

## A need for accurate information from PHE and AGNIR

- **Public Health England (PHE)/Health Protection Agency (HPA) has failed to inform that wireless computers can expose the users to electromagnetic fields as high as from mobile phones when close to the body.**
- **PHE/HPA failed to mention that studies have reported adverse biological or health effects of Wi-Fi and similar wireless signals. Schools, organisations and individuals are thus unable to make informed decisions.**
- **PHE/HPA has said that adults should be able to make their own choices about reducing their radiofrequency exposure should they so wish, but be able to do so from an informed position (PHE website, 1<sup>st</sup> December 2013). Their advice to schools on Wi-Fi and their failure to speak out about the use of mobile phones by children in schools has prevented children and parents from reducing their exposures in the school environment.**

### UK Organisations associated with the International EMF Alliance

We would like PHE to state that wireless computers can expose users to as high exposures as mobile phones, but for much longer periods of time.

We would like the same warnings for children and their use of wireless computers as exists for mobile phones: that children under the age of 16 should use them for essential purposes only (UK Chief Medical Officers). We would also like this guidance to be publicised and upheld.

We would like statements and assessments of the science, from AGNIR and PHE, to be accurate, honest, up-to-date and to include all available studies. We would like conclusions made to actually reflect the scientific evidence.

We would like the people involved in the 'independent' advisory group AGNIR to be independent from ICNIRP, the group whose guidelines they are assessing. Three people currently in AGNIR are also members of ICNIRP. We would like AGNIR to be independent of PHE/Department of Health (DH), the groups to whom they are reporting. Currently 50% of the people involved in AGNIR work for PHE/DH.

We would like children to be able to attend school without involuntary microwave radiofrequency exposures to Wi-Fi signals from access points, Wi-Fi-enabled computers and other wireless devices, mobile phones or smart meters. Children have a right to an education and a right not to be harmed; there is a legal duty for schools to provide a safe environment.

Evidence is described on pages 2-5, with supporting references and information in Appendices 1-4.

## **Evidence:**

### **Inaccurate statements about exposures from mobile phones and Wi-Fi-enabled computers:**

PHE/HPA has stated “Based on current knowledge and experience, radio frequency (RF) exposures from wi-fi are likely to be lower than those from mobile phones” (PHE document ‘Wi-fi radio waves and health’ 1<sup>st</sup> November 2013).

“Exposures from devices held further away from the body such as wireless-enabled laptop computers, ... are very much lower than those from mobile phones and community or individual measures to reduce exposures are not necessary.” (HPA Response to the 2012 AGNIR Report on the Health Effects from Radiofrequency Electromagnetic Fields, 1st April 2012).

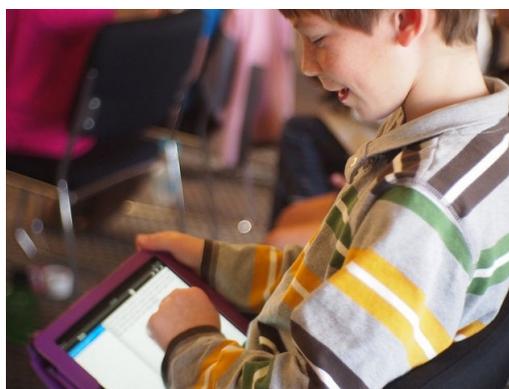
However, microwave radiation absorbed from tablet computers (Wi-Fi) positioned close to the body can be similar to that from mobile phones as they have similar maximum specific absorption rate (SAR) values.

Average maximum SAR for a sample of 358 digital mobile phones is **1.02 W/Kg in 1g tissue** (sarvalues.com; adult); iPad maximum SAR on Wi-Fi is **1.19 W/Kg in 1g tissue** (iPad Information Guide; adult). Thus, wireless computers positioned close to the body could expose the users to similar levels of radiation as mobile phones. PHE/HPA has stated that people use wireless computers away from the body (above). But in reality they can be used very close to or on the body, with fingers touching the screen, for prolonged periods of time. The pictures below illustrate how close children are to tablet computers when they use them in schools.



The abdomen and reproductive organs do not have the increased bone protection which the skull provides, thus we can expect more radiation to be absorbed into abdominal, breast and reproductive organs than from mobile phones into the brain.

The HPA measured electromagnetic fields from wireless laptops at a distance of 0.5m and 1m from the computers. Children do not use wireless computers at 1m, or even 0.5m away from their bodies, as their arms are not long enough. Statements of safety are therefore not based on current



exposures experienced by children in schools.

UK Chief Medical Officers advise children to use mobiles for essential purposes only. Given that wireless computers are used very close to the body and absorption rates can be at least as high as for mobile phones, it seems reasonable to expect similar warnings as exist for mobile phones to be made for wireless computers.

