The Effects of Soundwaves, Languages, and Electromagnetic Waves on Cells

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ABSTRACT

Waves are not only water movements that surfers ride on, but are also a disturbance or variance that travels through a medium. Two types of waves are called sound and electromagnetic waves, which are found throughout the world. Sound waves come from anything with sound, including traveling through human speech such as languages, while electromagnetic waves come from accelerated charged particles, including the sun, lightning, microwave ovens, and television signals. These waves can affect our bodies in unique and interesting ways, specifically targeting cells on a molecular level and altering them.

Introduction

Frogs in swamps, horses in farms, trees in forests, and humans in towns all have one thing in common: around 50-100 trillion cells living throughout their body. According to the National Cancer Institute [1], cells are the smallest unit of life that can live independently and make up all living organisms and tissues of the body. Each cell is composed of three main parts: the cytoplasm, the nucleus, and the cell membrane. Cytoplasm is the jelly-like fluid inside the cell that surrounds the nucleus. The cytoplasm has multiple other specific functions, like the Golgi complex, the mitochondria, and the endoplasmic reticulum, where chemical reactions and protein synthesis occur.

The nucleus [2] is commonly known as the brain of the cell, with one nucleus for each cell. Some cells, like skeletal muscle cells, contain two nuclei instead. The nucleus houses the majority of the cell's genetic material (DNA). The nucleus also sends out messages to tell the cell to grow, divide, or die. Lastly, the cell membrane [2] surrounds the cell and controls what type of substances can enter and exit, acting somewhat as a gate for the cell. These parts of the cells are known as organelles, similar to organs for humans such as the heart, lungs, or brain. One important organelle is the mitochondria. Mitochondria [3] produce the most chemical energy needed to power the cell and its many biochemical reactions. The chemical energy is stored in small molecules called adenosine triphosphate (ATP).

Cells, as they grow and divide, undergo a process called the cell cycle commonly referred to as Mitosis [4]. Cells spend most of their time in interphase, going through G1, synthesis, and G2 phase. During this time, they grow, replicate their chromosomes, and prepare for cell division. The cell then leaves interphase and enters metaphase, going through Prophase, Metaphase, Anaphase, Telophase, and Cytokinesis, completing its division. The result is two daughter cells, and the cycle begins again. This process allows the cell to replicate themselves and make new cells. Mutations in the genes that control cell proliferation (rapid reproduction in the cells) can cause a deadly disease known as cancer. Cancer [5] is unchecked cell growth that allows for the acceleration of cell division rates or inhibiting normal controls on the system, including cell cycle arrest (stopping points in the cell cycle) or programmed cell death.

Another way cells can be differentiated from each other is by indicating if they are either auditory or non-auditory cells, which is based on sound. Sound is a vibration that travels through a medium, and these vibrations are characterized by frequency. Frequency is measured in Hertz (Hz) and determines the pitch or the sound. These frequencies can be shown through music types, with different music types having different frequencies. For example, in music note frequencies, every note has a corresponding frequency attached to it. Auditory cells are finely tuned to detect specific sound frequencies, while non-auditory cells generally lack this frequency-specific responsiveness, meaning they can not detect sound frequencies.[6]

Music in Microbiology

Music, an integral part of human society since prehistoric times, has recently become a focal point in biological research. Emerging studies highlight its potential benefits in medicine, yet the mechanisms by which music influences us at the cellular level remain an ongoing mystery, with researchers continuing to reveal its effects. Numerous researchers have found that exposure to music and various sounds can directly impact the behavior and cell growth of both auditory and non-auditory cells. It has been shown that a volume of 261 Hz changed the development of human gingival fibroblasts (depending on the exposure time) [7]. The effects of sound stimulation in animals were also recorded, with results in one study showing the size and number of nerve cells were increased in embryonic chick hippocampus, along with Calcium-binding proteins (CaBPs) which are proteins that take part in calcium cell signaling pathways, leading to early maturation of the auditory pathway and behavior responses[8] suggesting music may have a similar influence on human cells.

