

**Ergänzende Informationen zu  
"Fehlerhafte offizielle Bewertung der Sicherheit von  
Funkstrahlung durch die Beratergruppe für nicht-  
ionisierende Strahlung"**

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**Supplementary Information for 'Inaccurate official assessment of  
radiofrequency safety by the Advisory Group on Non-ionising Radiation'.**

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## Supplementary Information for ‘Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionising Radiation’.

The AGNIR report 2012 considered publications from 2003 to 2010 and selective papers from 2011. To avoid bias, lists below contain references from 2003 to 2011.

Reactive oxygen species or oxidative stress	page 1
Male fertility	page 7
Genotoxicity	page 11

### References for reactive oxygen species (ROS) or oxidative stress

\*Indicates evidence for increased ROS or oxidative stress in response to radiofrequency signal.

†Indicates study was mentioned in the main text of the report for ROS or oxidative stress.

**Studies included in the ‘ROS’ section of the AGNIR report (p.94).** 57% of papers (4/7) found evidence of increased ROS or oxidative stress.

†Brescia, F. *et al.* Reactive oxygen species formation is not enhanced by exposure to UMTS 1950 MHz radiation and co-exposure to ferrous ions in Jurkat cells. *Bioelectromagnetics* **30**, 525-535 (2009).

\*†Crouzier, D., Perrin, A., Torres, G., Dabouis, V. & Debouzy, J.C. Pulsed electromagnetic field at 9.71 GHz increase free radical production in yeast (*Saccharomyces cerevisiae*). *Pathol. Biol. (Paris)* **57**, 245-251 (2009).

†Luukkonen, J., Juutilainen, J. & Naarala, J. 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 (2010).

\*†Sharma, V.P., Singh, H.P., Kohli, R.K. & Batish, D.R. Mobile phone radiation inhibits *Vigna radiata* (mung bean) root growth by inducing oxidative stress. *Sci. Total Environ.* **407**, 5543-5547 (2009).

\*†Xu, S. *et al.* Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons. *Brain Res.* **1311**, 189-196 (2010).

†Zeni, O. *et al.* 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 (2007).

\*†Zmyślony, M., Politanski, P., Rajkowska, E., Szmczak, W. & Jajte, J. 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 (2004).

**Studies on ROS or oxidative stress omitted from the AGNIR report** (AGNIR restriction to English language). 93% of papers (37/40) below found evidence of increased ROS or oxidative stress.

\*Aweda, M.A., Gbenebitse, S. & Meidinyo, R.O. Effects of 2.45 GHz microwave exposures on the peroxidation status in Wistar rats. *Niger. Postgrad. Med. J.* **10**, 243-246 (2003).

\*Ayata, A. *et al.* Oxidative stress-mediated skin damage in an experimental mobile phone model can be prevented by melatonin. *J. Dermatol.* **31**, 878-883 (2004).

\*Aydin, B. & Akar, A. Effects of a 900-MHz electromagnetic field on oxidative stress parameters in rat lymphoid organs, polymorphonuclear leukocytes and plasma. *Arch. Med. Res.* **42**, 261-267 (2011).

\*Balci, M., Devrim, E. & Durak, I. Effects of mobile phones on oxidant/antioxidant balance in cornea and lens of rats. *Curr. Eye Res.* **32**, 21-25 (2007).

\*Cenesiz, M., Atakisi, O., Akar, A., Önbilgin, G. & Ormanc, N. Effects of 900 and 1800 MHz electromagnetic field application on electrocardiogram, nitric oxide, total antioxidant capacity, total oxidant capacity, total protein, albumin and globulin levels in guinea pigs. *Kafkas. Univ. Vet. Fak. Derg.* **17**, 357-362 (2011).

Dasdag, S., *et al.* Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes. *Bioelectromagnetics* **24**, 182-188 (2003).

\*Dasdag, S., Akdag M.Z., Aksen, F., Bashan M. & Buyukbayram H. Does 900 MHz GSM mobile phone exposure affect rat brain? *Electromagn. Biol. Med.* **23**, 201-214 (2004).