The current guidance about mobile phone use by children (Chief Medical Officers) has not been well publicised, leading to the majority of the population being unaware of it. If the Chief Medical Officers offer advice, it needs to be publicised and upheld. When schools buy mobile phones for children to use in lessons, or let children use them in schools, the Department of Health needs to speak out to support their own advice.

Studies have found significantly increased risks of cancer from mobile and cordless phone use, including greater risks for those who started using them under the age of 20 (see accompanying document '2B Classification'). **Risks are comparable to those found for smoking and lung cancer, after similar periods of time since first use** (document '2B Classification'). Use of wireless/tablet computers held close to or on the body may be expected to also increase the risk of cancer, given the similar SAR values for mobile phones and tablet computers as well as evidence of damage to DNA and increased oxidative stress from Wi-Fi/2.4GHz signals ('2B Classification' document).

PHE only acknowledge the heating effects of radiofrequency fields and thus consider average exposures over time, as an indication of energy which may cause heating. However, a large number of studies now demonstrate effects of radiofrequency radiation below the values considered to cause heating (i.e. non-thermal effects). When signals alter rapid physiological and chemical processes in the body, we need to look at the maximum field exposures over short periods of time and not just the average, when investigating safety.

### **AGNIR 2012 report was not comprehensive**

AGNIR advise PHE/HPA on the safety of radiofrequency radiation.

PHE/HPA responded to the 2012 report from AGNIR with "The Health Protection Agency welcomes this comprehensive and critical review of scientific studies prepared by the independent Advisory Group on Non-Ionising Radiation (AGNIR)" (Health Protection Agency response to the 2012 AGNIR report on the health effects from radiofrequency electromagnetic fields, 1<sup>st</sup> April 2012; emphasis added).

However the report was not comprehensive, as it left out a large number of studies (none of the papers listed in Appendix 1 were included in the report; Appendices 2 and 3 describe some of the papers omitted).

### **AGNIR is not independent: conflicts of Interest**

The quote above from PHE/HPA describes AGNIR as an **independent** advisory group. They have said "AGNIR's main conclusion is that, although a substantial amount of research has been conducted in

this area, there is no convincing evidence that RF field exposures below guideline levels cause health effects in adults or children. These “guideline levels” are those of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which already form the basis of public health protection in the UK and in many other countries. Therefore, a recommendation to follow the ICNIRP guidelines will remain central to HPA’s advice on exposures to RF fields.” (Health Protection Agency response to the 2012 AGNIR report on the health effects from radiofrequency electromagnetic fields, 1<sup>st</sup> April 2012).

For a group to be independent, one would expect the members to be separate from the people who set the guidelines which the group is assessing. One outcome of the AGNIR report was that PHE/HPA recommended that the UK continue to follow the ICNIRP guideline values. However, several of the members of AGNIR are also members of ICNIRP. It is therefore not surprising that AGNIR decided that the ICNIRP guideline values, which they were part of setting and supporting, were still valid. AGNIR is not an independent group if any of its members are also part of the group whose guidelines they are assessing. AGNIR needs to be made up of scientists who are not members of ICNIRP.

AGNIR is also not independent of PHE/DH, the group to whom they are reporting. Currently 50% (8/16) of the people involved in AGNIR (consultant, representatives, observer, and secretariat) work for PHE/DH. A group cannot provide independent advice when half of the people represented are employed by the government and are the ones to whom you need to report your findings. It is not surprising that HPA/PHE were pleased with the AGNIR report, when they were so closely involved in it.

The Government clearly benefits financially from the wireless communications industry. An independent group must not have government employees contributing to the group’s reports.

#### **AGNIR 2012 report and PHE statements are misleading and inaccurate**

AGNIR 2012 concluded “studies provide no evidence of health effects of RF field exposures below internationally accepted guideline levels” (page 3). It also stated “the literature provides no substantial evidence of such effects, in particular in relation to ... reproductive effects” (page 4) and “there has been no consistent evidence of effects on ... fertility and reproductive function” (page 3).

These are astonishing and inaccurate conclusions given the large number of studies now published demonstrating damaging effects of radiofrequency radiation. In the report, 75% of the studies on male fertility (15/20; retracted papers not counted here) found damage to sperm or decreased measures of male fertility. Many papers were left out (Appendix 2). Overall, from 2003 - June 2014, 84% of studies (61/73) on male fertility and radiofrequency radiation exposures have found damaging effects on sperm, male reproductive organs or hormones (listed in Appendix 2). That is not ‘no evidence’ or ‘no substantial evidence’.

72% (18/25) of the studies in the report on oxidative stress and radiofrequency radiation found significantly increased oxidative stress (listed in Appendix 3). Many more studies were left out. 83% (39/47) of oxidative stress studies in the report, plus those which were left out, described evidence

for increased oxidative stress (listed in Appendix 3). Oxidative stress can lead to damage to DNA, RNA and cell membranes and can lead to cancer; it is known to damage fertility and other normal physiological processes.

