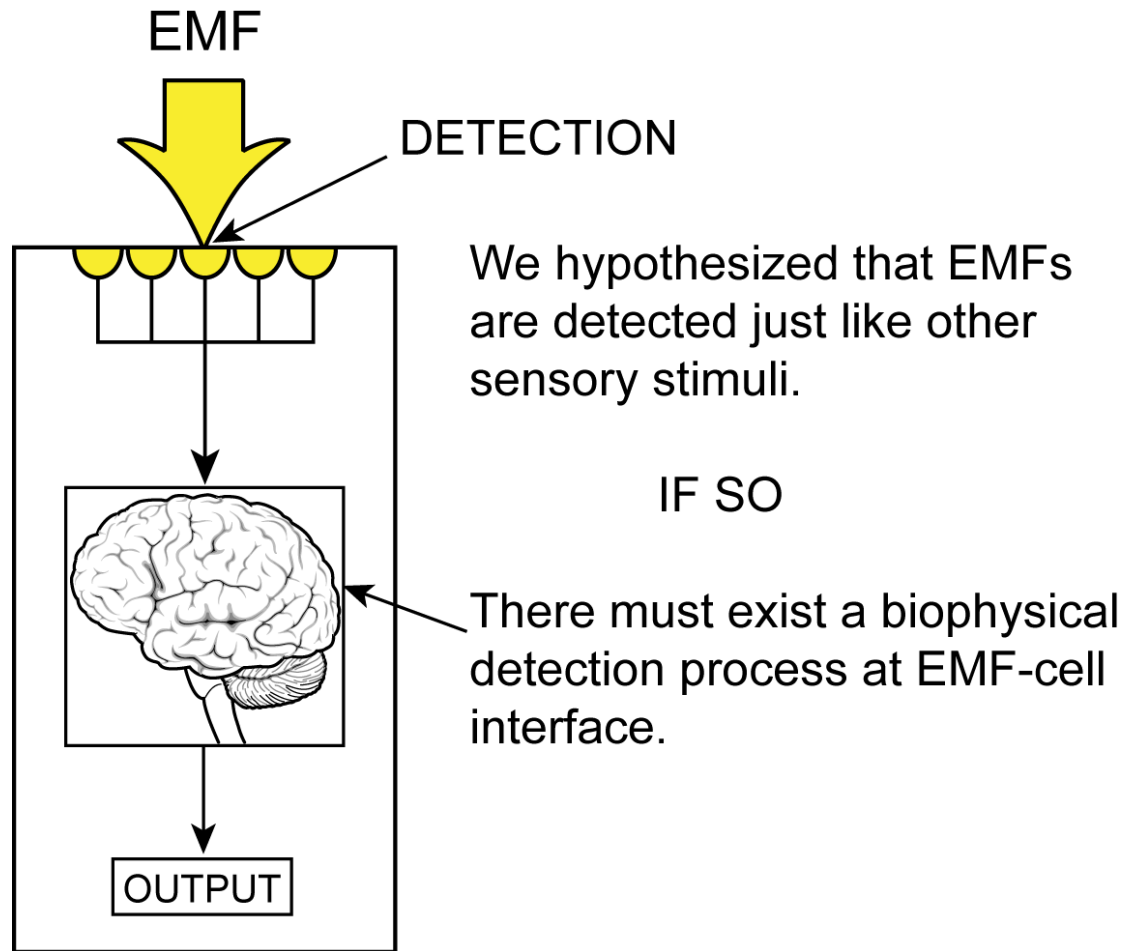


C. Frilot II, S. Carrubba, A.A. Marino: Synapse 63:421–428, 2009.

Location of the EMF-Induced Uptake of FDG in the Rat Cerebellum

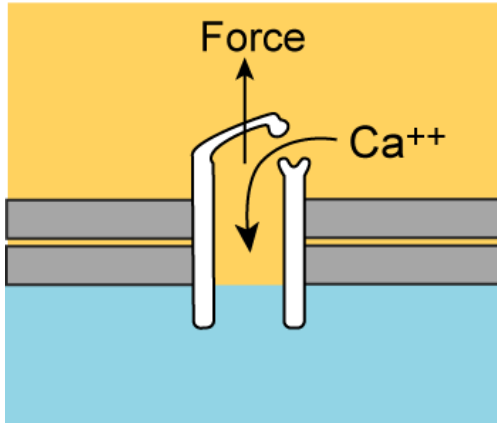


Focus on Immediate Early Process



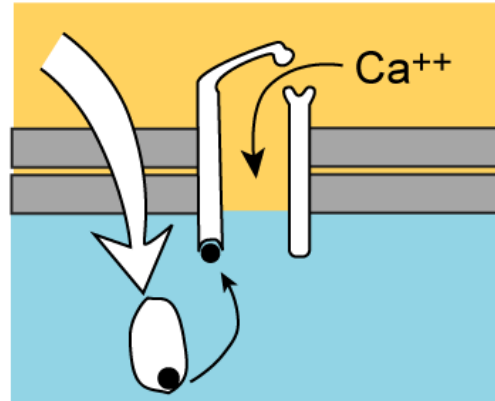
Signal Transduction in Sensory Receptors

Force receptor



