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**Extremely Low Frequency  
(power frequency) Magnetic  
Field Exposures & Health Risks**



**Radiation Epidemiology & Dosimetry Course**

National Cancer Institute

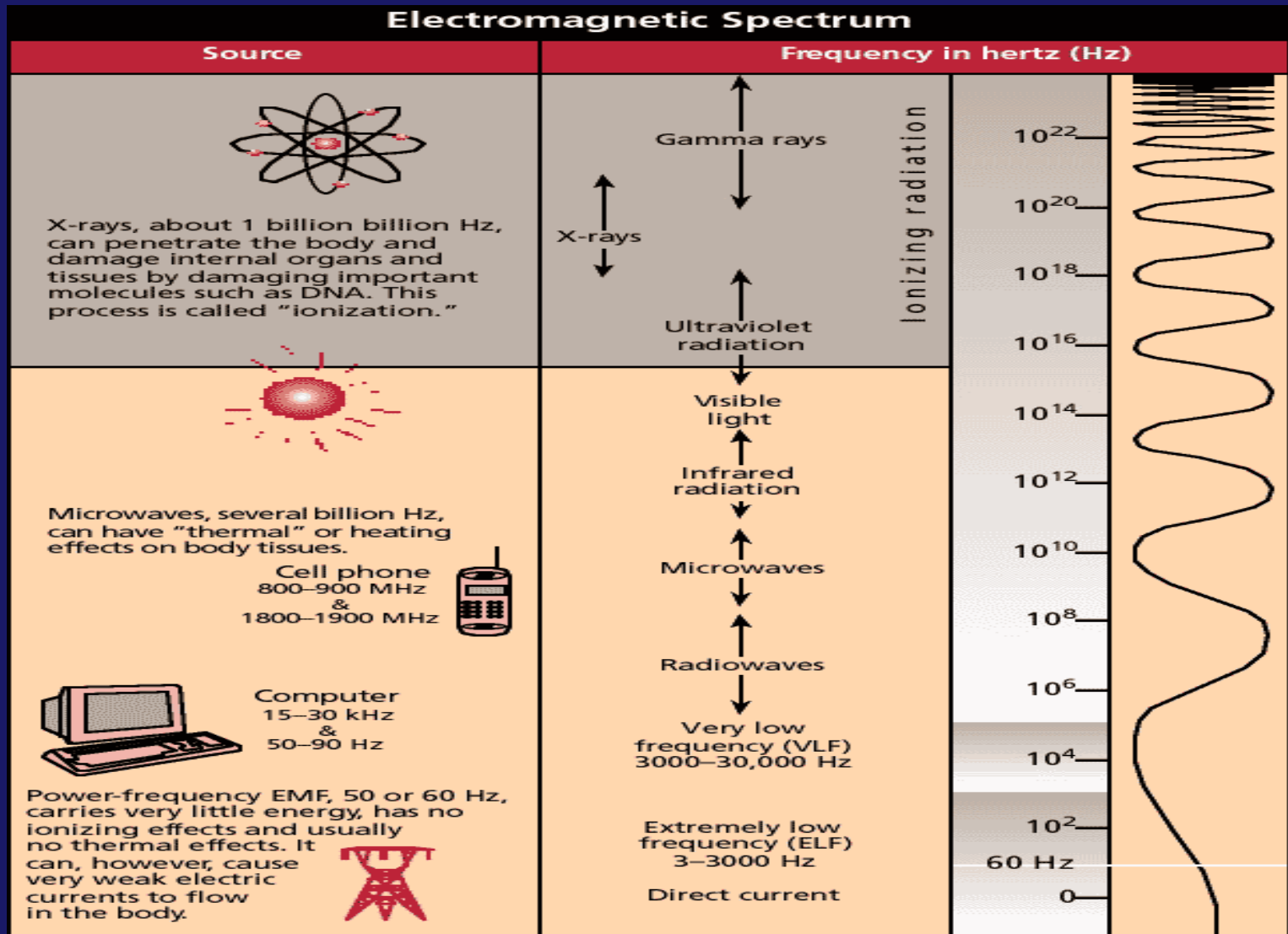
[www.dceg.cancer.gov/RadEpiCourse](http://www.dceg.cancer.gov/RadEpiCourse)

