

Feature Article

Wi-Fi Safety Questioned

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Scientists in the UK at the Health Protection Agency (HPA) recently completed a research project on wireless local area networks (WLAN). The HPA issued a press release which was reported by Medical News Today on September 15, 2009. Dr Simon Mann presented the team's findings and is quoted as saying, "Our findings are consistent with the HPA position that exposures to the radio waves from Wi-Fi equipment are expected to be well within internationally-accepted exposure guidelines and less than levels from mobile phones."

Simon's statement is designed to elicit the belief that Wi-Fi is safe, yet being within some randomly set exposure guideline does not in any way guarantee safety or lack of human health effects. Andrew Goldsworthy BSc PhD, a retired lecturer in biology at the Imperial College London explains why.

Comments by Andrew Goldsworthy on September 20, 2009

The following quote from the notes to editors is muddled and deeply misleading.



“There is no **consistent** evidence to date that exposure to RF signals from Wi-Fi and WLANs adversely affect the health of the general population”.

It is muddled because it confuses two completely separate issues.

1. Is there any evidence that Wi-Fi is harmful to health?

The answer to this is **DEFINITELY YES**.

2. Is the whole population affected?

The answer to this is **SEEMINGLY NOT**.

It is misleading because it is written in such a way as to imply that Wi-Fi is safe for EVERYONE and there is no reason why it should not be used universally in schools. What about the health of the students and staff who are affected? Do they not care?

The use of the word “consistent” in the quote is also worrying since it suggests that physicists and engineers, possibly from the mobile phone and Wi-Fi industries, rather than biologists and health experts, are in control.

No trained biologist or medical practitioner would ever expect the same level of consistency from experiments with complex living organisms as is possible with simple physical systems.

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Apart from identical twins, each one of us is genetically and physiologically unique and we do not all respond in the same way to metabolic insults. Not everyone who smokes dies of cancer, and we do not all suffer the same side effects from taking a medicinal drug. Even the same person may not be equally susceptible all of the time. For example, if we are ill, our resistance to further infections is usually lowered. Anyone who says that we must all show the same response to electromagnetic radiation before its effects can be regarded as real must have a very limited knowledge of biology. They are certainly not qualified to sit in judgement on important health issues that are likely to affect billions of people worldwide, let alone the health of unsuspecting UK school children and staff who have no choice.

Not Every Country Agrees On The Safety Guidelines

The press release is also misleading when it says that the electromagnetic radiation from wireless laptops and mobile phones fall within internationally agreed Safety Guidelines. It says nothing about the fact that **THESE**

**GUIDELINES ARE NOT UNIVER-
SALLY AGREED** and many other countries such as **Russia, China, Italy, Switzerland and the USA** (i.e. much of the industrialised world) are much more cautious than the UK, and set their safety limits between ten and one thousand times lower (www.bioinitiative.org).

These Guidelines Do Not Include Non-Thermal Effects

The guidelines that the UK Health Protection Agency refers to are based on those proposed by ICNIRP, using research that is at least a decade out of date. In particular, they make the assumption that the only way that non-ionising radiation can damage living cells is due to its heating effect. They do not include the direct electrical effects on cell membranes, which can occur at radiation levels that are hundreds or even thousands of times lower.

It Just Should Not Have Happened

Many of these *non-thermal* effects are catalogued in the Bioinitiative Report, which was drawn up by a team of expert scientists in 2007. They examined over two thousand peer-reviewed scientific papers on the effects of non-ionising radiation and found that over two thirds of them showed some sort of biological effect that could not be explained by heating (www.bioinitiative.org). Not all were directly concerned with health, but if the ICNIRP guidelines were valid, none of them should ever have occurred. We cannot therefore assume that radiation that falls within the ICNIRP guidelines is necessarily safe.



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What Causes These Non-Thermal Electrical Effects?