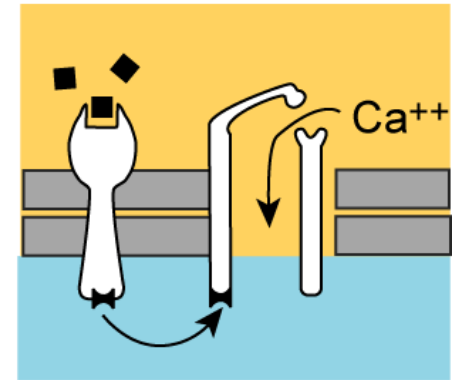
Model for low-frequency EMFs

Light receptor



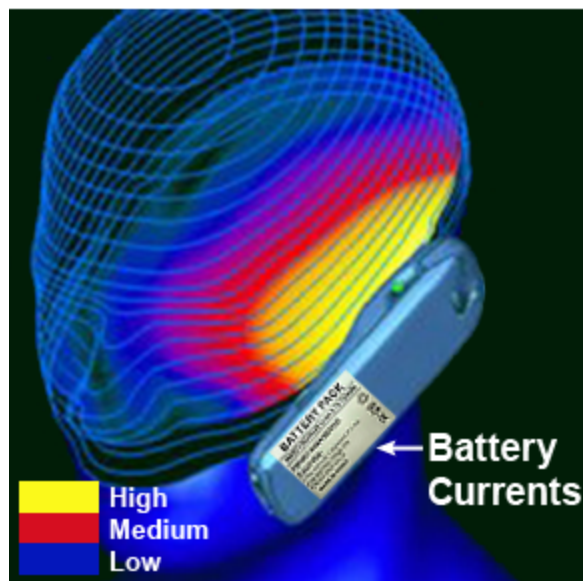
Model for high-frequency EMFs

Chemical receptor



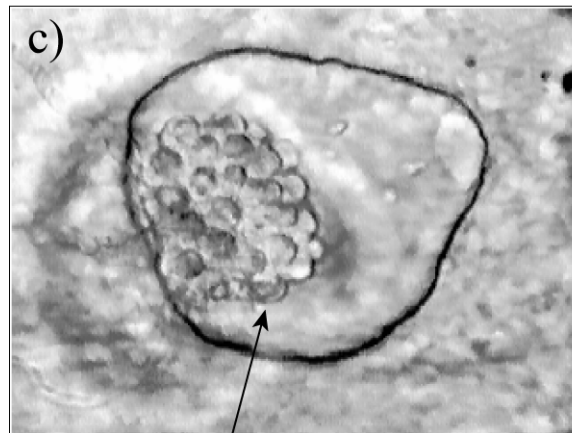
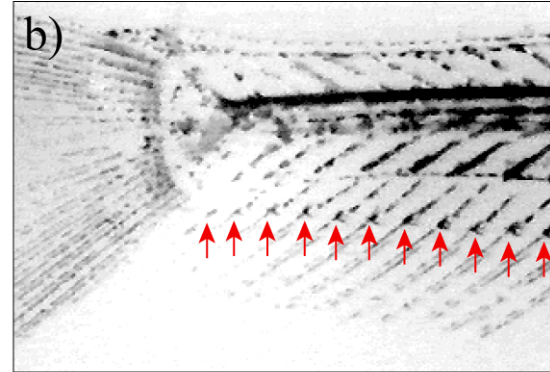
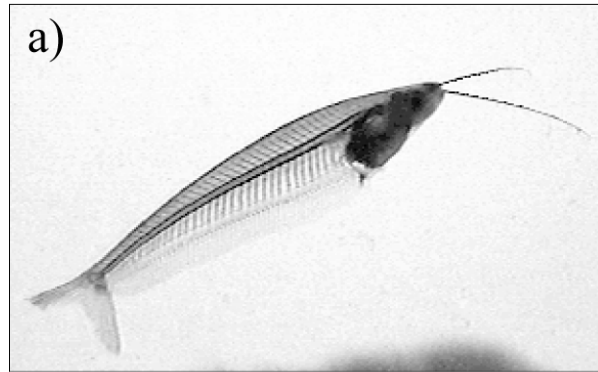
How Are Low-Frequency EMFs Transduced?