# Outline of Presentation

- Terminology
- Sources of exposure
- Characteristics of ELF-MF exposures
- Exposure assessment in epidemiologic studies
- Results of epidemiologic studies
- Animal studies



# Electromagnetic Spectrum



# **Terminology and Measurements**

# Terminology

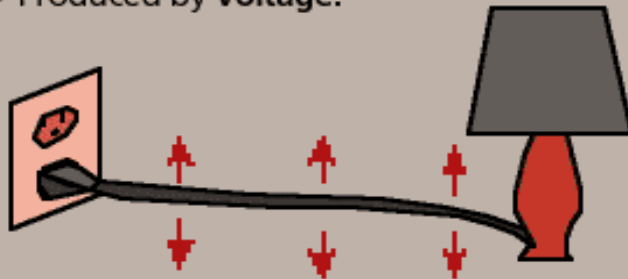
- Electromagnetic spectrum
  - > Frequency: cycles per second (Hertz)
  - > 1 cycle = 1 wavelength
  - > as frequency  $\uparrow$ , wavelength  $\downarrow$
- Electric fields
  - > measured in volts per meter
  - > easily shielded
- Magnetic fields (MF)
  - > measured in gauss (G) or tesla (T)
  - > not easily shielded

# Electric vs. Magnetic Fields

## A Comparison of Electric and Magnetic Fields

### Electric Fields

- Produced by **voltage**.

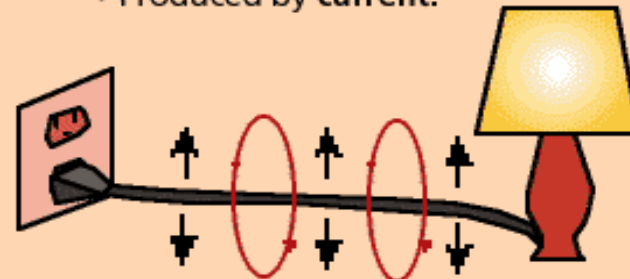


Lamp plugged in but turned off.  
Voltage produces an electric field.

- Measured in **volts per meter (V/m)** or in **kilovolts per meter (kV/m)**.
- **Easily shielded** (weakened) by conducting objects such as trees and buildings.
- Strength decreases rapidly with increasing distance from the source.

