



The effect of electromagnetic fields at Extremely Low Frequency (ELF) of 50 Hz in cell proliferation and DNA damage

Tayebah Ziveh

Institute of Biochemistry and Biophysics (IBB), University of Tehran, Tehran, Iran



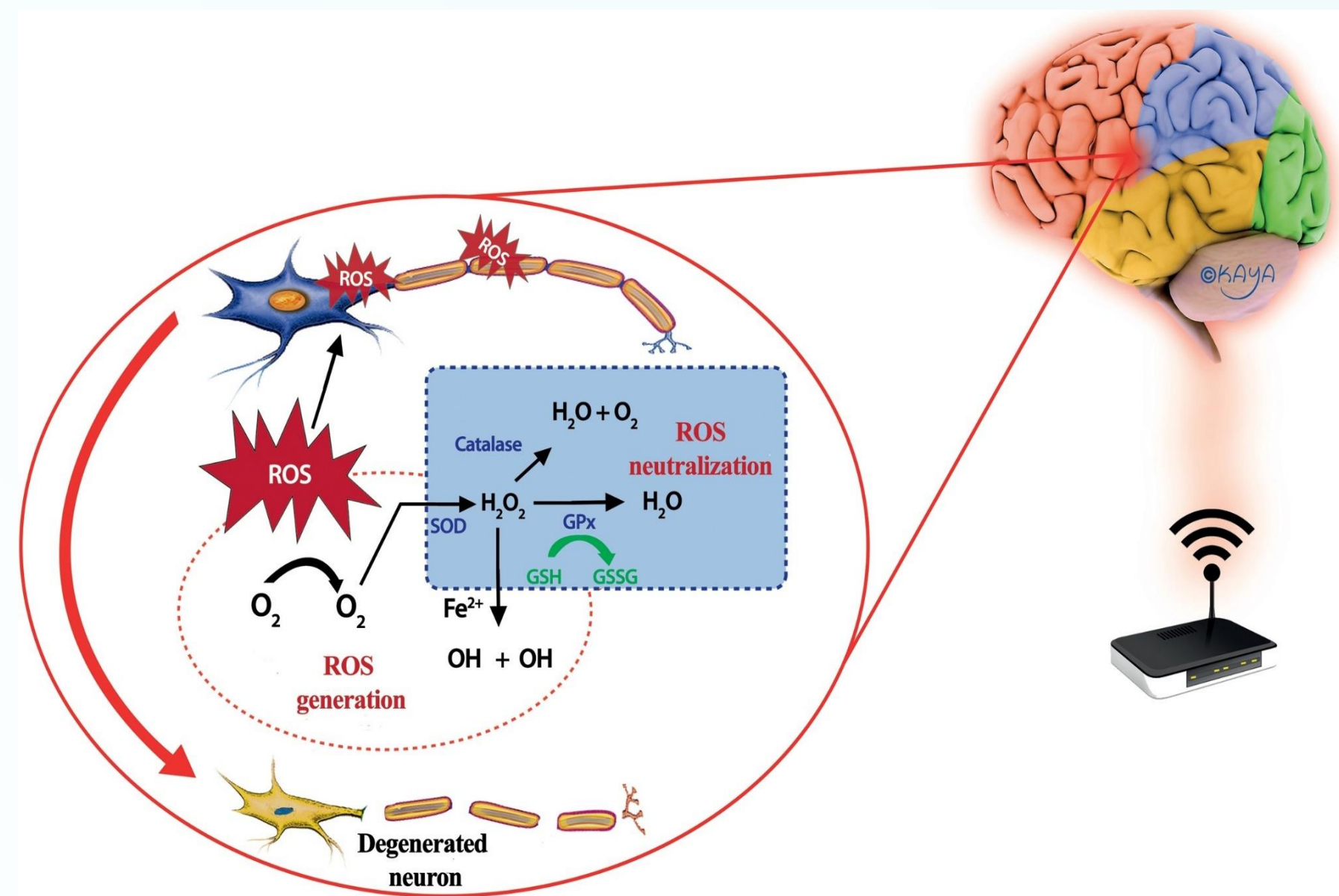
Abstract

The electromagnetic frequencies that induced normally in human body, comprise from the action potentials of nerves, heart tissue and skeletal muscles, were categorized in the range of extremely low frequencies. With increase in developed devices that produced or induced electromagnetic fields, human anxiety about effects of these fields on normal or abnormal body cell proliferation was increased. Researches show that electromagnetic fields at different strengths and frequencies effected on the cell proliferation and differentiation. The Extremely Low Frequency (ELF) electromagnetic field (EMF) is thought to prolong the life of free radicals and can act as a promoter. Therefore, ELF-EMF influences the proliferation and DNA damage in both normal and tumor cells through the action of free radical species. Methods of Electromagnetic fields with different frequencies, gel electrophoresis, microscopic imaging, High performance Liquid Chromatography (HPLC), fluorescence microscope and cytofluorometry were used to address the matter. The application of the (ELF-EMF) fields in frequencies between 15-60 Hz had more effects on cell proliferation and less effect on cell differentiation. This effect was related to multi session irradiation or cells long-term exposure. The ELF-EMF can be used as a safe stimulator for the cell proliferation and repair of tissue damages. Effects of ELF-EMF on cells depend on various factors, including field parameters and characteristics (frequency, intensity, wave-shape), cell type, and exposure duration. Thus, studies show that both cell growth and DNA damage can be observed in cell populations that are exposed to ELF-EMF for a sufficiently long time and are able to recover after treatment.

Keywords: Biophysics, Electromagnetic waves, cell proliferation, DNA damage, cancer treatment, free radicals.