Low Frequency (216 Hz)

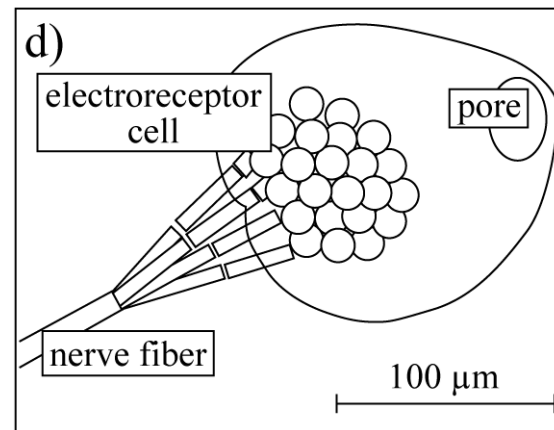


The Glass-Catfish Model

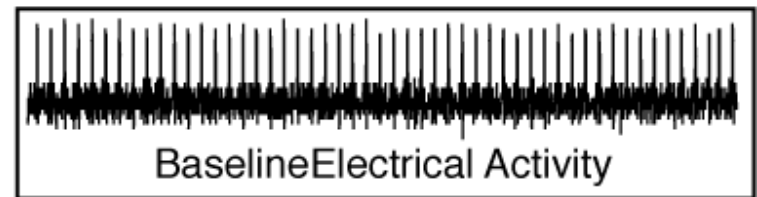
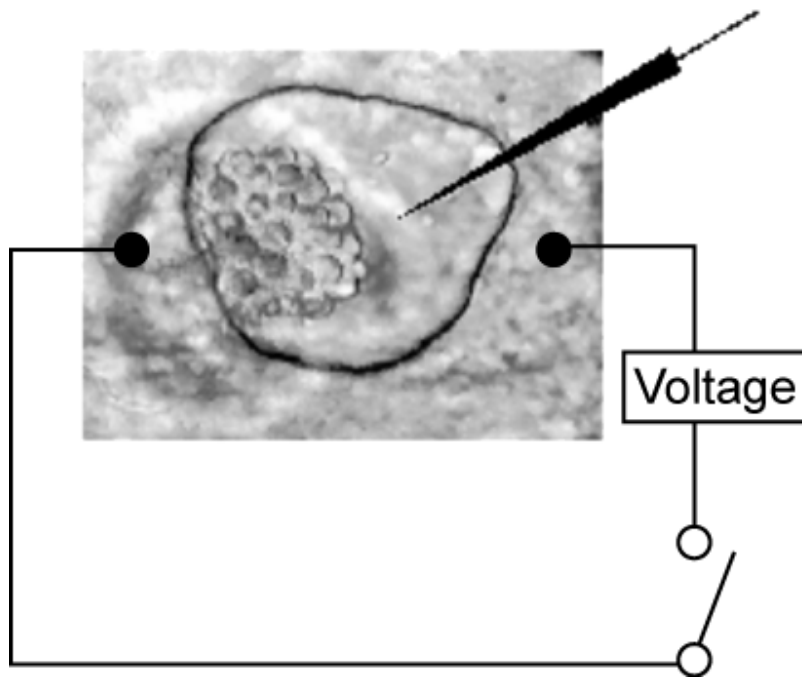
Electroreceptor System of the Glass Catfish



