Investigation of Controlling Biological Parameters via Background Static Magnetic Field

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***Abstract*—This study presents experimental findings demonstrating that changes in Static Magnetic Field (SMF) in presence of 16.5 Hz of time varying magnetic field with amplitude of 9.81 µT can alter the growth rates of HT-1080 fibrosarcoma cells in vitro. Results indicate that these changes in SMF can both increase and decrease the growth rates, in addition to altering membrane potential and calcium ion (Ca^{2+}) concentrations. These effects are hypothesized to arise from changes in chemical reaction rates mediated by changes in Zeeman shifting. The growth rates of fibrosarcoma cells were significantly modulated during 4-day exposures to SMFs with different amplitudes.**

I. INTRODUCTION

Environmental magnetic fields (MFs) can be categorized into two types: man-made and naturally occurring. Natural MFs include the geomagnetic field and fields generated by solar activity and atmospheric processes (Heilig et al., 2018). The geomagnetic field varies with the time period going up to million years and hence is considered to be in the static range for the purpose of this study. Examples of man-made MFs are induced fields by electrical power lines at 50 Hz or 60 Hz, static fields in transportation (Dietrich & Jacobs, 1999) and MRI machines. This chapter goes over the previous studies on the effects of electromagnetic fields (EMFs), why we use cancer cells for in vitro experiments and the pathways through which EMFs can interact with biological systems. Another aspect we investigate in this paper is through theory and experiments how Zeeman effect couples into MF effect. There have been numerous studies on the effects of extremely low-frequency fields and static magnetic fields. Here in this study, we study the combined effects of the change in Static fields in the presence of an AC field to understand the possibility of Zeeman effect being the interaction mechanism in Fibrosarcoma cells.

A. Why Fibrosarcoma Cells?

Cancer is the second-leading cause of death in the 21st century (Siegel et al., 2024). The most common types of cancer are lungs, breast, colorectal, prostate, skin cancer, and stomach cancer (Siegel et al., 2025). For this dissertation, skin cancer was picked as the ability to treat Fibrosarcoma with ionizing radiation therapy is one of the least successful. One of the rarest forms of skin cancer is fibrosarcoma, which is a highly malignant tumor of mesenchymal cell origin. It originates from fibroblast cells and has a very high division rate (Daniela Augsburger et al., 2017).

B. Electromagnetic Field Effects on Cells

EMF effects on biological systems have a complex set of results. Studies on response to static magnetic fields show that they induce changes in hydrogen peroxide, mitochondrial balance and antioxidant response (Van Huizen et.al, 2019; Gurhan et.al 2021). There are also studies that show how direction of the magnetic field might play an important role in the EMF exposure experiments. One of the studies (C. Martino, 2011), shows the effects due to the changing the AC field from horizontal to the cell surface to vertical to the cell surface on growth rate and superoxide production.
More on these effects are discussed in the sections below separated by the molecules or enzymes they could possibly influence.

C. Possible Molecules Effected by EMF

Hydrogen peroxide is a reactive oxygen species (ROS) present in biological systems that acts as a signaling molecule. It is generated by the dismutation of superoxide (O_2^-) as shown in Fig 1. Hydrogen Peroxide is identified to be a signaling particle between various cells and is used a switch to turn on and off proteins/enzymes production. Studies indicate that hydrogen peroxide can be produced when a biological system detects the presence of extracellular signals here, electromagnetic fields. Hydrogen Peroxide can then introduce downstream effects in the biological systems. All aerobic cells produce ROS and reactive nitrogen species (RNS) (Halliwell et al., 1986). In the cells, the consumption of Oxygen (O_2) is then accompanied by an initial generation of Superoxide (O_2^-). This is then followed by the secondary production of ROS, such as hydrogen peroxide (H_2O_2), HOCL (Hypochlorous acid), Hydroxyl Radical (OH^-) nitric oxide, NO, and singlet oxygen (Forman et al., 2003). Hydrogen peroxide and other ROS can help non-destructive and reversible oxidative (Forman et al., 2003).

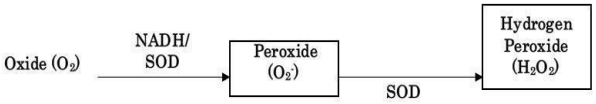

Figure 1: The formation of Peroxide from oxide with NADH/SOD as catalyst. The formation of Hydrogen Peroxide from the Peroxide formed with SOD as catalyst.

Low levels of Oxidative stress stimulate the proliferation of cells in culture and high levels of oxidative stress decreases cell proliferation in culture and has many toxic effects (Halliwell et al., 1986). Oxidative stress here represents the production of ROS. Production of excess ROS could lead to damage to DNA (Deoxyribonucleic acid), lipids and proteins