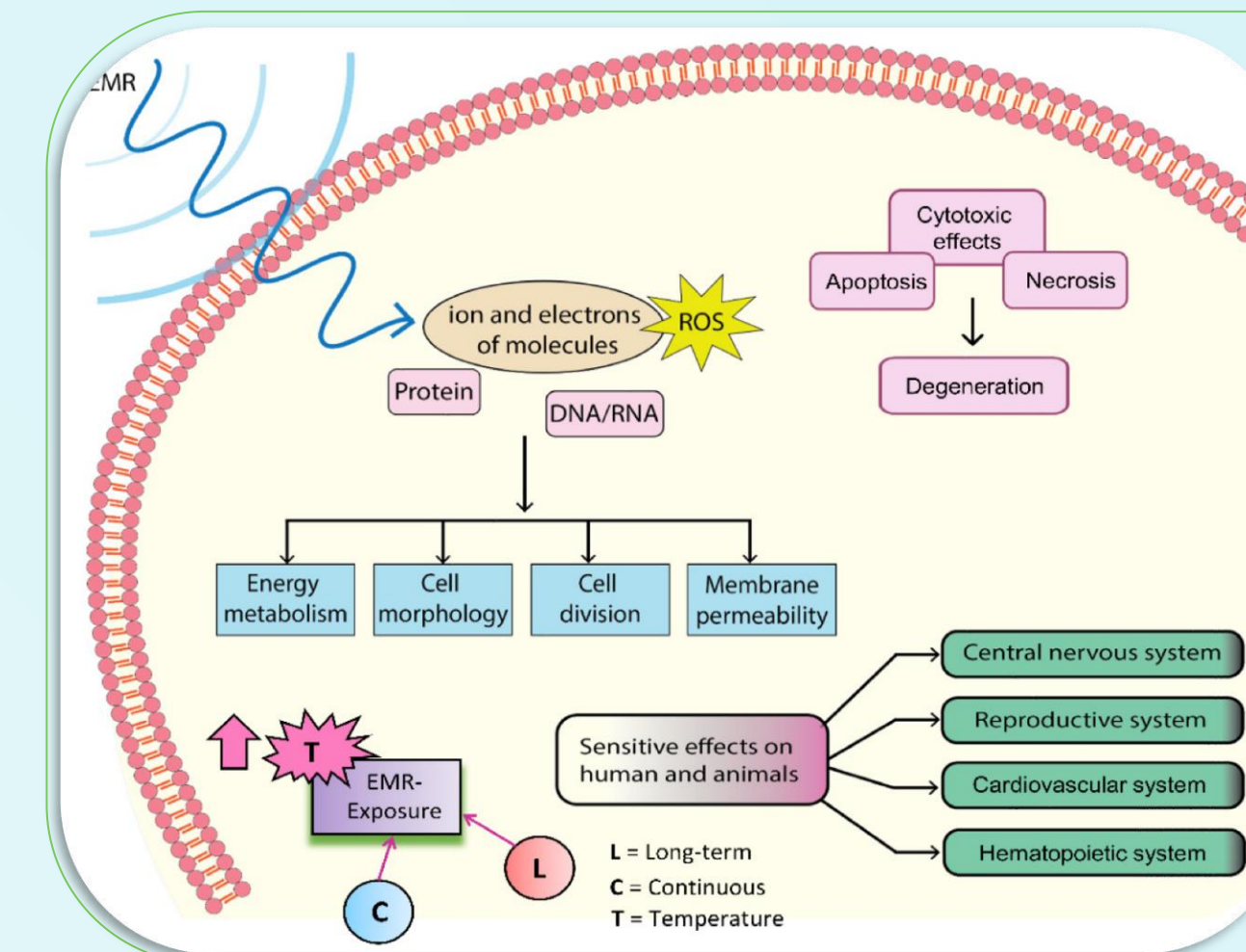
Introduction

Technological devices have become essential components of daily life. However, their deleterious effects on the body are well known. Electromagnetic fields (EMF) have various chemical effects, including causing deterioration in large molecules in cells and imbalance in ionic equilibrium. Despite being essential for life, oxygen molecules can lead to the generation of hazardous by-products, known as reactive oxygen species (ROS), during biological reactions. These