By separating out evidence throughout the report, omitting a large number of papers and not accurately reflecting the science in the summaries and conclusions, the report is misleading those who look to it for an accurate assessment of the evidence.

PHE has stated “They (AGNIR reports) have been a valuable input to HPA advice and have been used in the development of exposure guidelines as well as being widely circulated and used by the UK Government and the devolved administrations” (emphasis added) ( WHO International EMF Project IAC Meeting 06-07 June 2013, Report from Public Health England).

If the AGNIR report has such an important role in advising PHE and the Government on public health and safety, then it needs to be accurate, comprehensive and honest. The evidence presented in this document indicates that it is none of these.

“HPA supports and appreciates this thorough review of the evidence prepared by AGNIR.” (Health Protection Agency response to the 2012 AGNIR report on the health effects from radiofrequency electromagnetic fields, 1<sup>st</sup> April 2012).

#### Wi-Fi studies

PHE/HPA has said “PHE sees no reason why wi-fi should not continue to be used in schools and in other places” (PHE document ‘Wi-fi radio waves and health’, 1<sup>st</sup> November 2013).

The 2B classification of radiofrequency radiation as a possible human carcinogen and increasing evidence published since the classification (see accompanying document ‘2B Classification’) are reasons why it should not be used in schools. The papers listed at the end of this document (Appendix 1) which describe damage to DNA, increased oxidative stress, damage to fertility and pregnancy, changes in brain activity, cardiac arrhythmias and tachycardia in response to Wi-Fi/2.4GHz signals are also reasons why children should not sit next to the transmitters every day. The Wi-Fi papers are supported by a very large body of literature published on effects of mobile phones and similar wireless signals.

Children have the right not to be placed at increased risk of cancer, not to have their DNA damaged, not to have their fertility reduced, not to have their brain development adversely affected, or to be put at increased risk of a cardiac arrest whilst at school. These are forms of physical damage to the body and safeguarding laws should be protecting children from these forms of damage in school and elsewhere. But PHE have not informed schools or the public about the existence of studies which find effects from Wi-Fi/2.4GHz signals. PHE imply that there is no evidence of damaging effects of radiofrequency radiation below guideline values.

PHE has therefore prevented organisations from being able to fulfil their legal responsibilities to protect children, employees and members of the public. PHE has prevented individuals from reducing their microwave exposures if they so wish, from an informed position, by failing to accurately inform and allowing a dramatic increase in involuntary environmental exposures.

## Appendix 1

Some Wi-Fi/2.4GHz studies:

Atasoy H.I. et al, 2013. Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices. *Journal of Pediatric Urology* 9(2): 223-229. <http://www.ncbi.nlm.nih.gov/pubmed/22465825>

Avendaño C. et al, 2012. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. *Fertility and Sterility* 97(1): 39-45. <http://www.ncbi.nlm.nih.gov/pubmed/22112647>

Aynali G. et al, 2013. Modulation of wireless (2.45 GHz)-induced oxidative toxicity in laryngotracheal mucosa of rat by melatonin. *Eur Arch Otorhinolaryngol* 270(5): 1695-1700. <http://www.ncbi.nlm.nih.gov/pubmed/23479077>

Dasdag S. et al, 2014. Effect of long-term exposure of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on testes functions. *Electromagn Biol Med*. Epub ahead of print. <http://www.ncbi.nlm.nih.gov/pubmed/24460421>

Gumral N. et al, 2009. Effects of selenium and L-carnitine on oxidative stress in blood of rat induced by 2.45-GHz radiation from wireless devices. *Biol Trace Elem Res*. 132(1-3): 153-163. <http://www.ncbi.nlm.nih.gov/pubmed/19396408>

Ghazizadeh V. and Naziroglu M., 2014. Electromagnetic radiation (Wi-Fi) and epilepsy induce calcium entry and apoptosis through activation of TRPV1 channel in hippocampus and dorsal root ganglion of rats. *Metab. Brain Dis*. Epub ahead of print. <http://www.ncbi.nlm.nih.gov/pubmed/24792079>

Havas M. et al, 2010. Provocation study using heart rate variability shows microwave radiation from 2.4GHz cordless phone affects autonomic nervous system. *European Journal of Oncology Library Vol.* 5: 273-300. <http://www.icems.eu/papers.htm?f=/c/a/2009/12/15/MNHJ1B49KH.DTL> part 2.