\*Dasdag, S., Bilgin, H.M., Akdag, M.Z., Celik, H. & Aksen, F. Effect of long term mobile phone exposure on oxidative-antioxidative processes and nitric oxide in rats. *Biotechnol. Biotechnol. Equip.* **22**, 992-997 (2008).

\*Elhag, M.A., Nabil, G.M. & Attia, A.M. Effects of electromagnetic field produced by mobile phones on the oxidant and antioxidant status of rats. *Pak. J. Biol. Sci.* **10**, 4271-4274 (2007).

\*El Nabrawy, N.A. & El Desouky, M.A. Protective effect of caffeic acid phenethyl ester (CAPE) on liver and kidney of rats after exposure to 900 MHz electromagnetic field. *J. Am. Sci.* **7**, 937-944 (2011).

\*Esmekaya, M.A., Ozer, C. & Seyhan, N. 900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues. *Gen. Physiol. Biophys.* **30**, 84-89 (2011).

Ferreira, A.R. *et al.* Oxidative stress effects on the central nervous system of rats after acute exposure to ultra high frequency electromagnetic fields. *Bioelectromagnetics* **27**, 487-493 (2006).

\*Garaj-Vrhovac, V. *et al.* Assessment of cytogenetic damage and oxidative stress in personnel occupationally exposed to the pulsed microwave radiation of marine radar equipment. *Int. J. Hyg. Environ. Health* **214**, 59-65 (2011).

\*Gumral, N. *et al.* 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**, 153-163 (2009).

- \*Güney, M., Özgüner, F., Oral, B., Karahan, N. & Mungan, T. 900 MHz radiofrequency-induced histopathologic changes and oxidative stress in rat endometrium: protection by vitamins E and C. *Toxicol. Ind. Health* **23**, 411-420 (2007).
- \*Kesari, K.K. & Behari, J. Fifty-gigahertz microwave exposure effect of radiations on rat brain. *Appl. Biochem. Biotechnol.* **158**, 126-139 (2009).
- \*Kesari, K.K., Kumar, S. & Behari, J. 900-MHz microwave radiation promotes oxidation in rat brain. *Electromagn. Biol. Med.* **30**, 219-234 (2011).
- \*Kesari, K.K., Kumar, S. & Behari, J. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. *Appl. Biochem. Biotechnol.* **164**, 546-559 (2011).
- \*Kim, M.J. & Rhee, S.J. Green tea catechins protect rats from microwave-induced oxidative damage to heart tissue. *J. Med. Food* **7**, 299-304 (2004).
- \*Köylü, H., Mollaoglu, H., Özgüner, F., Naziroglu, M. & Delibas, N. Melatonin modulates 900 MHz microwave-induced lipid peroxidation changes in rat brain. *Toxicol. Ind. Health* **22**, 211-216 (2006).
- \*Koyu, A. *et al.* Caffeic acid phenethyl ester modulates 1800 MHz microwave-induced oxidative stress in rat liver. *Electromagn. Biol. Med.* **24**, 135-142 (2005).
- \*Koyu, A. *et al.* The protective effect of caffeic acid phenyl ester (CAPE) on oxidative stress in rat liver exposed to the 900 MHz electromagnetic field. *Toxicol. Ind. Health* **25**, 429-434 (2009).
- \*Kumar, S., Kesari, K.K. & Behari, J. 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**, 1237-1245 (2011).
- \*Lee, K.S., Choi, J.S., Hong, S.Y., Son, T.H. & Yu, K. Mobile phone electromagnetic radiation activates MAPK signaling and regulates viability in *Drosophila*. *Bioelectromagnetics* **29**, 371-379 (2008).
- \*Liu, M.L., Wen, J.Q. & Fan, Y.B. Potential protection of green tea polyphenols against 1800 MHz electromagnetic radiation-induced injury on rat cortical neurons. *Neurotox. Res.* **20**, 270-276 (2011).
- \*(CW but not GSM) Luukkonen, J., Hakulinen, P., Mäki-Paakkanen, J., Juutilainen, J. & Naarala, J. 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**, 54-58 (2009).
- \*Meral, I. *et al.* 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 (2007).
- \*Naziroğlu, M. & Gümral, N. 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**, 680-689 (2009).