reactive oxygen species can damage cellular components such as proteins, lipids and DNA. The role of EMF emitted from devices, depicting an increase in the generation of ROS and consequent oxidative stress and the inability of the antioxidant defense system to cope with this increase in ROS.



The amount of frequency absorbed by the body is represented by a unit called SAR

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dv} \right)$$

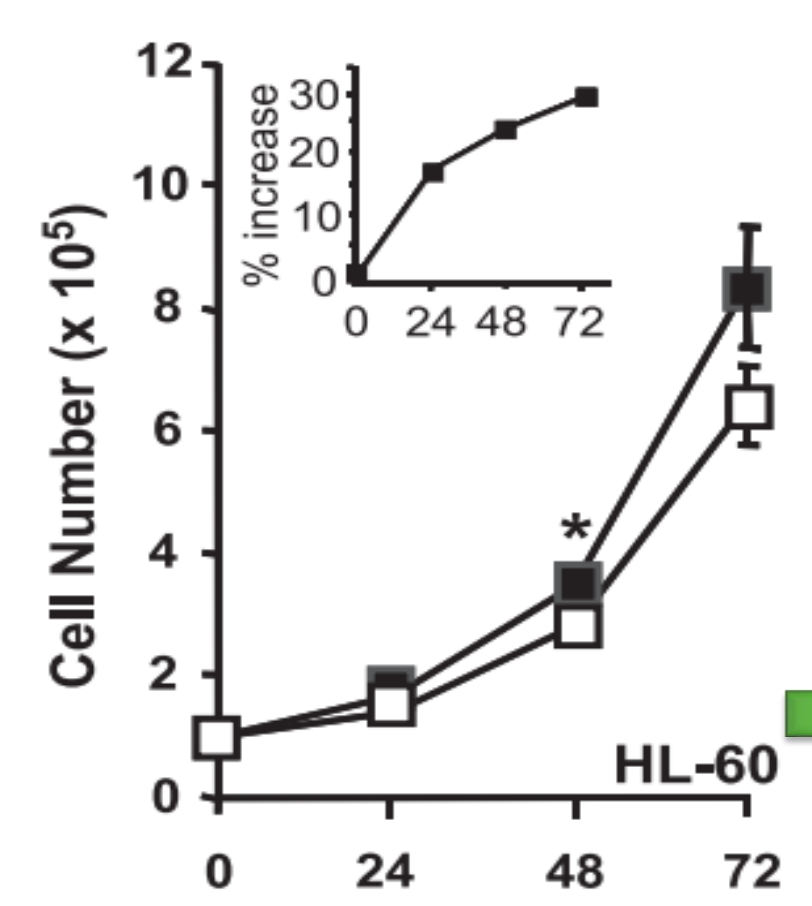


ROS(Reactive Oxygen Species)