Havas M. and Marrongelle J. 2013. Replication of heart rate variability provocation study with 2.45GHz cordless phone confirms original findings. *Electromagn Biol Med* 32(2): 253-266. <https://www.ncbi.nlm.nih.gov/pubmed/23675629>

Maganioti A. E. et al, 2010. Wi-Fi electromagnetic fields exert gender related alterations on EEG. 6th International Workshop on Biological Effects of Electromagnetic fields. <http://wifiinschools.org.uk/resources/Maganioti+etal+2010.pdf>  
<http://www.istanbul.edu.tr/6internatwshopbioeffemf/cd/pdf/poster/WI-FI%20ELECTROMAGNETIC%20FIELDS%20EXERT%20GENDER.pdf>

Margaritis L.H. et al, 2013. Drosophila oogenesis as a bio-marker responding to EMF sources. *Electromagn Biol Med*., Epub ahead of print. <http://www.ncbi.nlm.nih.gov/pubmed/23915130>

Meena R. et al, 2014. Therapeutic approaches of melatonin in microwave radiations-induced oxidative stress-mediated toxicity on male fertility pattern of Wistar rats. *Electromagn Biol Med* 33(2): 81-91. <http://www.ncbi.nlm.nih.gov/pubmed/23676079>

- Naziroğlu M. and Gumral 2009. Modulator effects of L-carnitine and selenium on wireless devices (2.45 GHz)-induced oxidative stress and electroencephalography records in brain of rat. *Int J Radiat Biol.* 85(8): 680-689. <http://www.ncbi.nlm.nih.gov/pubmed/19637079>
- Naziroğlu M. et al, 2012. 2.45-Gz wireless devices induce oxidative stress and proliferation through cytosolic Ca<sup>2+</sup> influx in human leukemia cancer cells. *International Journal of Radiation Biology* 88(6): 449–456. <http://www.ncbi.nlm.nih.gov/pubmed/22489926>
- Naziroğlu M. et al, 2012b. Melatonin modulates wireless (2.45 GHz)-induced oxidative injury through TRPM2 and voltage gated Ca(2+) channels in brain and dorsal root ganglion in rat. *Physiol Behav.* 105(3): 683-92. <http://www.ncbi.nlm.nih.gov/pubmed/22019785>
- Ozorak A. et al, 2013. Wi-Fi (2.45 GHz)- and mobile phone (900 and 1800 MHz)- induced risks on oxidative stress and elements in kidney and testis of rats during pregnancy and the development of offspring. *Biol Trace Elem Res*, Epub ahead of print. <http://www.ncbi.nlm.nih.gov/pubmed/24101576>
- Oksay T. et al, 2012. Protective effects of melatonin against oxidative injury in rat testis induced by wireless (2.45 GHz) devices. *Andrologia* doi: 10.1111/and.12044, Epub ahead of print. <http://www.ncbi.nlm.nih.gov/pubmed/23145464>
- Papageorgiou C. C. et al, 2011. Effects of Wi-Fi signals on the p300 component of event-related potentials during an auditory hayling task. *Journal of Integrative Neuroscience* 10(2): 189-202. <http://www.ncbi.nlm.nih.gov/pubmed/21714138>
- Salah MB, 2013. Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals. *Environ Toxicol Pharmacol* 36(3): 826-834. <https://www.ncbi.nlm.nih.gov/pubmed/23994945>
- Sangun O. et al., 2014. The effects of long-term exposure to a 2450MHz electromagnetic field on growth and pubertal development in female Wistar rats. *Electromagn Biol Med.* Epub ahead of print. <https://www.ncbi.nlm.nih.gov/pubmed/24460416>
- Shahin S. et al, 2013. 2.45 GHz Microwave Irradiation-Induced Oxidative Stress Affects Implantation or Pregnancy in Mice, *Mus musculus*. *Appl Biochem Biotechnol* 169: 1727–1751. <http://www.ncbi.nlm.nih.gov/pubmed/23334843>
- Shahin S. et al, 2014. Microwave irradiation adversely affects reproductive function in male mouse, *Mus musculus*, by inducing oxidative and nitrosative stress. *Free Radic Res.* Epub ahead of print. <https://www.ncbi.nlm.nih.gov/pubmed/24490664>
- Tök L. et al, 2014. Effects of melatonin on Wi-Fi-induced oxidative stress in lens of rats. *Indian Journal of Ophthalmology* 62(1): 12-15. <http://www.ncbi.nlm.nih.gov/pubmed/24492496>
- Türker Y. et al, 2011. Selenium and L-carnitine reduce oxidative stress in the heart of rat induced by 2.45-GHz radiation from wireless devices. *Biol Trace Elem Res.* 143(3): 1640-1650. <http://www.ncbi.nlm.nih.gov/pubmed/21360060>

## Appendix 2

### Wi-Fi and other wireless technologies damage male fertility

Effects described include decreased sperm motility, decreased sperm counts, sperm head abnormalities, DNA damage, decreased tubule diameters and weights and increased oxidative stress. 84% of radiofrequency and male fertility studies since 2003 have found damage to male fertility.

