DNA Damage Induced by Cell Phone RF Radiation

Purpose

This study is intended to discover any effects of degradation and base pair loss on DNA that cell phone radiofrequency radiation in the LTE band has, using standard gel electrophoresis to measure a difference in DNA molecule length between exposed and non-exposed DNA.

Background

Global cancer rates are increasing, with a projected increase in cancer rates of 61.7% by 2040. This rising rate indicates that there is something changing in terms of exposure to carcinogens, part of which can be attributed to hazardous substances used for manufacturing in industrializing nations and the increase of processed foods in developed nations, along with a complex mix of other factors. The most important part of targeting any disease is prevention, as it usually requires less resources than treatment, often a simple change in behavior in the case of cancer. Prevention is especially important for those who cannot afford treatment, which even after development, can take many years for the price to go down. One potential culprit for the increase of cancer rates is the relatively recent burst of development in new modes of electronic communication, including cell phones, Wi-Fi, and Bluetooth.

Carcinogens function by damaging a cell's DNA, which causes mutation into a cancer cell when it affects one of a few genes called proto-oncogenes, which regulate cellular metabolism. Ionizing electromagnetism starting at a wavelength of 124 nm, in the ultraviolet range, and lower, has enough energy to eject electrons from atoms and ionize them, which disrupts chemical bonds, and can cause damage to DNA that often leads to cancer. LTE communication functions in the microwave-radio band with much lower energy at wavelengths between 0.158 and 0.375 mm, so it cannot ionize atoms. However, DNA is a very complex molecule with a wide range of types of bonds and interactions, which absorb electromagnetic waves differently and may absorb enough energy during exposure to LTE radiation to break, denaturing the molecule. In the case of one type of damage to DNA, base pair deletion, the DNA's polynucleotide chain is broken in half for every nucleotide base lost. This makes the DNA molecules smaller, which would be detected in gel electrophoresis and indicated by an increased distance traveled by the molecules.

The World Health Organization classifies radiofrequency radiation emitted by cell phones in Group 2B, or a potential human carcinogen. If adverse health effects of mobile communication are confirmed, the implication is a worldwide health crisis. As of 2016, 94% of the earth's terrestrial surface is in range of mobile network signals, so most people are continuously exposed. In the case that it is carcinogenic, a safe alternative to modern mobile communication would need to be developed to overhaul the current network.

Hypothesis

It was hypothesized that DNA exposed to LTE radiofrequency radiation would travel a greater distance for DNA exposed to LTE radiofrequency radiation than the control, indicating base pair loss.

Results

Figure 1 - Control - Photo of the gel of unexposed trials.

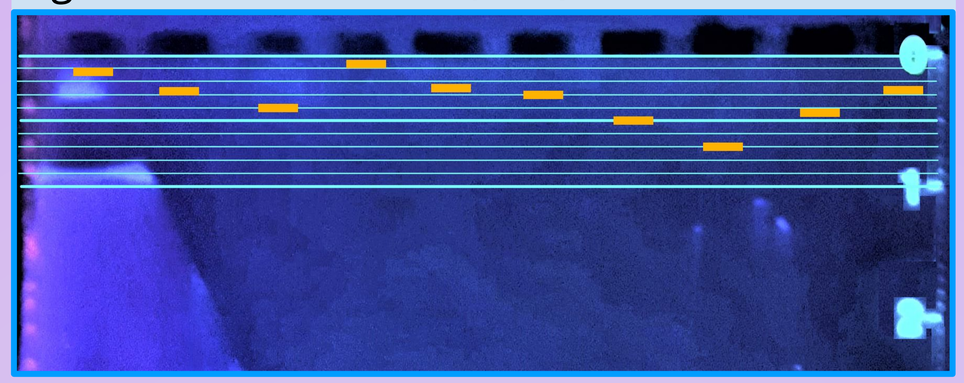


Figure 2 - Control - Length traveled in electrophoresis by unexposed DNA.