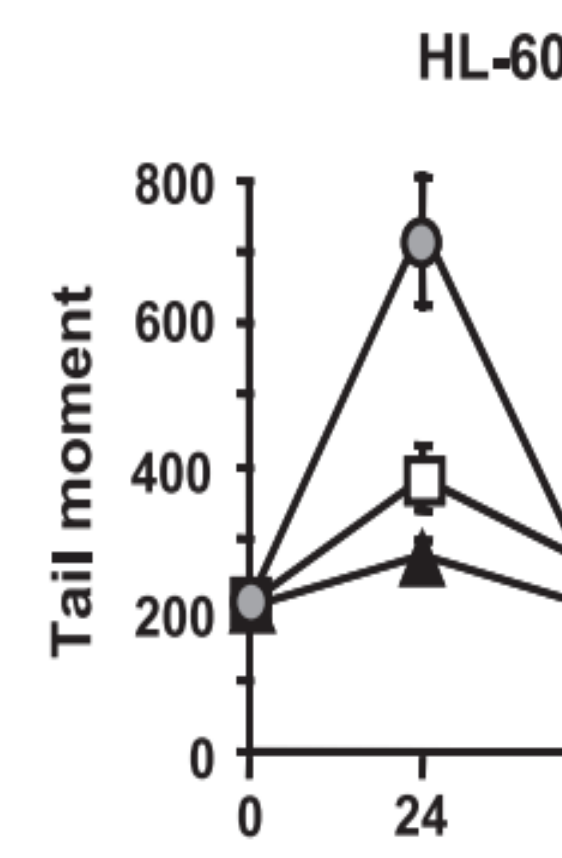
Is a product of natural aerobic metabolism and is generally produced in mitochondria. ROS production processes also play a decisive role in important biological processes.

Results & Discussion

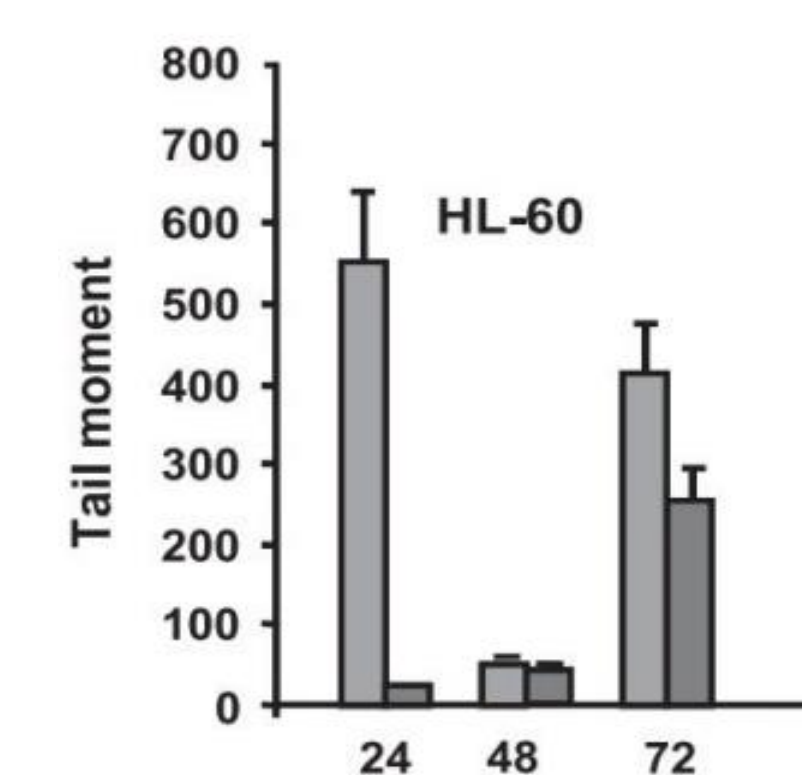
Data reported in the articles confirm that ELF-EMF affects cell proliferation and susceptibility to DNA damage and explore mechanisms through which ROS may be important in these settings.