Guidance from PHE/HPA about the safety of radiofrequency radiation is influenced by the assessment of scientific evidence by AGNIR. In the most recent AGNIR report (2012), the conclusions did not reflect the published science, as described below.

75% of studies on male fertility included in the AGNIR 2012 report (15/20; 3 retracted papers have not been counted here) found damage to sperm or decreased measures of male fertility.

79% (30/38) of studies on male fertility in the AGNIR 2012 report, plus those which were omitted, described damage to sperm or decreased measures of male fertility.

Overall, from 2003 - June 2014, 84% of studies (61/73) on male fertility and radiofrequency radiation exposures found damaging effects on sperm, reproductive organs or hormones.

It is therefore surprising, given the published scientific evidence, that the AGNIR report concluded “studies provide no evidence of health effects of RF field exposures below internationally accepted guideline levels”. It also stated “the literature provides no substantial evidence of such effects, in particular in relation to ... reproductive effects” and “there has been no consistent evidence of effects on ... fertility and reproductive function.”

There is considerable evidence for damaging effects of microwave, radiofrequency radiation on male fertility. The reproductive health of males who use radiofrequency-emitting devices (including mobile phones, tablets computers and Wi-Fi-enabled devices) or work in wireless environments, may be at risk. Damage to sperm DNA by radiofrequency signals (as reported in studies below) could increase the risk of genetic damage in the children of exposed males.

### Relevant studies omitted by the AGNIR report 2012

(83%, of papers (15/18) found damaging effects on sperm or male reproductive organs)

\* indicates adverse effects on male fertility.

\*Aitken R.J., Bennetts L.E., Sawyer D., Wiklendt A.M. and King B.V. 2005. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. *Int J Androl.* 28(3): 171-179.  
<http://www.ncbi.nlm.nih.gov/pubmed/15910543>

\*Avendaño C., Mata A., Sanchez Sarmiento C.A. and Doncel G.F. 2012. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. *Fertil Steril.* 97(1): 39-45. (full paper published online October 2011)  
<http://www.ncbi.nlm.nih.gov/pubmed/22112647>

\*Chen H.Y., Wang S.M., Peng R.Y., Gao Y.B., Wang L.F., Zhao L., Zuo H.Y., Dong J. and Su Z.T. 2011. Long-term microwave radiation affects male reproduction in rats. *Zhonghua Nan Ke Zue*. 17(3): 214-218. <http://www.ncbi.nlm.nih.gov/pubmed/21485541> [Chinese]

\*Esmekaya M.A., Ozer C. and Seyhan N. 2011. 900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues. *Gen Physiol Biophys* 30(1): 84-89. <http://www.ncbi.nlm.nih.gov/pubmed/21460416>

Falzone N., Huyser C., Franken D.R. and Leszczynski D. 2010. Mobile phone radiation does not induce proapoptosis effects in human spermatozoa. *Radiat Res* 174: 169-76. <http://www.ncbi.nlm.nih.gov/pubmed/20681783>

\*Falzone N., Huyser C., Becker P., Leszczynski D. and Franken D.R. 2011. The effect of pulsed 900-MHz GSM mobile phone radiation on the acrosome reaction, head morphometry and zona binding of human spermatozoa. *Int J Androl*. 34: 20-26. <http://www.ncbi.nlm.nih.gov/pubmed/20236367>

\*Gutschi T., Mohamad Al-Ali B., Shamloul R., Pummer K. and Trummer H. 2011. Impact of cell phone use on men's semen parameters. *Andrologia* 43(5): 312-316. <http://www.ncbi.nlm.nih.gov/pubmed/21951197>

Imai N., Kawabe M., Hikage T., Nojima T., Takahashi S. and Shirai T. 2011. Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones. *Syst Biol Reprod Med*. 57(4): 204-9. <http://www.ncbi.nlm.nih.gov/pubmed/21204746>

\*Kesari K.K., Kumar S. and Behari J. 2010. Mobile phone usage and male infertility in Wistar rats. *Indian J Exp Biol*. 48(10): 987-92. <http://www.ncbi.nlm.nih.gov/pubmed/21299041>

\*Kesari K.K., Kumar S. and Behari J. 2011. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. *Appl Biochem Biotechnol*. 164(4): 546-559. <http://www.ncbi.nlm.nih.gov/pubmed/21240569>

\*Kilgallon S.J. and Simmons L.W. 2005. Image content influences men's semen quality. *Biol Lett*. 1(3): 253-5. <http://www.ncbi.nlm.nih.gov/pubmed/17148180>

\*Kumar S., Kesari K.K. and Behari J. 2011. The therapeutic effect of a pulsed electromagnetic field on the reproductive patterns of male Wistar rats exposed to a 2.45-GHz microwave field. *Clinics (Sao Paulo)*. 66(7): 1237-45. <http://www.ncbi.nlm.nih.gov/pubmed/21876981>