### Magnetic Fields

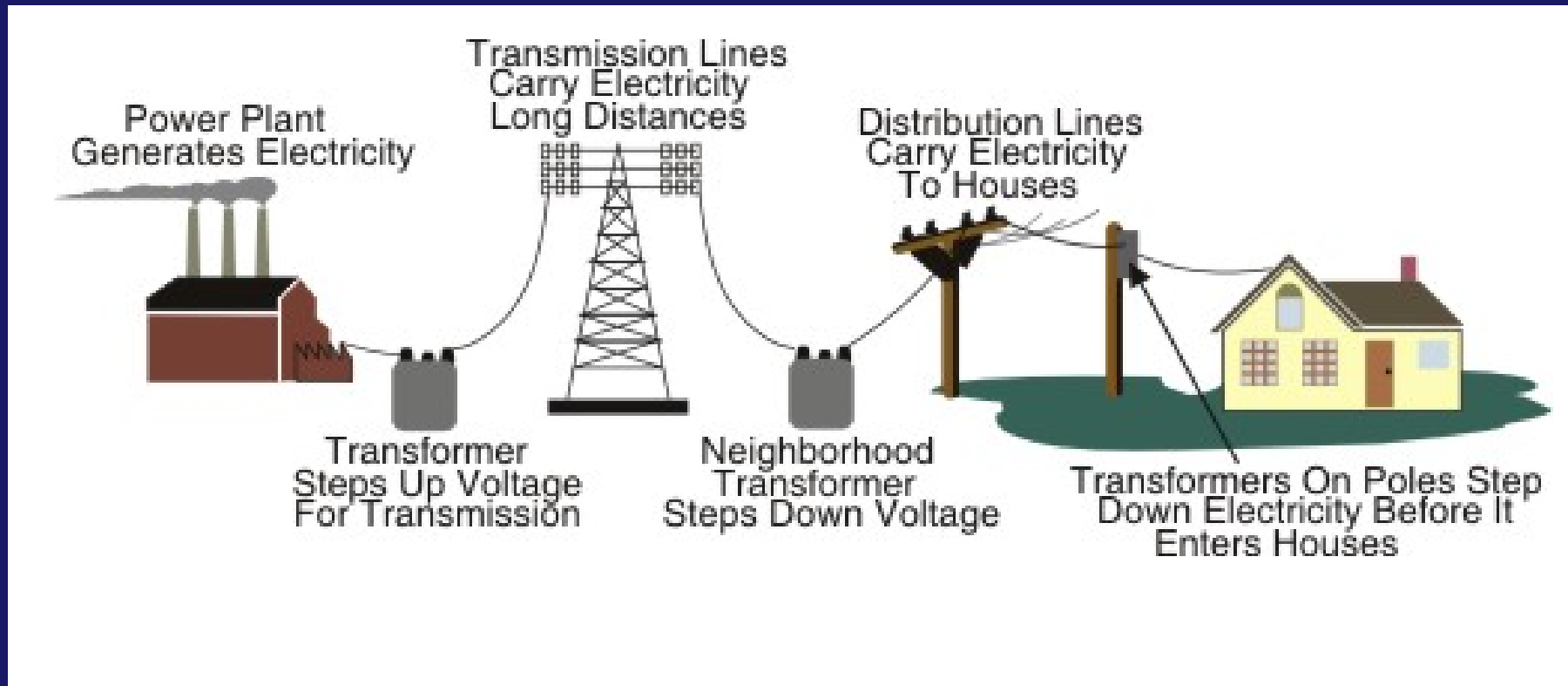
- Produced by **current**.



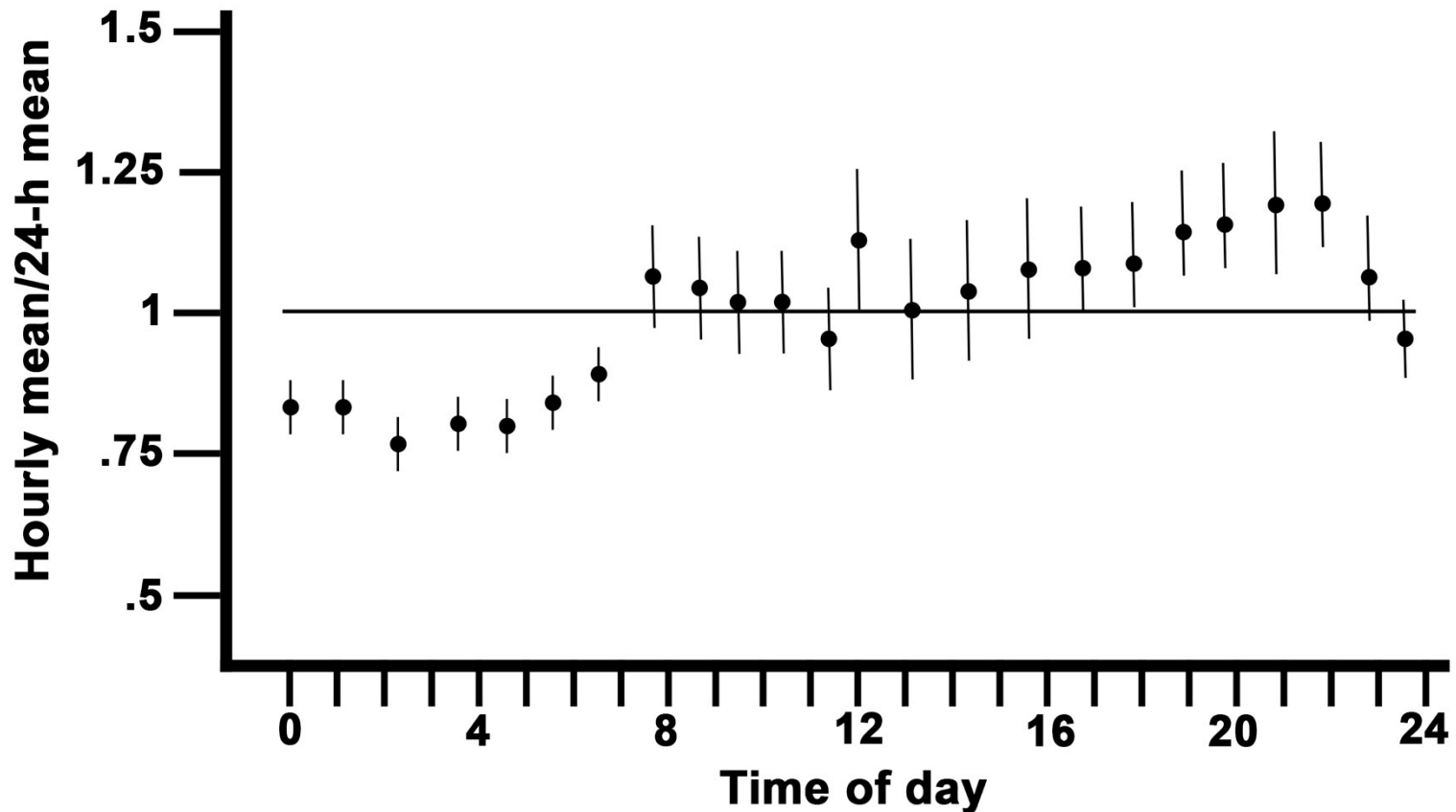
Lamp plugged in and turned on. Current  
now produces a magnetic field also.