Electroreceptor
Cells

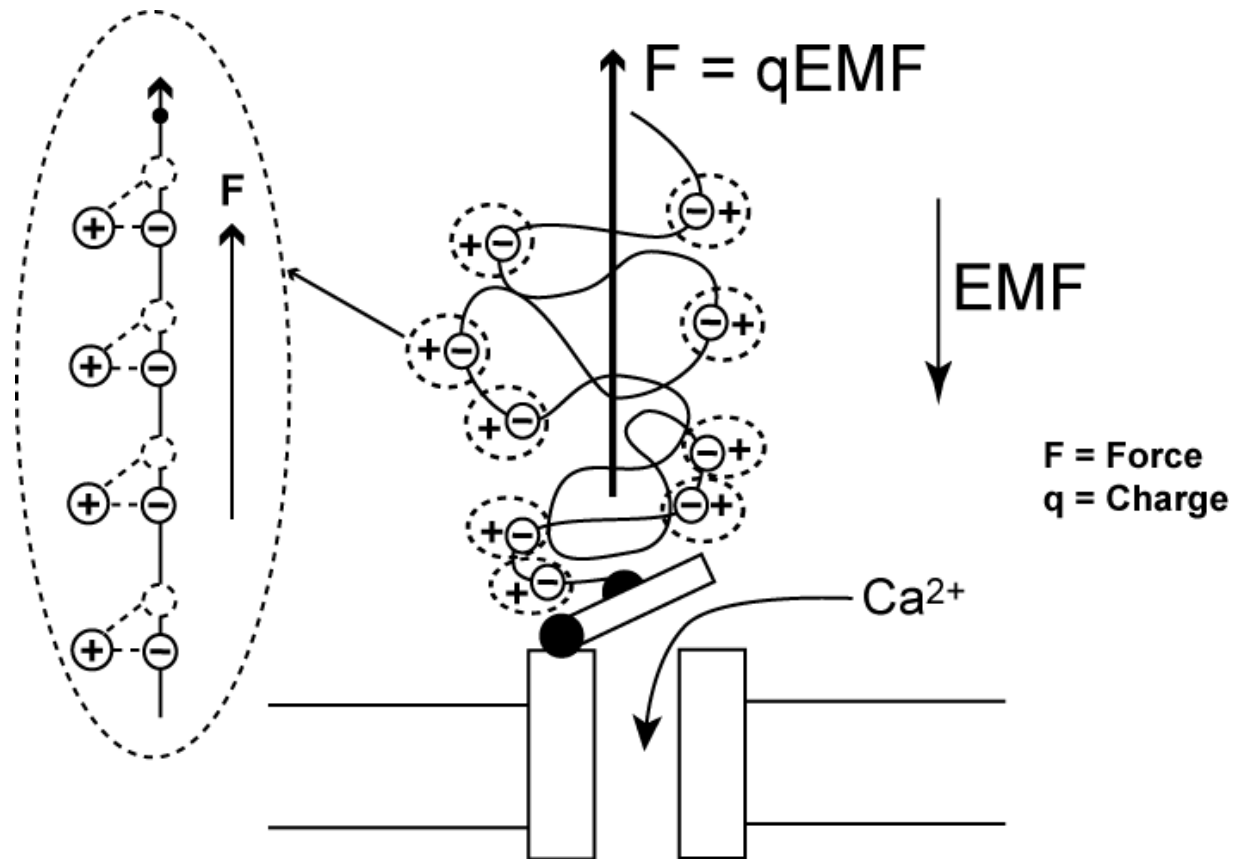


Detection of Ultra-Weak Electric Field



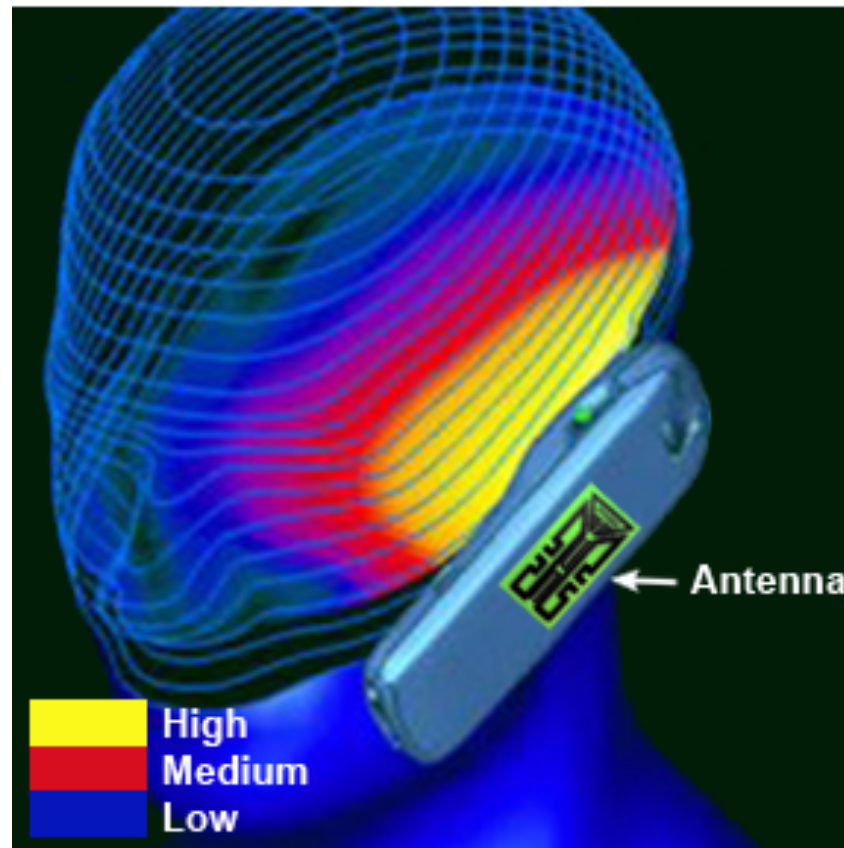
Kolomytkin OV, Dunn S, Hart FX, Frilot C, Kolomytkin D, Marino AA. Glycoproteins bound to ion channels mediate detection