

Cell phone radio waves have insufficient energy to damage DNA and cause serious illness - an enduring fallacy

A commentary

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Introduction

It is said that unlike X-rays and gamma-rays, the energy of the electromagnetic radiation* (radio waves) used by cell phones is insufficient to ionise atoms or molecules and therefore cannot damage DNA and cause illnesses such as cancer.

This ancient assertion has been put more explicitly: *radio waves used by cell phones lack the quantum energy to eject electrons from atoms or molecules and therefore cannot cause cancer.*

Both forms of the assertion are a fallacy.

To explain this fallacy, we first need to understand the precise meaning of these statements.

In physics, ionisation refers to the ejection of electrons well away from their parent atom or molecule. The situation is different to that, familiar to chemists, of ions in solution.

X-rays and gamma-rays come in individual wave packets called photons. Each photon has energy, known as its quantum energy. The energy is indeed sufficient to cause ionisation.

Radio waves are ultimately composed of photons and indeed the individual energy of these photons is insufficient to cause ionisation – this is why radio waves are termed *non-ionising radiation*. There is, however, a crucial difference between radio waves and X- and gamma-rays that I will come on to later.

Most known cancer-causing agents (carcinogens) are non-ionising

Here is a simple question: If cell phone radio waves cannot cause cancer *because* they are non-ionising, then how do asbestos particles, cancer viruses and carcinogenic chemicals cause cancer because none of these are ionising in the sense of ionising radiation?

The answer is also simple. Asbestos particles, cancer viruses and carcinogenic chemicals cause cancer by distinct processes and *not* by ionisation.

[I estimate less than 1% of annual cancer deaths in the UK population can be attributed to ionising radiation, such as from radon-induced lung cancer. The rest, if there are attributable causal factor(s), arise from agents or factors that are non-ionising].

So, are there distinct processes by which cell phone radio waves could cause cancer? The answer is yes as I will explain in more detail later.

But first, a little more about the action of ionising radiation in biology.

Historically, it was known that when biological cells were irradiated by X- or gamma-rays this resulted in differences in chromosome structure, indicative of DNA damage, which was visible under the microscope. The 1946 textbook by D E Lea traces the history of these findings. The DNA damage was not observed directly at the time of irradiation of the cells, rather later when the cells were dividing and individual chromosomes were visible.

The differences in chromosome structure were initially termed *changes in chromosome architecture*. Later, the term chromosome *breakage* was introduced and therefore the idea that the chromosomes, and hence the DNA had been *broken* by the radiation. Furthermore, the sites of these chromosome breaks were assumed to correspond to the actual points where radiation hit the DNA.

The Bystander Effect.

The above concepts became established in radiobiology and endured for 50 years.

Then, in 1992 scientists at Harvard, USA, found that cells that had not been irradiated with ionising radiation but were in the vicinity of those that had, exhibited the same chromosome damage as the irradiated cells. This profound observation was quickly confirmed by others, indeed the effect was also found in cells grown in the same culture medium as irradiated cells, but had never been anywhere near the irradiated cells or the actual radiation.

These findings, since termed *The Bystander Effect* showed that direct damage, such as that by ionising radiation, is not required to induce DNA damage in cells. The effect has since been shown with genotoxic chemicals, metals and nano-particles.

Genomic Instability, ionising radiation and magnetic fields

Also in 1992, scientists at the former UK MRC Radiobiology Unit at Chilton, exposed blood cells to ionising (alpha-particle) radiation. Instead of looking at the first cell division, the authors waited 10 – 15 cell divisions, after which a miscellany of radiation damage appeared. This observation, known as *Genomic Instability* has since been confirmed with both ionising radiation and chemical agents. Genomic Instability has since been recognised as a hallmark of cancer progression.

Together, the *Bystander Effect* and *Genomic Instability* have transformed our understanding of radiation biology away from direct quantum energy 'hit-effects' towards complex ongoing 'cellular responses' shared by DNA damaging agents in general, including magnetic fields.

In 2014, scientists at the University of Eastern Finland, using human neuroblastoma cells, demonstrated that *magnetic fields** also engender Genomic Instability, a finding that has been replicated.