Most of the non-thermal effects of electromagnetic radiation can be explained in terms of the leakage of cell membranes following the electromagnetic removal of structurally important calcium ions. It has been known since the work of Suzanne Bawin and her co-workers in 1975 (Bawin *et al.* 1975. *Ann. N.Y. Acad Sci*, **247**: 74-81) that otherwise harmless radio waves could remove calcium ions from brain cell membranes when they were amplitude modulated at a low frequency; i.e. when the strength of the radio signal rose and fell in time with the low frequency. These experiments have been repeated many times and also with other tissues such as heart muscle (For a review, see Blackman 2009. *Pathophysiology*, **16**: 205-216).

The general conclusion from these and many similar experiments is that low frequency electromagnetic fields, or radio waves that are amplitude modulated at a low frequency, can remove calcium ions from the membranes of some but not all kinds of living cells. Pulses are more effective than sine waves, possibly because their sharp rise and fall times are more effective at jerking the calcium away from the membrane and also allow more time for it to be replaced by other ions before the field reverses. Pulses carried by microwaves should be particularly effective because the high frequency of the carrier permits faster rise and fall times for the pulses.

The Mechanism Of Calcium Removal

Living tissues can absorb non-ionising radiation and convert it into alternating electric currents, just like the antenna of a radio set. The only real difference is that, in living tissues, these currents are carried by ions (electrically charged atoms and molecules) rather than electrons. When these currents impinge on cell membranes, which are normally negatively charged, they vibrate like miniature loudspeakers in time with the signal. This loosens some of the positive ions bound to them since they are driven in the opposite direction.

If the signal is strong, all the ions bounce on and off the membrane more or less equally, but if the signal is weak, only the more strongly charged ions, such as calcium (which has a double charge) are pulled off. Ions with only one charge, such as potassium then take their place. Very little energy is needed, since the ions have only to be moved by molecular dimensions and the effect is simply to change the natural chemical equilibrium between the different ions bound to the membrane. However, the effect can be devastating.

Only Weak Signals Do This

Only weak signals can **selectively** remove calcium in this way. Even then, it can only occur in narrow ranges of signal strength called *amplitude windows*, above and below which there is little or no effect. The exact positions of these windows are indeterminate since they depend on the nature of the membrane, the availability of other ions to replace the calcium and how well the tissue is acting as an antenna.



“Many of the so-called “modern illnesses” that have increased... can be linked to cell membrane leakage due to.. non-ionising electromagnetic radiation.”

Cells Are Constantly Moving In And Out Of Their Windows.

Living tissues are dynamic systems and their characteristics, including their electrical characteristics, are constantly changing, which means that they will not always be equally efficient as antennas. Also, as we go about our daily business, our exposure to electromagnetic fields and our orientation to them are constantly changing so that individual cells may not stay long enough in their windows to do significant harm.

However, all this changes when the source and orientation of the field is constant, such as when using a mobile phone or sleeping near a base station. Some cells may then be in their windows for long enough to do significant damage. The important thing to note is that any assertion that Wi-Fi and mobile phones must be safer than other forms of electromagnetic radiation just because the signal is weaker is both false and dangerous. Mobile phones and Wi-Fi laptops, by leaving individual cells for prolonged periods in their amplitude windows may do more damage than general electromagnetic pollution. Under some circumstances, a weaker signal may even drive more cells into their amplitude windows and make matters worse.

How Calcium Loss Makes Cell Membranes Leak

The calcium ions lost due to electromagnetic exposure were important. Because they have a double charge they

have an especially strong attraction to the negatively charged membrane components on either side and bind them together just as mortar binds together the bricks in a wall. However, the ions with only one charge that replace them do this less well, so the membrane may now develop temporary pores and leak. This leakage can then cause all sorts of harmful effects.

The Biological Effects Of Membrane Leakage

Many of the so-called “modern illnesses” that have increased, sometimes dramatically, in the last few decades can be linked to cell membrane leakage due to our increasing exposure to non-ionising electromagnetic radiation. More details of these, together with journal references, can be found at <http://tinyurl.com/5ru6e6> but I will outline a selection of them here.