of electric fields: a proposed mechanism and supporting evidence. *Bioelectromagnetics* 28:379–385, 2007.

First (and only) Biophysical Model Shown Capable of Detecting Low-Frequency EMFs

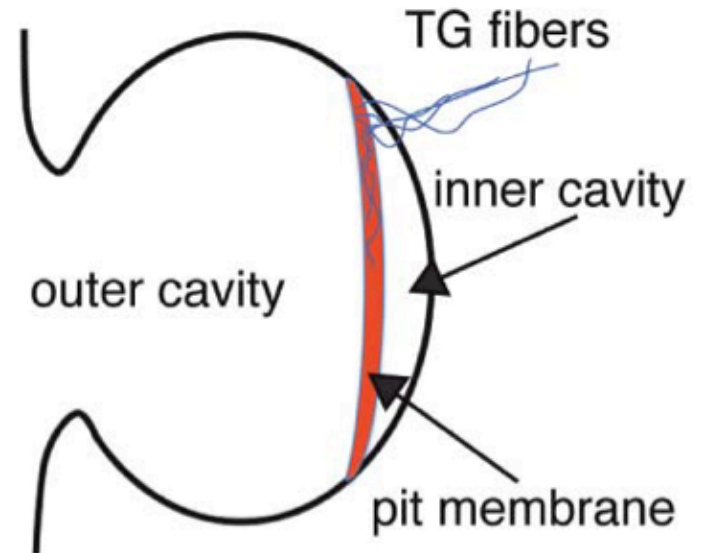
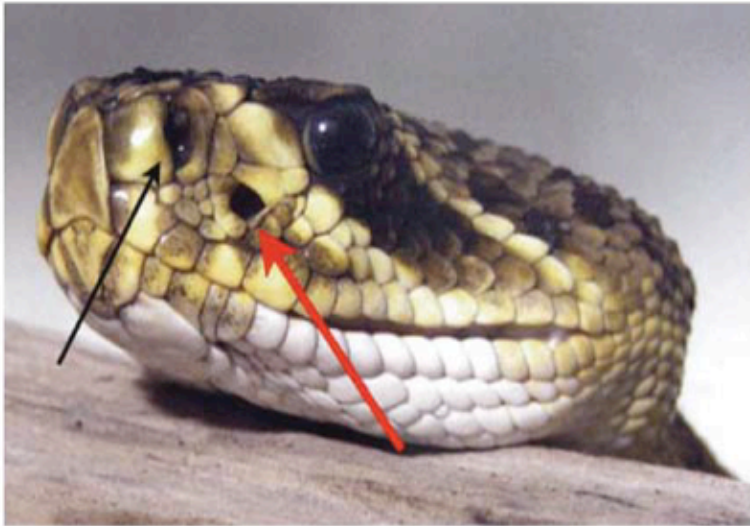