Lee H.J., Jin Y.B., Kim T.H., Pack J.K., Kim N., Choi H.D., Lee J.S. and Lee Y.S. 2011. The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function. *Bioelectromagnetics*. [Epub ahead of print] <http://www.ncbi.nlm.nih.gov/pubmed/22012556>

\*Lukac N., Massanyi P., Roychoudhury S., Capcarova M., Tvrda E., Knazicka Z., Kolesarova A. and Danko J. 2011. In vitro effects of radiofrequency electromagnetic waves on bovine spermatozoa motility. *J Environ Sci Health A Tox Hazard Subst Environ Eng*. 46(12): 1417-23. <http://www.ncbi.nlm.nih.gov/pubmed/21942395>

\*Meo S.A., Arif M., Rashied S., Khan M.M., Vohra M.S., Usmani A.M., Imran M.B. and Al-Drees A.M. 2011. Hypospermatogenesis and spermatozoa maturation arrest in rats induced by mobile phone radiation. *J Coll Physicians Surg Pak.* 21(5): 262-5. <http://www.ncbi.nlm.nih.gov/pubmed/21575531>

\*Saygin M., Caliskan S., Karahan N., Koyu A., Gumral N. and Uguz A. 2011. Testicular apoptosis and histopathological changes induced by a 2.45 GHz electromagnetic field. *Toxicol Ind Health* 27(5):455-463. <http://www.ncbi.nlm.nih.gov/pubmed/21310776>

\*Wdowiak A., Wdowiak L., Wiktor H. 2007. Evaluation of the effect of using mobile phones on male fertility. *Ann Agric Environ Med.* 14(1): 169-72. <http://www.ncbi.nlm.nih.gov/pubmed/17655195>

\*Ye L.L., Suo Y.S., Cao W.L., Chen M. 2007. Radar radiation damages sperm quality. *Zhonghua Nan Ke Xue.* 13(9): 801-3. <http://www.ncbi.nlm.nih.gov/pubmed/17929556>

### **Male fertility studies included in the AGNIR report 2012**

(75%, of papers (15/20) found damaging effects on sperm or male reproductive organs; 3 retracted papers are not counted here)

\*Agarwal A., Deepinder F., Sharma R.K., Ranga G. and Li J. 2008. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. *Fertil Steril.* 89(1):124-128. <http://www.ncbi.nlm.nih.gov/pubmed/17482179>

\*Agarwal A., Desai N.R., Makker K., Varghese A., Mouradi R., Sabanegh E. and Sharma R. 2009. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones in human ejaculated semen: an in vitro pilot study. *Fertil Steril* 92: 1318-1325. <http://www.ncbi.nlm.nih.gov/pubmed/18804757>

\*Baste V., Riise T. And Moen B.E. 2008. Radiofrequency electromagnetic fields: male infertility and sex ratio of offspring. *Eur J Epidemiol.* 23(5): 369-377. <http://www.ncbi.nlm.nih.gov/pubmed/18415687>

Dasdağ S., Akdag M.Z., Ulukaya A.K. and Yegin D. 2008. Mobile phone exposure does not induce apoptosis on spermatogenesis in rats. *Arch Med Res.* 39(1): 40-44. <http://www.ncbi.nlm.nih.gov/pubmed/18067994>

\*De Iuliis G.N., Newey R.J., King B.V. and Aitken R.J. 2009. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* 4:e6446. <http://www.ncbi.nlm.nih.gov/pubmed/19649291>

\*Erogul O., Oztas E., Yildirim I., Kir T., Aydur E., Komesli G. et al. 2006. Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. *Arch Med Res.* 37: 840-843. <http://www.ncbi.nlm.nih.gov/pubmed/16971222>

\*Falzone N., Huyser C., Fourie F., Toivo T., Leszczynski D. And Franken D. 2008. In vitro effect of pulsed 900 MHz GSM radiation on mitochondrial membrane potential and motility of human spermatozoa. *Bioelectromagnetics* 29:268-276. <http://www.ncbi.nlm.nih.gov/pubmed/18163440>

Falzone N., Huyser C., Franken D.R. and Leszczynski D. 2010. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. *Radiat Res.* 174:169-176. <http://www.ncbi.nlm.nih.gov/pubmed/20681783>

\*Fejes I., Zavaczki Z., Szollosi J., Koloszar S., Daru J., Kovacs L. and Pal A. 2005. Is there a relationship between cell phone use and semen quality? *Arch Androl* 51(5): 385-393. <http://www.ncbi.nlm.nih.gov/pubmed/16087567>

\*Kesari K.K. and Behari J. 2010. Microwave exposure affecting reproductive system in male rats. *Appl Biochem Biotechnol.* 162(2): 416-428. <http://www.ncbi.nlm.nih.gov/pubmed/19768389>