Electromagnetic hypersensitivity (EHS)

Electromagnetic hypersensitivity is a condition in which people experience physical symptoms such as rashes and/or a wide range of unpleasant sensory disturbances during or shortly after exposure to electromagnetic fields. It can develop in previously healthy people after prolonged exposure and appears to be largely irreversible. It was first noticed in radar technicians, when it was called microwave sickness, but it has increased dramatically in recent years in the general population. About three percent of the population are now affected in this way, and its incidence often appears to be associated with prolonged exposure to microwave based telecommunications.



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Virtually all of the symptoms can be explained by electromagnetically-induced cell membrane leakage. Sufferers are characterised by already having unusually leaky cell membranes as measured by skin conductance. This makes them more prone to the consequences of additional electromagnetically-induced leakage. When their skin cells leak, it can result in inflammation and rashes. When their sensory cells leak, it can result in numerous unpleasant sensory disturbances.

We all have many different kinds of sensory cells, but they all work by “deliberately” leaking ions through their membranes when they sense whatever they are programmed to sense. This reduces the natural voltage across their external membranes, which in turn triggers the release of neurotransmitters that stimulate neighbouring nerve cells to send signals to the brain. Unscheduled leakage due to electromagnetic exposure can therefore trigger false sensations such as pins and needles, heat, pain and pressure, depending on which cells are most affected. When the hair cells of the inner ear are affected, it can cause tinnitus, which is a false sensation of sound. When it affects those concerned with balance, it can cause dizziness and trigger symptoms of motion sickness, including nausea. Prolonged exposure to the radiation seems to damage these cells permanently so they become even more inclined to leak and the person becomes sensitised for life.

Brain Hyperactivity

When cells of the brain and nervous system leak, free calcium ions can enter the neurons from outside. In normal circumstances, neurons require a “deliberate” brief inflow of calcium ions to trigger the release of neurotransmitters so that they can send signals to neighbouring neurons. Unscheduled steady calcium inflow due to electromagnetic radiation makes them more likely to release neurotransmitters, some of which will send false messages. This in turn can trigger brain hyperactivity leading, amongst other things, to sleep disturbances, loss of concentration (giving rise to ADHD) and stress headaches.

Autism

Electromagnetically-induced brain hyperactivity and confused thought during early childhood may cause autism (which has gone up 60-fold in the last thirty years). Basic social skills are learnt during the first 18-months of life, after which they become hard-wired into the child’s psyche by pruning under-used synapses. This enables them to become automatic and require very little thought. However, this mass cull of under-used synapses is a normal stage in development that occurs only once at around 18 months. If the initial learning process has been disrupted by brain hyperactivity, many social skills may remain poorly learnt by the time the synapses are pruned, and the child may become irreversibly autistic. Babies exposed to the radiation from cordless baby monitors may be particularly at risk but this has not been tested.



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Dementia

Dementia in the elderly also seems to be on the increase, and some of it can be attributed to electromagnetic exposure. Salford and co-workers (Salford *et al.* 2003. *Environmental Health Perspectives III*: 881-883) showed that extremely weak electromagnetic radiation such as that from mobile phones could disrupt the blood-brain barrier and allow unwanted materials, such as albumin from the blood stream to enter and kill neurones. Although the effect may not be immediately noticeable, prolonged exposure is likely to lead to early dementia.

Allergies

All of our body surfaces, both inside and out, are normally protected from unwanted materials entering by barriers similar to the blood-brain barrier, where the gaps between the cells are sealed, forming what are known as *tight junctions*. There is strong evidence that these too leak in response to weak electromagnetic radiation, which would allow the more rapid entry of allergens, foreign chemicals and other unwanted materials. This may account for the massive increases in asthma, aller-

gies and multiple chemical sensitivities that have accompanied our increasing exposures to electromagnetic radiation in recent years.