\*Oktem, F., Ozguner, F., Mollaoglu, H., Koyu, A. & Uz, E. Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin. *Arch. Med. Res.* **36**, 350-355 (2005).

\*Oral, B. *et al.* Endometrial apoptosis induced by a 900-MHz mobile phone: preventive effects of vitamins E and C. *Adv. Ther.* **23**, 957-973 (2006).

\*Ozguner, F. *et al.* Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study. *Toxicol. Ind. Health* **20**, 133-139 (2004).

\*Ozguner, F. *et al.* Mobile phone-induced myocardial oxidative stress: protection by a novel antioxidant agent caffeic acid phenethyl ester. *Toxicol. Ind. Health* **21**, 223-230 (2005).

\*Ozguner, F., Oktem, F., Ayata, A., Koyu, A. & Yilmaz, H.R. A novel antioxidant agent caffeic acid phenethyl ester prevents long-term mobile phone exposure-induced renal impairment in rat. *Mol. Cell. Biochem.* **277**, 73-80 (2005).

\*Ozguner, F. *et al.* Comparative analysis of the protective effects of melatonin and caffeic acid phenethyl ester (CAPE) on mobile phone-induced renal impairment in rat. *Mol. Cell. Biochem.* **276**, 31-37 (2005).

\*Ozguner, F., Bardak, Y. & Comlekci, S. Protective effects of melatonin and caffeic acid phenethyl ester against retinal oxidative stress in long-term use of mobile phone: a comparative study. *Mol. Cell. Biochem.* **282**, 83-88 (2006).

Poullétier de Gannes F. *et al.* Effect of exposure to the EGDE signal on oxidative stress in brain cell models. *Radiat. Res.* **175**, 225-230 (2011).

\*Tkalec, M., Malarić, K. & Pevalek-Kozlina, B. Exposure to radiofrequency radiation induces oxidative stress in duckweed *Lemna minor* L. *Sci. Total Environ.* **388**, 78-89 (2007).

\*Türker, Y. *et al.* 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**, 1640-1650 (2011).

\*Yariktas, M. *et al.* Nitric oxide level in the nasal and sinus mucosa after exposure to electromagnetic field. *Otolaryngol. Head Neck Surg.* **132**, 713-716 (2005).

\*Yurekli, A.I. *et al.* GSM base station electromagnetic radiation and oxidative stress in rats. *Electromagn. Biol. Med.* **25**, 177-188 (2006).

**Studies on ROS or oxidative stress scattered throughout the AGNIR report (but without summaries or conclusions).** 67%, of papers below (20/30) found evidence of increased ROS or oxidative stress; retracted papers not counted.

\*†Agarwal, A. *et al.* Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. *Fertil. Steril.* **92**, 1318-1325 (2009).

†Arendash, G.W., *et al.* Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice. *J. Alzheimers Dis.* **19**, 191-210 (2010).

\*Campisi, A. *et al.* Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. *Neurosci. Lett.* **473**, 52-55 (2010).

(decreased ROS in cerebral cortex and hippocampus of Tg mice) Dragicevic, N. *et al.* Long-term electromagnetic field treatment enhances brain mitochondrial function of both Alzheimer's transgenic mice and normal mice: a mechanism for electromagnetic field-induced cognitive benefit? *Neuroscience* **185**, 135-149 (2011).

Dasdag, S., Akdag, M.Z., Ulukaya, E., Uzunlar, A.K. & Ocak, A.R. Effect of mobile phone exposure on apoptotic glial cells and status of oxidative stress in rat brain. *Electromagn. Biol. Med.* **28**, 342-354 (2009).

\*†De Iuliis, G.N., Newey, R.J., King, B.V. & Aitken, R.J. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* **4**, e6446 (2009).

\*Del Vecchio, G. *et al.* Effect of radiofrequency electromagnetic field exposure on in vitro models of neurodegenerative disease. *Bioelectromagnetics* **30**, 564-572 (2009).