How High-Frequency EMFs Are Transduced

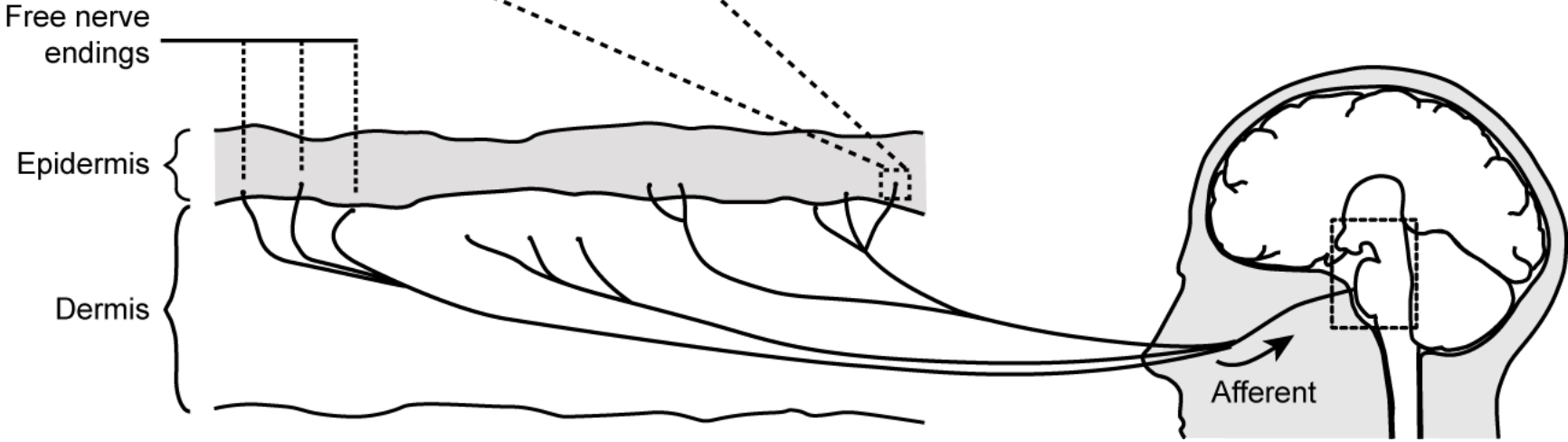
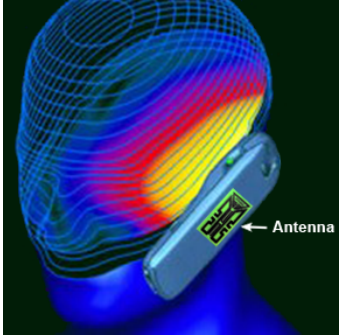
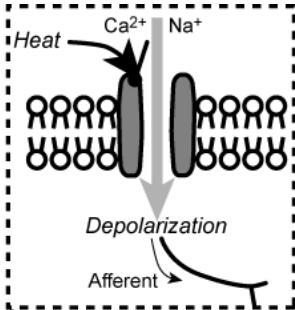
High Frequency (1 GHz)