- Measured in **gauss (G)** or **tesla (T)**.
- **Not easily shielded** (weakened) by most material.
- Strength decreases rapidly with increasing distance from the source.

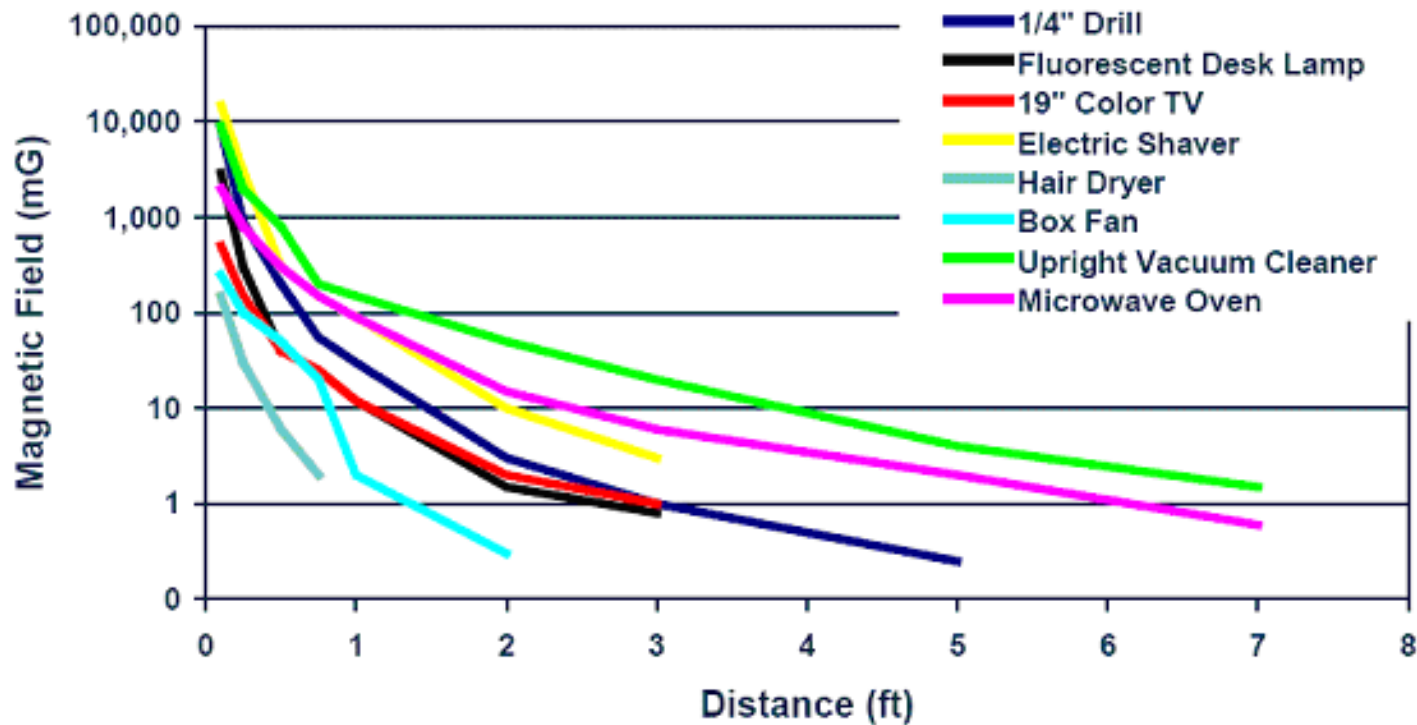
# Electric Power: From Power Plant to Home