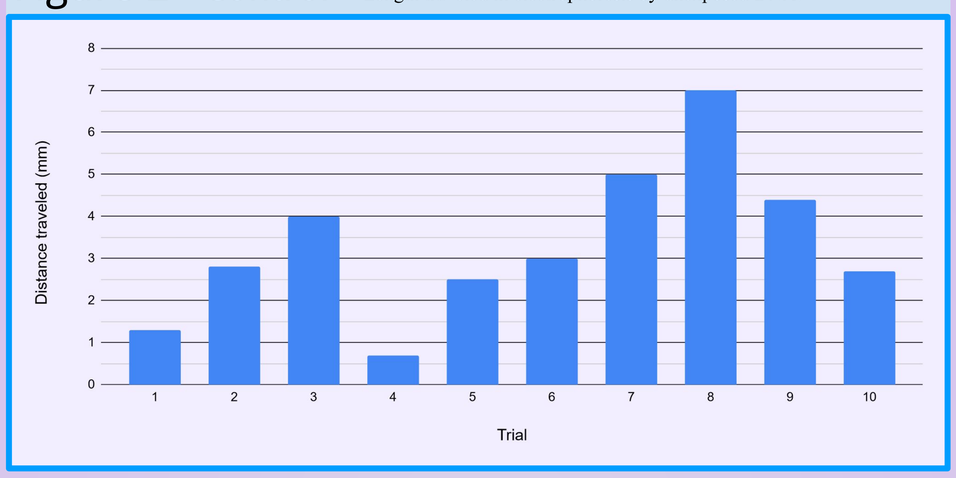


Figure 3 - Exposed - Photo of the gel of exposed trials.

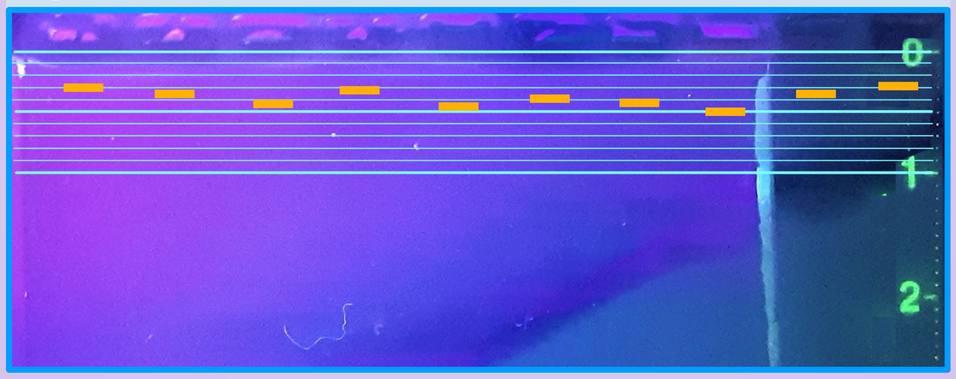


Figure 4 - Exposed - Length traveled in electrophoresis by exposed DNA.

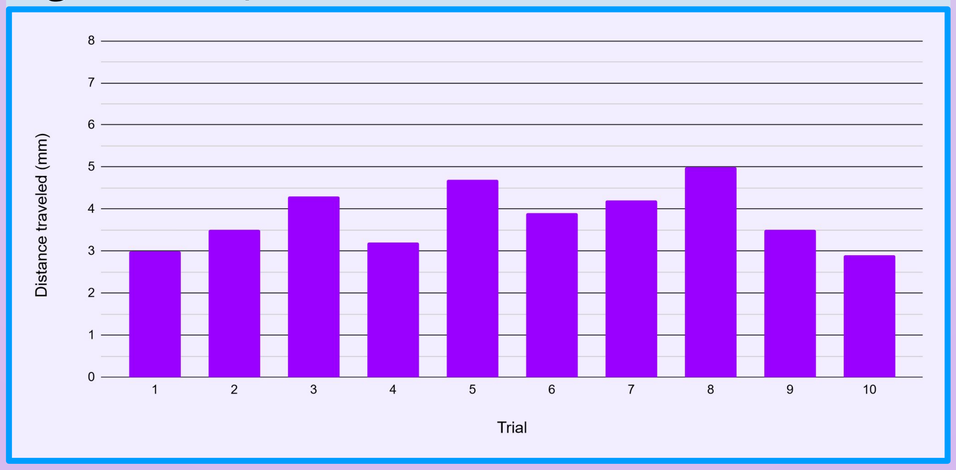
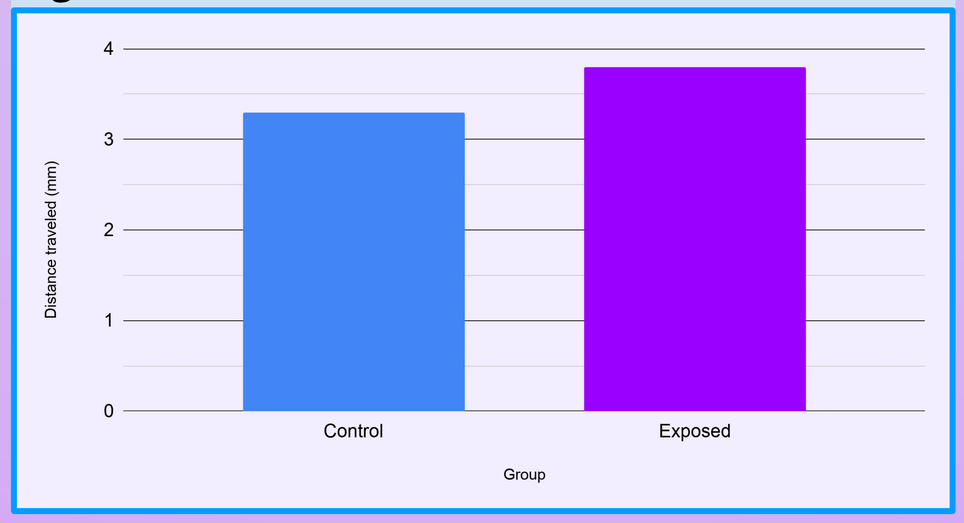