Autoimmune Diseases

These include type-1 diabe-

tes, multiple sclerosis and celiac disease, all of which are on the increase. This has been attributed to an increased leakiness of the gut barrier (also known as leaky gut syndrome) and may be exacerbated by electromagnetic exposure. It allows particles of partially digested food to enter the bloodstream. From there, they may be engulfed by body cells by endocytosis, followed by an attempt to digest them internally. However, some materials, e.g. gluten, are difficult to digest and may be mistaken for a virus. The cell responds by displaying it on its surface, which identifies it to the white blood cells of the immune system as a cell that must be killed to prevent the spread of the “infection”. This triggers inflammation, which is both painful and attracts more white blood cells to the area, which may make matters worse and results in the death of perfectly healthy cells. Celiac disease is an autoimmune response, triggered by gluten, which causes inflammation of the gut, but autoimmune diseases in other parts of the body may have a similar aetiology.

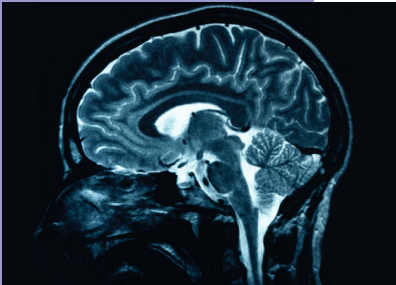
Effects On Internal Membranes And DNA

There are at least two mechanisms by which the leakage of the cell’s internal membranes can damage DNA. Living cells are divided into various internal compartments by membranes that are all variations of the same basic structure as the outer membrane. From our standpoint, the two most important compartments are the *lysosomes* and the *mitochondria*.



The lysosomes are membrane-bound structures full of digestive enzymes that digest cellular waste ready for recycling. Membrane leakage here releases these enzymes, which can digest and damage the rest of the cell, including its DNA.

The mitochondria are the cell's power stations. They carry out the controlled oxidation of materials derived from our food to generate ATP, which is the main energy currency of the cell. This oxidation actually goes on in groups of enzymes embedded in their membranes and involves highly reactive chemicals called free radicals. Damage to these membranes is likely to release of some of these free radicals that can then react with and destroy other cellular components, including DNA. It's like blowing up a furnace scattering burning embers everywhere.



There is even some similarity to blowing up a nuclear power station since, although no radioactivity is involved, the free radicals that are normally locked safely away in the mitochondrial membranes, have very similar activities to those that do most of the damage when a cell is irradiated with gamma rays. Indeed, many concerned scientists have noted the similarity between the biological effects of non-ionising radiation and gamma rays. Non-ionising radiation should therefore be treated with as much caution as ionising radiation until much more is known about its biological effects.

Brain Cancer

DNA damage has been found in many experiments in many laboratories

when cultured cells have been exposed to mobile phone radiation, even for less than a day (see www.bioinitiative.org). It can therefore account for the brain and other head cancers that we are now beginning to see in people who have been heavy users of mobile phones for ten years or more; with children being at greatest risk (Hardell *et al.* 2009 *Pathophysiology* **16**: 113-122).

Thyroid Cancer

There has also been an unexplained increase in thyroid cancer in recent years (the thyroid gland is in the neck; just inches from where you hold your mobile phone) and may have a similar aetiology to brain cancer.

Mobile phones may make you fat

Another consequence of DNA damage is a partial loss of function in the exposed organ. For example, Rajkovic and co-workers (Rajkovic *et al.* 2003 *Tissue & Cell* **35**: 223–231) showed that exposing rats to power line frequencies for over three months caused a seemingly permanent loss of thyroid function. If this were to occur in humans as a result of the radiation from wireless telecommunications, we would expect to see widespread symptoms of hypothyroidism, which include fatigue, loss of muscle tone and obesity. It may be no coincidence that about thirty percent of our population is now either overweight or clinically obese (with all the extra risks to health that this implies) and the number of teenagers on anti-obesity drugs has gone up 15-fold in the ten years since the use of mobile phones, DECT cordless phones and Wi-Fi became almost universal.