# ELF-MF in Home: 24-Hr Measurements



# Dramatic Decline in ELF-MF with Short Distances

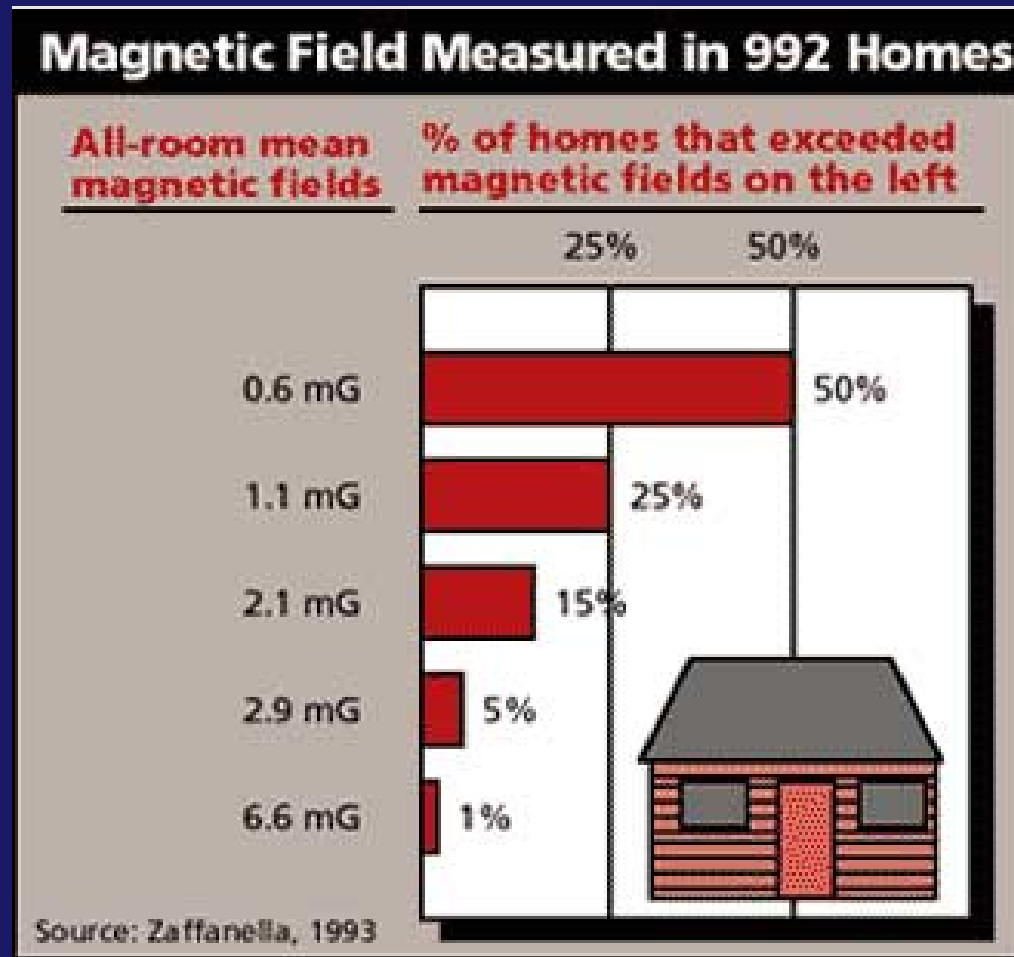


Source: Household Appliance Magnetic Field Survey (Gauger, 1985)