This is a profound observation. While the magnetic fields were of the type associated with powerlines and our electricity supply rather than the specific magnetic component of electromagnetic radiation (radio waves), they demonstrate that **in this regard magnetic fields behave just like any other carcinogen.**

So how might cell phone radio waves damage DNA?

To reiterate, the individual energy of radio wave photons is insufficient to cause ionisation. However, this argument confuses what is called "*Quantum Physics*" from the traditional "*Classical Physics*".

X-rays or gamma-rays tend in practice to be well spaced out so that their ionising action is that of a single photon. In complete contrast, a magnetic field associated with for example a typical cell phone consists of a rather massive number of photons (in technical terminology around $1e+20$ of them per cubic wavelength). As such, we are not concerned with the energy of *individual photons*, rather the *coherent energy* of the whole group. Such energy far exceeds the individual "quantum" energy. The technical aspects of this basic flaw in the "quantum energy" argument have been discussed by Dr William Bruno, Los Alamos, USA.

The Radical Pair Mechanism of magnetic field interaction with biological systems.

The *Radical Pair Mechanism* or RPM is deeply rooted in basic physics and chemistry. Its home is in so-called spin chemistry, originating in the 1960s. However, the concepts involved date from the late 19th Century and the discovery of the Zeeman Effect in 1896 for which Pieter Zeeman was awarded the Nobel Prize in 1902.

The RPM is the process by which low intensity magnetic fields can alter the spin state of pairs of free radicals from the so-called short-lived singlet state (nano-second lifetime) to the so-called longer-lived (micro-second lifetime) triplet state making them more available to cause biological damage. The process operates at energy levels *some ten million times lower than thermal energies*. It has been widely discussed in chemical and biological systems and in the context of human health.

The RPM has been particularly successful in offering a mechanism to explain the action of the magnetic compass in animals, for example the ability of birds, other species including potentially humans, to detect tiny changes in the Earth's magnetic field for navigation and migration. The process is believed to act via cryptochrome protein molecules in the eye. Such molecules including those in humans have been shown to be magneto-sensitive.

The experimental evidence supporting the role of the RPM in magneto-reception lies in the ability of magnetic fields in the radio wave band to disrupt animal compass orientation. Of particular interest here are the observations by scientists at the University of Oldenburg, Germany that ambient electromagnetic radiation from nearby radio transmitters disrupts the orientation of migratory birds in captivity.

Summary

The idea that since cell phone radio waves do not have the quantum energy to damage DNA and therefore cannot cause ill health is a fallacy. It is flawed at a number of levels, from the very physics upon which it is supposedly based, to chemistry and biology. Most of all, the idea is not born out by the tens of thousands of peer-reviewed studies reporting biological

effects from exposure to electric, magnetic and electromagnetic fields and electromagnetic radiation, including those associated with radio wave frequencies used by cell phones.

*Explanation of technical terms

- In simple terms, *electromagnetic radiation* consists of electric and magnetic waves which are intrinsically linked and which travel through the air at the speed of light. Radio waves including those used by cell phones, visible light, X- and gamma-rays are all forms of electromagnetic radiation and are part of the *electromagnetic spectrum*.
- A *magnetic field* is an area where one can experience a magnetic force, for example around a fridge magnet. Similarly, an *electric field* is an area where one can experience an electric force, for example one created by static electric charge. Electric and magnetic fields exist around powerlines (where in essence they exist separately) without radiating away from the powerline.
- So what is the difference between *electromagnetic fields* (EMF) and *electromagnetic radiation* (EMR)? Let's start with the magnetic field around a bar magnet sitting on a table. The magnetic field is stationary, it does not move. Now wave the magnet around. The associated magnetic field is now also moving around. In doing so, it radiates into the air. So does a moving electric field. A radiating magnetic field will generate an associated radiating electric field and *vice versa*, hence electromagnetic radiation. Importantly, the electric and magnetic fields around powerlines while they are changing 50 times per second in the UK and Europe and 60 times per second in the USA, this is too slow to result in any meaningful electromagnetic radiation from powerlines. Indeed, if there were such radiation, the powerline would be acting as an aerial transmitting power into the air rather than down the powerline!

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