\*Kumar S., Kesari K.K. and Behari J. 2011. Influence of microwave exposure on fertility on male rats. *Fertil Steril* 95(4): 1500-1502. <http://www.ncbi.nlm.nih.gov/pubmed/20723534>

Lee H.J., Pack J.K., Kim T.H., Kim N., Choi S.Y., Lee J.S., Kim S.H. and Lee Y.S. 2010. The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis. *Bioelectromagnetics* 31(7): 528-534. <http://www.ncbi.nlm.nih.gov/pubmed/20607737>

\*Mailankot M., Kunnath A.P., Jayalekshmi H., Koduru B. and Valsalan R. 2009. Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8 GHz) mobile phones induces oxidative stress and reduces sperm motility in rats. *Clinics (Sao Paulo)* 64(6): 561-565. <http://www.ncbi.nlm.nih.gov/pubmed/19578660>

\*Møllerløgken O.J. and Moen B.E. 2008. Is fertility reduced among men exposed to radiofrequency fields in the Norwegian Navy? *Bioelectromagnetics* 29(5): 345-252. <http://www.ncbi.nlm.nih.gov/pubmed/18240289>

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(\*) Article retracted. It is listed here but not included in the data analysis. Salama N., Kishimoto T., Kanayama H.O. and Kagawa S. 2010b. Effects of exposure to a mobile phone on sexual behaviour in adult male rabbit: an observational study. *Int J Impot Res.* 22(2): 127-133. <http://www.ncbi.nlm.nih.gov/pubmed/19940851>

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### **Male fertility studies published since the AGNIR 2012 report (to June 2014)**

(89%, of papers (31/35) found damaging effects on sperm, male reproductive organs or hormones)

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\*Al-Ali B.M., Patzak J., Fischereder K., Pummer K. and Shamloul R. 2013. Cell phone usage and erectile function. *Cent European J Urol.* 66(1): 75-77. <http://www.ncbi.nlm.nih.gov/pubmed/24578997>

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Jin Y.B., Choi H.D., Kim B.C., pack J.K., Kim N. and Lee Y.S. 2013. Effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on serum hormone levels in rats. *J Radiat Res* 54(3): 430-437. <http://www.ncbi.nlm.nih.gov/pubmed/23239176>

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- \*Shahin S., Mishra V., Singh S.P. and Chaturvedi C.M. 2014. Microwave irradiation adversely affects reproductive function in male mouse, *Mus musculus*, by inducing oxidative and nitrosative stress. *Free Radic Res.* 48(5): 511-525. <http://www.ncbi.nlm.nih.gov/pubmed/24490664>
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## Appendix 3

### Oxidative stress

Free radicals can cause damage to the body and are a known cause of cancer. Oxidative stress is when the number of free radicals (also called reactive oxygen species) increases beyond that which can be 'mopped up' by protective antioxidants. Oxidative stress is thus a damaging state. When considering the safety of wireless radiofrequency signals, it is important to find out whether they can increase oxidative stress in the body.

Reading the AGNIR 2012 report, it would be easy to assume that there were only seven new papers on oxidative stress and radiofrequency radiation since 2003, as these are the only ones included in the section entitled 'Reactive oxygen species' (page 94). In fact the report included a further 18 papers on oxidative stress, but the rest were scattered throughout the report.

83% (39/47) of the oxidative stress studies mentioned in the report, plus those which were omitted, found increased oxidative stress in response to radiofrequency radiation (listed below).

The majority of studies published on the subject have found increased oxidative stress in response to radiofrequency exposures, with increased free radicals, changes in antioxidant concentrations, increased damage to cell membranes with lipid peroxidation, or effects blocked by antioxidants.

The AGNIR 2012 report is used by Public Health England and other decision makers to assess whether mobile communication devices/ microwave radiofrequency transmitters are safe for the public. By separating out evidence throughout the report, omitting a large number of papers and not accurately reflecting the science in the summaries and conclusions, the report is misleading those who look to it for an accurate assessment of the evidence.

Contrary to the reassurances given in the report, the science indicates that radiofrequency signals from wireless technologies (including Wi-Fi and mobile phones) can increase oxidative stress.

\* indicates increased oxidative stress (increased free radicals, decreased antioxidant concentrations, increased lipid peroxidation or RF effects blocked by antioxidant(s)).