# Types of ELF-MF Measurements in Health Risk Studies

- Direct measures
  - > reported in milligauss (mG) or microtesla ( $\mu$ T):
  - > “spot” (30-second) or 24-hour measurements
- Personal monitoring (residence, school, job)
- Proxy measures
  - > wire codes: based on power line distance, thickness, configuration
  - > historical estimated exposures: transmission line distance & load
  - > distance of residence from transmission lines

# Summary of ELF-MF in Homes



# Childhood Cancer Residential Studies: Temporal Changes in Exposure Assessment

- Early studies (Denver): wire codes (1979, 1988) or spot measurements (1988)
- Scandinavian studies (1993-97): historical estimated levels from registry data
- North American, German, UK, Australian, Japanese: direct measurements

# Health Effects Studies

# Childhood Cancer Residential Studies Results

- Ahlbom et al, 2000
  - > Combined 9 well-conducted studies
  - > **No childhood leukemia risk increase  $\leq 0.4 \mu\text{T}$  MF exposure;**  
two-fold excess risk associated with MF exposure  $> 0.4 \mu\text{T}$
- Greenland et al, 2000
  - > Combined 15 studies
  - > **No childhood leukemia risk increase  $\leq 0.3 \mu\text{T}$ ;**  
two-fold excess risk at MF levels  $> 0.3 \mu\text{T}$

# Childhood Cancer & Electrical Appliances

- 5 studies: all interviewed mothers to assess prenatal and postnatal exposure
  - leukemia (4 studies)
    - > use of electric blankets (2 studies prenatal and 3 postnatal), hair dryers (2), TV watching (2)
    - > no consistent dose-response
    - > TV linked with duration, not distance; measurements at typical distances same as ambient MF levels in homes
  - brain (3 studies)
    - > little consistency among results

# Adult Cancer Studies Results

## ■ Residential

- > Leukemia (4 studies: 3 null, 1 small risk)
- > Brain (4 studies: all null)
- > Breast (9 studies: 8 null, 1 small risk)

## ■ Occupational

- > Leukemia (job titles:  $RR=1.2$ ; measurements: inconsistent)
- > Brain (job titles:  $RR=1.2$ ; measurements: inconsistent)
- > Breast (most null)

# Outcomes Other than Cancer

- Limited data on outcomes other than cancer, results not clear or consistent
  - neurodegenerative diseases
    - > amyotrophic lateral sclerosis
    - > Alzheimer's disease
  - suicide and depression
  - reproductive disorders
    - > spontaneous abortion
    - > low birth weight
    - > congenital malformations
  - cardiac effects
    - > heart rate
    - > cardiovascular disease mortality

# Animal Studies

- Voluminous literature, no replication of positive studies (Portier and Wolfe (eds) NIH Publ No. 98-3981, Research Triangle Park, NC, NIEHS, 1998; IARC monograph Vol 80, Lyon, France, 2002)
- Large, well-controlled studies all null (Boorman GA et al. 1997, 1999, 2000a, b; McCormick et al. 1999)

# Summary

- Two well-conducted pooled analyses find 2-fold increase in childhood leukemia for small fraction of children at highest residential ELF-MF exposure levels, some potentially due to bias; no association with other childhood cancers
- Childhood cancer and electrical appliances: questionnaire data inconsistent , but no clear dose-response
- Adult residential studies mostly null for leukemia, brain, and breast
- Adult occupational studies: modest (20% ) increase in leukemia and brain tumors based on job titles
- Limited data on outcomes other than cancer
- Large, well-controlled studies animal studies: all null

# Questions and Answers

U.S. Department of Health and Human Services  
National Institutes of Health | National Cancer Institute

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