

**Theoretical Bases That Electromagnetic Fields with a
Frequency less than 3000 GHz can not induce Cancer**

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Introduction

Static electric and magnetic fields, and electromagnetic wave of less than 3000 GHz are a matter of interest over the world. The reason is that they have a potential affecting human health. In 1979, Wertheimer, et al first reported that electromagnetic field from power lines increase childhood leukemia. Since then, many researchers over the world have studied the effect of electromagnetic field on human health, epidemiologically, experimentally and theoretically.

However, it has not arrived at any agreement. The reason is that harmness of electromagnetic field or radiofrequency has statistically weak relationship and also weak causality. Nonetheless, the most of mass media report hazard of radiofrequency and power line frequency with more importance. As a result, the general public get to be under some vague uneasiness at the radiofrequency. Some national and international agencies have recommended safety guide. On 1996, WHO commenced a massive International EMF Project on a 10-year scheme.

Hypothesis

Static electromagnetic field and radiofrequency are not material. So, for static electromagnetic field and radiofrequency to induce cancer, the frequency should create ions or free radicals, influence the flow of molecules or ions through cell membrane, or change the distribution of ions in extracellular liquid.

Theory

Ionization and excitation of molecules by radiofrequency

3000 GHz is the maximum frequency of SEHF. The energy of the photon is 12.4 meV, which is approximately 1/130 of the lowest energy of light photon. At body temperature 37°C, the thermal energy of a material is 26.8 meV. 3000 GHz photon with 12.4 meV less than thermal energy is too low to create ions or free radicals, so, the photon can not

create ions or free radicals absolutely.

Electric fields

The force F on a particle of charge q in electric field E and magnetic field B is given by

$$F = q (E + v \times B)$$

where v is the velocity of the particle.

Cell membrane is a kind of capacitor with insulator of high resistance between plates. The inner wall of the membrane is charged negatively and the outer charged positively. The electric field between the inner and outer walls is approximately 7~10 MV/m. For electric field applied to the membrane or induced from magnetic field to affect the flow of ions through cell membrane, the electric field should be comparable to the electric field existing between membrane. Mobility of Cl^- ion in tissue is $7.9 \times 10^{-8} \text{ m}^2/\text{Vs}$. Velocity of Cl^- in membrane or tissue is less than 79 cm/s.

For low frequencies such as power lines, the relation between the internal electric field E_{int} and the external field in air E_{air} is

$$|E_{int}/E_{air}| \approx \omega \epsilon_0 / \sigma_{int}.$$

For 60 Hz, the ratio of the internal field to the external is 0.7×10^{-8} . Even though the field in air is as strong as lightning, 3 MV/m, the internal field is 21 mV/m.

Magnetic fields

Static magnetic field can accelerate moving charged particles by Lorentz force but cannot change kinetic energy of any charged material. When a man travels in air with a speed 1,000 km/h in 50 μT , ions in human body experience horizontal electric field 14 mV.

Changing magnetic field induces electromotive force in a closed circuit. In a closed circuit of radius r , induced electric E_i by a magnetic induction $B_0 \sin \omega t$ is

$$E_i = -0.5r\omega B_0 \cos \omega t.$$

Uniform magnetic field of 60 Hz and 1 μT rms induce 19 $\mu\text{V}/\text{m}$ of 10 cm radius circuit.

Conclusion

EMF of lower frequency than 3000 GHz cannot create ions and electric field induced in body is too weak to affect to flow of ions in human body. So. EMF of lower frequency than 3000 GHz cannot induce cancer.