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Effects on Fertility

There have been several studies showing that mobile phone use reduces male fertility. One of the more recent, by Agarwal and co-workers (Agarwal *et al.* 2008 *Fertil Steril* **89**: 124-8) showed that using a mobile phone for more than four hours a day caused a reduction in sperm numbers, motility and viability, each of around 25 percent. The prolonged use of a Wi-Fi laptop computer on or near the lap could have even more serious consequences for male fertility. Effects on female fertility have not yet been studied but, since all the eggs that a woman will ever have were already in her ovaries before she was born, the cumulative effect could be considerable. All of these effects can be attributed to electromagnetic DNA damage, which could also lead to miscarriages, deformities in the offspring and genetic mutations that may not appear for several generations. Anyone who considers Wi-Fi to be safe should think again.

On The Brighter Side

We do not have to abandon mobile telecommunications; all we have to do is make them safer by a wiser use of technology that takes into account the vagaries of biological systems. The

problems that arise are not due to the heating effect of the radiation. Instead, they are largely due to the way in which the radio signals are modulated

to carry information (Blackman 2009. *Pathophysiology*, **16**: 205-216). This makes them much easier to solve just by changing the way in which the signals are encoded. In particular, we need to remove all vestiges of low frequency amplitude modulation or anything that might be perceived by a cell (or a simple diode) as low frequency amplitude modulation.

It is well established that low frequency electromagnetic fields, including those from power lines, can have adverse biological effects. It is also clear that living cells can demodulate amplitude modulated radio signals (including microwaves) to extract the biologically-active low frequencies. Little work has been done on how they do this, but the most plausible mechanism is that the countless ion channels that pierce virtually all cell membranes act as electrically-biased point-contact diodes capable of rectifying and therefore demodulating the signals. The normal voltage across a typical 10nm-thick cell membrane is of the order of 100mV, giving a voltage gradient of around ten million volts per metre. This should provide adequate bias.

An interesting example of this effect can be found at <http://tinyurl.com/m4u75o>, where you can see and hear a complete radio set constructed from a single carbon nanotube of similar diameter to a cellular ion channel. It is capable of amplifying and demodulating radio signals even at microwave frequencies. If the analogy with the living cell is valid, the extracted, and possibly amplified, low frequency components would appear across the cell membrane where they could do most damage.



Sources Of Low Frequency Amplitude Modulation

In the case of digital transmissions, the equivalent of low frequency amplitude modulation may arise from low frequency beacons, traffic where individual packets of information are transmitted separated by long gaps, and frequency hopping where reflections may give different cancellation effects at different frequencies.

Perhaps all we need do is to take a lesson from DNA, where the gaps between genes are filled with DNA that codes for nothing, with the beginning and end of each gene denoted by a special coding sequence. In the case of digital communications, if we can fill the gaps between transmitted pulses and packets with code that the receiver

is programmed to recognise as blank spaces, but still look to a cell as if it were a continuous transmission, we may be well on the way to achieving a relatively safe means of wireless telecommunication.

One wonders why this sort of research is not already under way.

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Reference

Scientist probe laptops Wi-Fi Emissions. Medical News Today. 15 Sep 2009 - 20:00 PDT. Retrieved on October 18, 2009 from: <http://www.medicalnewstoday.com/articles/163988.php>



Andrew Goldsworthy was born in 1939. After a conventional Grammar School education he obtained a First Class Honors Degree in Botany followed by a PhD for research into plant physiology and biochemistry at the University of Wales. He went on to lecture at Imperial College London, where he spent the rest of his career. He has had many teaching and research interests, ranging from the biochemistry of photorespiration to the biology of space flight. He retired in 2004 but remains as an honorary lecturer. He was also a scientific advisor to the European Space Agency and is currently a scientific advisor to several European charities concerned with the environment and electromagnetic fields, including the Bio Electromagnetic Research Initiative, the Radiation Research Trust, and Electrosensitivity-UK. He has always had a strong interest in how living organisms use internally-generated electric currents to control their growth and metabolism, and in their disruption by externally-applied currents and fields. In his retirement, he pieced together nuggets of information from a wide range of scientific journals and created simple layperson's explanations of how weak electromagnetic fields affect us all. Some of these can be found on the www.bemri.org website at: <http://tinyurl.com/L7dbps>, which corresponds to <http://bemri.org/archive/hese-uk/en/niemr/resonance1.php>.