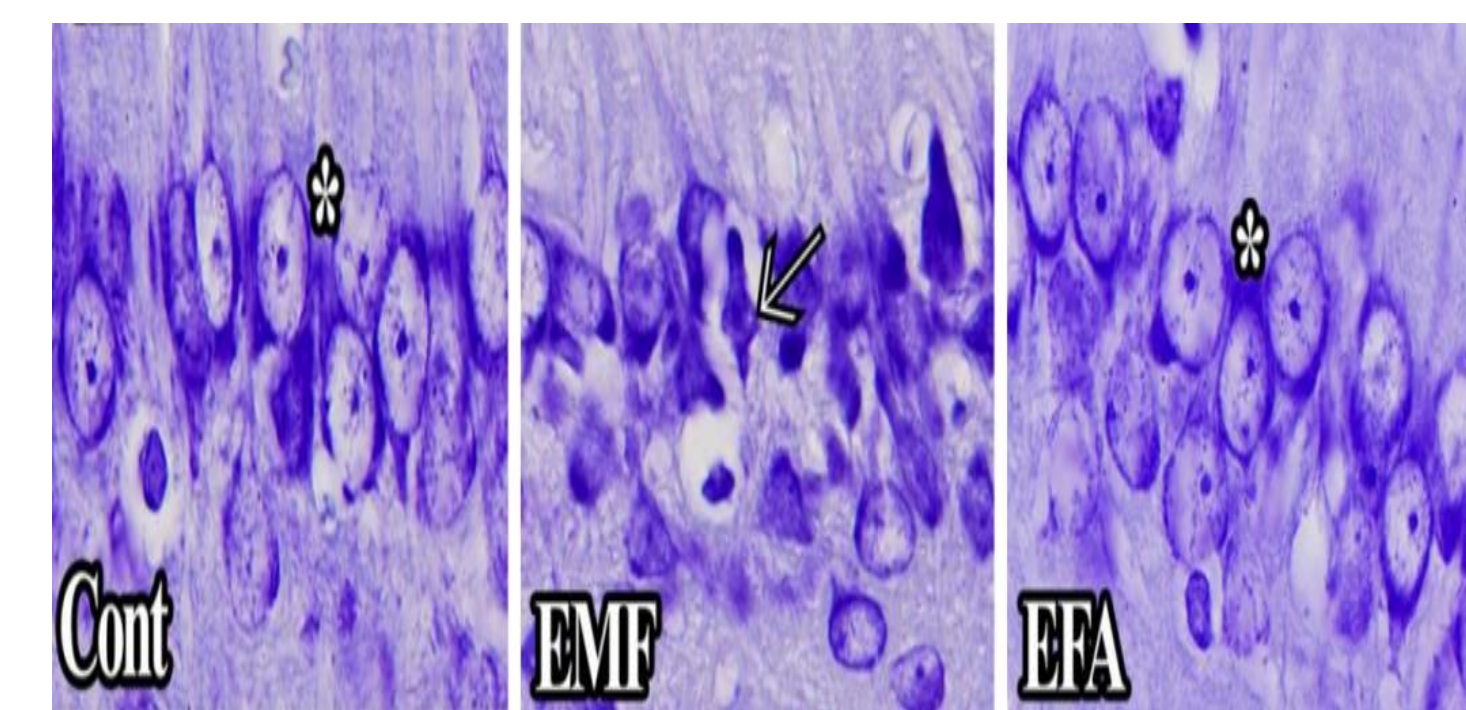
Effect of ELF-EMF exposure to 1.0 mT/50 Hz for 72 h on proliferation of HL-60 cells. After plating cells were grown for 72 h under continuous ELF-EMF exposure.