Not only can sound increase or decrease the speed at which cells complete a chemical process, but it can also entirely change the behavior of cells. Studies have shown that music could act directly on MCF-7, a human breast cancer cell line, altering cell cycle, proliferation, and viability [9]. One study revealed that sound vibration (SV) treatments of the Thale cress (Arabidopsis thaliana) induced significant global changes in gene expression and protein profiles. Sound vibrations triggered a wide range of cellular responses similar to other mechanical stimuli, such as scavenging of reactive oxygen species ROS< alterations in primary metabolism, and changes in hormonal signaling. The study [10] showed how sound vibrations have a variety of molecular alterations, including changes in gene expression, protein levels, and hormonal balances. However, the study used plants as the test subject, so further studies should be conducted on how applicable the findings are to other organisms such as humans. Sounds were also evident in changing the structure of the protein of tobacco cells. The results showed that the change in plasma membrane protein was related to the strength and frequency of the sound wave that was applied to the cells. The study showed how the membrane proteins of certain cells are highly responsive to sound simulation [11].

It's been well-established that sound affects cells in different ways, changing the structure, mechanism, and rate of growth. However, the type of sound is also a key factor in this unique process. According to Music Care, a previous study performed by Lestrad et al. proved that when breast cancer cells were exposed to music, cell death was increased while cell growth was decreased. With this knowledge, the researchers then used three different musical pieces, Mozart's Sonata for Two Pianos in D major KV.448, Beethoven's 5th Symphony, and Ligeti's Atmosphere on the same cells as before. All four songs showed the same effect of cell death increased while cell growth decreased, yet compared with the silent control groups they showed different rates of cell growth and cell death rates compared to each other. They repeated the experiment and found that the different musical pieces also affected the ability of the cells to move and migrate [12].

Lastly, another study [13] focused on the mitochondria and compared the effects of Chinese five-element, heavy metal, and classical music on mitochondrial function, oxidative capacity, and growth using HEK293T cells(human embryonic kidney cells). They found that five-element music increased ATP levels by 17%, glutathione (GSH) by 21%, and cell growth rates by 14%. Five-element music also had a significant decreasing effect on ROS (reactive oxygen species). Classical music increased GSH by 8% and increased cell growth by 14% as well. Heavy metal music, on the other hand, increased ROS by 16% and reduced cell viability by 11%.

Linguistics Sounds and Biology

Language has been an essential foundation for human interaction, evolving uniquely across different cultures and regions. Each language has different acoustic properties characterized by specific sound frequencies and patterns.

Recent studies have started to investigate how these distinct acoustic properties of various languages, including tonality, pitch, and rhythm, might influence the behavior of cells at a molecular level. Typically, human speech ranges from 50 Hz and 300 Hz, with most men being anywhere from 85-180 Hz and women being between 165-225 Hz.

A study conducted an experiment by sampling audio recordings from thirty-nine languages, finding differences and variations in sound frequencies across the chart. Variations in sound frequencies were also found within languages, with Spanish having the largest variation in frequencies, most notably in females. [14]

Another study shows the difference of frequencies between native and second language speakers with native speakers in English having a lower frequency output compared to second language speakers. This is in contrast with Dutch, in which native speakers had a higher frequency output than second language speakers. [15]

The frequencies of languages vary from each other due to acoustic characteristics such as tonality, pitch and rhythm. For example, tonal languages like Chinese rely on pitch variations to convey meaning, emphasizing lower frequency ranges more than non-tonal languages like English. On the other hand, Portuguese places importance on nasal sounds, being understood in frequencies from 125-2000 HZ and Russian contains palatalization, with the most important frequencies range being from 3000-3500 hz.[16]

Frequency ranges for languages can be defined as specific bands of sounds that are crucial for distinguishing phonemic and tonsil differences. The frequency ranges of major languages consist of Portuguese being from 250 Hz to 3999Hz, Italian from 2000 to 3999Hz, US English from 1000 to 3999Hz, and more. [17]

Building upon our previous understanding that sound frequencies can affect cellular functions, it is possible that exposure to the unique acoustic patterns of different languages might elicit varied cellular responses. Previous studies have shown that sound waves can influence behavior of various cell types, affecting processes such as growth, gene expression, and protein synthesis. For example, a previous study stated that exposure to specific sound frequencies have been shown to alter the development of human gingival fibroblast and increase the size and number of nerve cells in the embryonic chick hippocampus.[2][3].