Figure 5 - Comparison of average length traveled in electrophoresis by DNA.



Methodology

A Sierra Wireless SW7588-B LTE module is connected to a PC via ethernet. The device is connected to a power source of less than 0.4 A and between 8 V and 24 V. A Taoglas Maximus antenna connected to the communicator is attached to the inside wall of an incubator set to 37°C, directly over a shelf. The PC is set to never automatically go into sleep mode or turn off the screen. PuTTY is booted on the PC and used to SSH into the device. When the vim text window opens, AT commands are run for AT+WMTXPOWER=0 to prepare the device.

E. coli is swabbed into two 3-mL vials of luria broth. One of the vials is placed in the incubator directly in front of the antenna, 6.25 cm away from it. The other is placed in a different incubator also set to 37°C. An AT command for AT+WMTXPOWER=1, 2, 18600, 160, 4 (On, LTE Band 2, Band 2 Channel, 10 dBm, 15 MHz) is executed on PuTTY to start signal emission. The vials are incubated for a 72-hour period.

A 1% agarose gel of TBE buffer with 2 mL of ethidium bromide per 100 mL of gel is boiled, then set in an electrophoresis mold. After cooling and solidifying, the well rack is removed and TBE buffer is poured over the gel up to the fill line.

A lysis solution is produced by mixing 5 mL of 1 M tris-HCl, 1 mL of 0.5 M EDTA, and 20 mL of 10% SDS solution with 400 mL distilled water, then bringing the volume up to 500 mL with distilled water.

After the 72-hour period, the AT+WMTXPOWER=0 command is executed on PuTTY to end emission. The contents of each vial are centrifuged for 15 minutes to pellet the cells. The supernatant is discarded and 40 µL of lysis solution per 1.5 mL of broth that the pellet came from is added to each pellet. The pellet is pipetted gently through the solution until it dissolves. Small volumes of potassium acetate are added to the solution to precipitate the SDS until new KDS precipitate stops forming. This mixture is centrifuged for 30 minutes to pellet the KDS.

10 25-µL aliquots of the supernatant from the control group are prepared and stained with a dot of tracking dye. 3 µL of ethidium bromide is added to each aliquot. Each aliquot is pipetted into a well in the gel. The electrophoresis apparatus is connected to a 110-V electricity source and left for 30 minutes, after which it is disconnected. A UV light is shined on the gel to view the ethidium bromide-stained DNA and the distance of each band of DNA from the well from which it originated is recorded.

The used gel and TBE buffer are removed from the apparatus and the electrophoresis process is repeated using the DNA extracted from the exposed bacteria.

Conclusion

A one-tailed heteroscedastic *t*-test comparing the control and exposed groups yields a *p*-value of 0.2284, which is greater than the α-value of 0.05, indicating that the control and experimental groups are likely to be from the same data set. The hypothesis was not supported as there was no statistical significance in the difference between the exposed and unexposed DNA.

All images and charts were produced by the experimenter