Effect of ELF-EMF exposure at 0.5–1.0 mT/50 Hz for 72 h on DNA damage evaluated as strand breaks in HL-60 cells. Cells were exposed for different extent of time to ELF-EMF from 0.5 to 1.0 mT/50 Hz and single strand breaks were evaluated by Comet assay.



Effect of antioxidant treatment on DNA damage induced by ELF-EMF at 1.0 mT/50 Hz up to 72 h in HL-60 cells. After removal of excess antioxidant, treated cells were exposed to ELF-EMF from 24 to 72 h.



Microscopic images of cell destruction in exposure to ELF-EMF and cell treatment with antioxidants and no cell destruction due to the effect on ROS

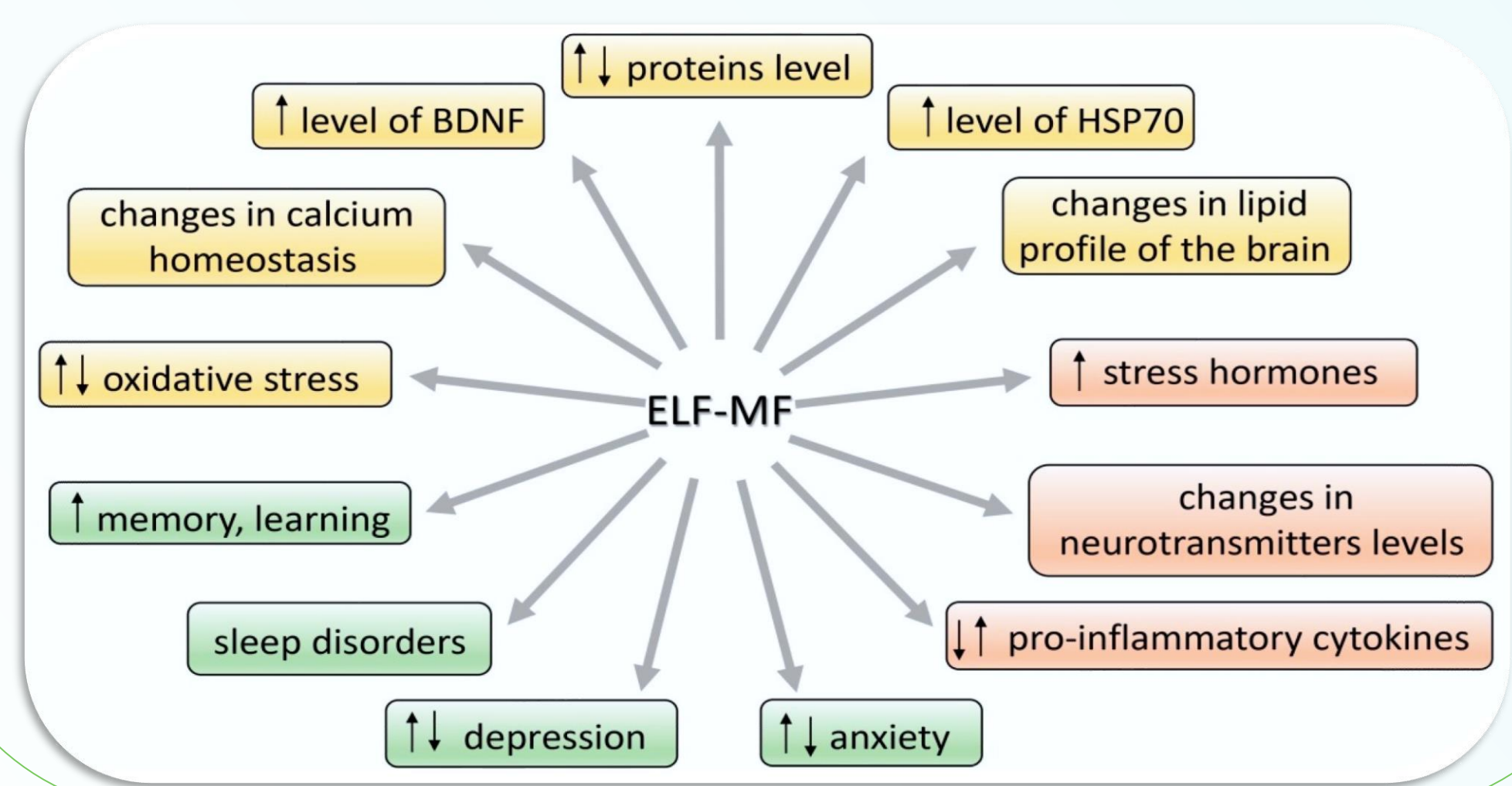
Maxwell's equations

Maxwell's equations describe how electric and magnetic fields are produced by electric charges and currents, and how one of these fields is produced by changing the other field.

Integral equations	Differential equations
$\oint_{\partial\Omega} \mathbf{E} \cdot d\mathbf{S} = \frac{1}{\epsilon_0} \iiint_{\Omega} \rho dV$	$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$
$\oint_{\partial\Omega} \mathbf{B} \cdot d\mathbf{S} = 0$	$\nabla \cdot \mathbf{B} = 0$
$\oint_{\partial\Sigma} \mathbf{E} \cdot d\mathbf{l} = -\frac{d}{dt} \iint_{\Sigma} \mathbf{B} \cdot d\mathbf{S}$	$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$
$\oint_{\partial\Sigma} \mathbf{B} \cdot d\mathbf{l} = \mu_0 \left(\iint_{\Sigma} \mathbf{J} \cdot d\mathbf{S} + \epsilon_0 \frac{d}{dt} \iint_{\Sigma} \mathbf{E} \cdot d\mathbf{S} \right)$	$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$

Combining chemotherapy with electromagnetic waves for greater treatment effect

Electrochemotherapy (ECT), the combination of electric pulses (EPs) and an anticancer drug, is a type of cancer treatment method. Low-frequency electromagnetic waves increase membrane permeability and drug access to the cytosol.