Since languages have their own set of dominant frequencies (frequency ranges), it is plausible to suggest that the cells of individuals exposed to different languages may exhibit distinct responses. For instance, lower frequency emphasis in tonal languages might influence cellular activities differently compared to higher frequency patterns prevalent in non-tonal languages. This hypothesis aligns with observations that sound vibration can produce significant changes in the gene expression and protein profiles in plant cells.[5]

Electromagnetic Waves and Cell Behavior

Electromagnetic waves, like sound waves, interact and impact with cells on a molecular level, however instead of vibrating molecules like sound, they affect cellular structure at a molecular and atomic level, sometimes being used in radiation therapy, while other times increasing cancer risk by altering DNA. Electromagnetic waves are broad ranges of frequencies, ranging from low-energy non-ionizing radiation, like radio waves and microwaves, to high-energy ionizing radiation, including X-rays and gamma rays. [18]

The potential link between electromagnetic fields and cancer has been extensively researched into. According to the American Cancer Society, high-energy radiation, which includes x-rays, gamma rays, and ultraviolet rays, are classified as ionizing radiation. This means that they have enough energy to remove an electron from an atom, damaging the DNA inside the cells, and possibly leading to cancer. When talking about electromagnetic radiation, scientists are referring to two parts, being the electric field and the magnetic field. Electric fields are forces acting on charged particles, like electrons or protons, causing them to move, while magnetic fields are created when charged particles are in motion.[19]. Non-ionizing electromagnetic fields, like those emitted by household appliances and power lines, do not have enough energy to damage DNA directly. Because of this, no mechanism by which these electromagnetic fields could cause cancer has been identified, since they do not damage DNA or cells directly. Some scientists have speculated that they can cause cancer through other mechanisms, such as reducing levels of the hormone melatonin, which might influence tumor development, however no definite evidence has been found. [20]

Ionizing radiation can result in damage such as genetic mutations, elevating the risk of cancer. However, most natural sources of ionizing radiation release ionizing energy at low levels, so the amount of radiation absorbed by our bodies is usually small. Man-made sources of ionizing energy are also around us everyday too, in our smoke detectors or medical diagnostic exams, which is the main source of manmade ionizing energy in the USA. [21]

Ionizing energy isn't just used in medical diagnostic exams too in clinics, but is also harnessed therapeutically in radiation therapy to treat existing cancers. This treatment utilizes high-energy radiation to target and destroy cancer cells by inflicting damage to the DNA. Techniques such as external beams of intense energy radiation direct x-ray beams at tumors, missing harm to surrounding healthy tissues.[22]

One study experimented on daily exposure of B16-Bl6 mouse melanoma cell cultures to Thomas-EMF, inhibiting their proliferation by 45±6% after 5 days. This suggests that combating electromagnetic fields with traditional radiation therapy might enhance treatment efficiency more.[23] Research has already begun on how to better enhance the treatment efficiency, exploring the impacts of electromagnetic radiation effects on cell proliferation, apoptosis, genotoxicity, and cytoskeleton status.[24]

Conclusion

Sound waves, and specifically the sound waves produced by the languages we speak, and electromagnetic waves both equally affect our cells at the molecular level, being able to change their functions, proliferation, and more. However, not a lot of research has been produced on these, leaving many of my citations and sources to come from places under scientific journals. In order to understand more about this subject, more research has to be done directly into these areas of science. Even with the little research done though, scientists have still found multiple interesting discoveries, being able to change the future of music therapy or radiation therapy through the use of sound waves and electromagnetic waves. Doctors can learn how to better their methods in radiation therapy, and use sound therapy to start initiating many of the responses found in these journals in patients cells, specifically proliferation. This makes the research incredibly valuable, as the waves produced can revolutionize modern medicine and technology in general as we know it.

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