#### **Oxidative stress studies omitted from the AGNIR 2012 report**

(95%, of papers (21/22) found increased oxidative stress)

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- \*Guney M., Ozguner F., Oral B., Karahan N. and Mungan T. 2007. 900 MHz radiofrequency-induced histopathologic changes and oxidative stress in rat endometrium: protection by vitamins E and C. *Toxicol Ind Health* 23(7): 411-420. <http://www.ncbi.nlm.nih.gov/pubmed/18536493>
- \*Kesari K.K., Kumar S. and Behari J. 2011. 900 MHz microwave radiation promotes oxidation in rat brain. *Electromagn Biol Med.* 30(4): 219-234. <http://www.ncbi.nlm.nih.gov/pubmed/22047460>
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- \*Kumar S., Kesari K.K. and Behari J. 2011. The therapeutic effect of a pulsed electromagnetic field on the reproductive patterns of male Wistar rats exposed to a 2.45-GHz microwave field. *Clinics (Sao Paulo)* 66(7): 1237-1245. <http://www.ncbi.nlm.nih.gov/pubmed/21876981>
- Luukkonen J., Hakulinen P., Maki-Paakkanen J., Juutilainen J. and Naarala J. 2009. Enhancement of chemically induced reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells by 872 MHz radiofrequency radiation. *Mutat Res.* 662(1-2): 54-8. <http://www.ncbi.nlm.nih.gov/pubmed/19135463>
- \*Meral I., Mert H., Mert N., Deger Y., Yoruk I., Yetkin A. and Keskin S. 2007. Effects of 900-MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels of guinea pigs. *Brain Res.* 1169: 120-124. <http://www.ncbi.nlm.nih.gov/pubmed/17674954>
- \*Oktem F., Ozguner F., Mollaoglu H., Koyu A. and Uz E. 2005. Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin. *Arch Med Res.* 36(4):350-355. <http://www.ncbi.nlm.nih.gov/pubmed/15950073>
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\*Yurekli Al., Ozkan M., Kalkan T., Saybasili H., Tuncel H., Atukeren P., Gumustas K. and Seker S. 2006. GSM base station electromagnetic radiation and oxidative stress in rats. *Electromagn Biol Med.* 25(3): 177-188. <http://www.ncbi.nlm.nih.gov/pubmed/16954120>

### **Studies included in the 'Reactive oxygen species' section in the AGNIR 2012 report**

(43%, of papers (3/7) found increased oxidative stress)

Brescia F., Sarti M., Massa R., Calabrese M.L., Sannino A. and Scarfi M.R. 2009. Reactive oxygen species formation is not enhanced by exposure to UMTS 1950 radiation and co-exposure to ferrous ions in Jurkat cells. *Bioelectromagnetics* 30(7): 525-535. <http://www.ncbi.nlm.nih.gov/pubmed/19475646>

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Luukkonen J., Juutilainen J. and Naarala J. 2010. Combined effects of 872 MHz radiofrequency radiation and ferrous chloride on reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells. *Bioelectromagnetics* 31: 417-424. <http://www.ncbi.nlm.nih.gov/pubmed/20564172>

\*Sharma V.P., Singh H.P., Kohli R.K. and Batish D.R. 2009. Mobile phone radiation inhibits *Vigna radiata* (mung bean) root growth by inducing oxidative stress. *Sci Total Environ.* 407: 5543-5547. <http://www.ncbi.nlm.nih.gov/pubmed/19682728>

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Zeni O., Di Pietro R., d'Ambrosio G., Massa R., Capri M., Maarala J. et al 2007. Formation of reactive oxygen species in L929 cells after exposure to 900 MHz RF radiation with and without co-exposure to 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone. *Radiat Res.* 167: 306-311. <http://www.ncbi.nlm.nih.gov/pubmed/17316071>

Zmyslony M., Politanski P., Rajkowska E., Szmczak W. and Jajte J. 2004. Acute exposure to 930 MHz CW electromagnetic radiation in vitro affects reactive oxygen species level in rat lymphocytes treated by iron ions. *Bioelectromagnetics* 25: 324-328. <http://www.ncbi.nlm.nih.gov/pubmed/15197754>

### **Oxidative stress studies scattered throughout the AGNIR 2012 report**

(83%, of papers (15/18) found increased oxidative stress)

\*Agarwal A., Desai N.R., Makker K., Varghese A., Mouradi R., Sabanegh E. and Sharma R. 2009. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. *Fertil Steril.* 92(4): 1318-1325. <http://www.ncbi.nlm.nih.gov/pubmed/18804757>

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\*Friedman J., Kraus S., Hauptman Y., Schiff Y. and Seger R. 2007. Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochem J.* 405(3): 559-568. <http://www.ncbi.nlm.nih.gov/pubmed/17456048>

\*Gajski G. and Garaj-Vrhovac V. 2009. Radioprotective effects of honeybee venom (*Apis mellifera*) against 915-MHz microwave radiation-induced DNA damage in Wistar rat lymphocytes: in vitro study. *Int J Toxicol* 28(2): 88-98. <http://www.ncbi.nlm.nih.gov/pubmed/19482833>

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## Appendix 4

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