Heat Detection by Pit Vipers

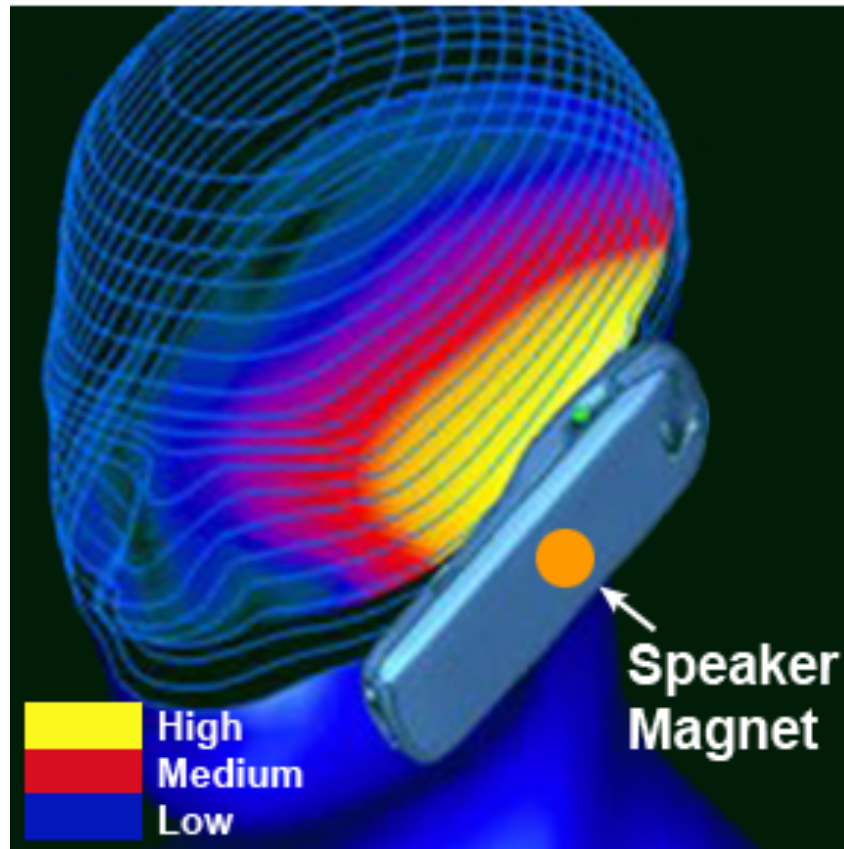


Thermo-TRP Channels in Trigeminal Neurons



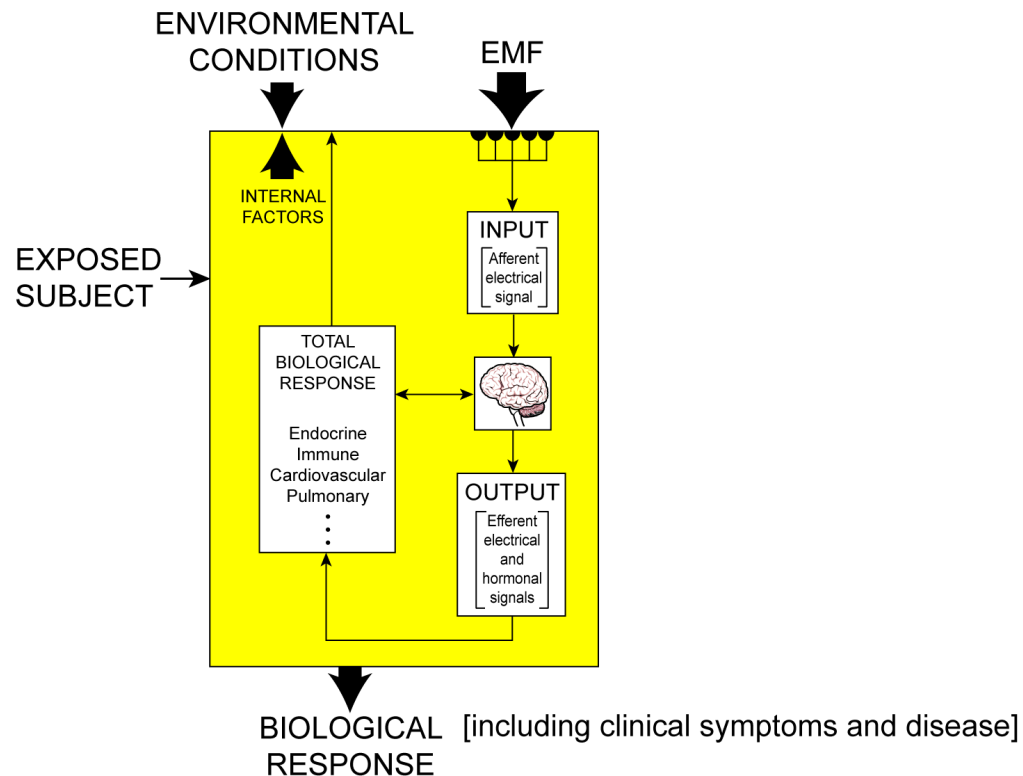
How DC EMFs are Transduced

Zero Frequency (DC)



Conclusion

Regulatory System Linking Cell-Phone EMFs to Brain Tumors: An Answer to the Meaning of *Cause* and *How*



Relative Reliability of Knowledge About Hazards of Cell-Phone EMFs