Conclusion

- Depending on the frequency, energy, duration and distance, electromagnetic waves can have destructive effects on body tissues.
- Extremely Low Frequency Electromagnetic Field (ELF-EMF) can affect intracellular reactive oxygen species (ROS) levels and antioxidant enzyme activity.
- ELF-EMF 50 Hertz increase cellular proliferation and DNA damage.
- Treatment of antioxidants with different mechanisms can reduce the destructive effects of magnetic fields.
- Electrochemical therapy (ECT) can be a suitable method for more effective cancer treatment.

Reference

- R.Sadeghipour, Sh.Ahmadian, B.Bolouri, Y.Pazhang, & M.Shafiezhadeh: Effects of extremely low-frequency pulsed electromagnetic fields on morphological and biochemical properties of human breast carcinoma cells (T47D):Electromagnetic Biology and Medicine, 2012,31(4): 425–435.
- F.Wolf, A.Torselloa, B.Tedescoa, S.Fasanellaa, A.Boninsegnaa: 50-Hz extremely low frequency electromagnetic fields enhance cell proliferation and DNA damage: Possible involvement of a redox mechanism:Biochimica et Biophysica Acta., 2005,1743 120 – 129.
- J.YAN, L.DONG, B.ZHANG, Effects of Extremely Low-Frequency Magnetic Field on Growth and Differentiation of Human Mesenchymal Stem Cells :Electromagnetic Biology and Medicine, 2010,29: 165–176.
- M.Mansourian, M.Firoozabadi & Z.Hassan, The role of 217-Hz ELF magnetic fields emitted from GSM mobile phones on electrochemotherapy mechanisms: Electromagnetic Biology and Medicine,2020: 10.1080/15368378.
- M. HONG, N.Kyung, et al: Extremely Low Frequency Magnetic Fields Do Not Elicit Oxidative Stress in MCF10A Cells:Radiation Research,2012, 53, 79–86.

E-mail: t.ziveh@gmail.com