†Falzone, N., Huysen, C., Franken, D.R. & Leszczynski, D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. *Radiat. Res.* **174**, 169-176 (2010).

Ferreira, A.R. *et al.* Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. *Life Sci.* **80**, 43-50 (2006).

\*Friedman, J., Kraus, S., Hauptman, Y., Schiff, Y. & Seger, R. Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochem. J.* **405**, 559-568 (2007).

\*Gajski, G. & Garaj-Vrhovac, V. 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**, 88-98 (2009).

(\* ) Article retracted; listed here but not included in the data. Garaj-Vrhovac, V., Gajski, G., Trošić, I. & Pavčić, I. Evaluation of basal DNA damage and oxidative stress in Wistar rat leukocytes after exposure to microwave radiation. *Toxicology* **259**, 107-112 (2009).

\*†Guler, G., Tomruk, A., Ozgur, E. & Seyhan, N. The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. *Gen. Physiol. Biophys.* **29**, 59-66 (2010).

Hook, G.J. *et al.* Evaluation of parameters of oxidative stress after in vitro exposure to FMCW- and CDMA-modulated radiofrequency radiation fields. *Radiat. Res.* **162**, 497-504 (2004).

\*†Höytö, A., Luukkonen, J., Juutilainen, J. & Naarala, J. Proliferation, oxidative stress and cell death in cells exposed to 872 MHz radiofrequency radiation and oxidants. *Radiat. Res.* **170**, 235-243 (2008).

- \*† İlhan, A. *et al.* Ginkgo biloba prevents mobile phone-induced oxidative stress in rat brain. *Clin. Chim. Acta.* **340**, 153-162 (2004).
- \*† Imge, E.B., Kiliçoğlu, B., Devrim, E., Cetin, R. & Durak, I. Effects of mobile phone use on brain tissue from the rat and a possible protective role of vitamin C - a preliminary study. *Int. J. Radiat. Biol.* **86**, 1044-1049 (2010).
- \* Kesari, K.K., Behari, J. & Kumar, S. Mutagenic response of 2.45 GHz radiation exposure on rat brain. *Int. J. Radiat. Biol.* **86**, 334-343 (2010a).
- \*† Kesari, K.K. & Behari, J. Microwave exposure affecting reproductive system in male rats. *Appl. Biochem. Biotechnol.* **162**, 416-428 (2010b).
- \*† Kumar, S., Kesari, K.K. & Behari, J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. *Indian J. Exp. Biol.* **48**, 586-592 (2010).
- \*† Kumar, S., Kesari, K.K. & Behari, J. Influence of microwave exposure on fertility of male rats. *Fertil. Steril.* **95**, 1500-1502 (2011).
- Lantow, M. *et al.* ROS release and Hsp70 expression after exposure to 1,800 MHz radiofrequency electromagnetic fields in primary human monocytes and lymphocytes. *Radiat. Environ. Biophys.* **45**, 55-62 (2006).
- Lantow, M., Schuderer, J., Hartwig, C. & Simkó, M. Free radical release and HSP70 expression in two human immune-relevant cell lines after exposure to 1800 MHz radiofrequency radiation. *Radiat. Res.* **165**, 88-94 (2006).
- Lee, H.J. *et al.* The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis. *Bioelectromagnetics* **31**, 528-534 (2010).
- \* Mailankot, M., Kunnath A.P., Jayalekshmi H., Koduru B. & Valsalan R. Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8GHz) mobile phones induces oxidative stress and reduces sperm motility in rats. *Clinics (Sao Paulo)* **64**, 561-565 (2009).
- \*† Orendáčová, J. *et al.* Effects of short-duration electromagnetic radiation on early postnatal neurogenesis in rats: Fos and NADPH-d histochemical studies. *Acta Histochem.* **113**, 723-728 (2011).
- \*† Ozgur, E., Güler, G. & Seyhan, N. Mobile phone radiation-induced free radical damage in the liver is inhibited by the antioxidants N-acetyl cysteine and epigallocatechin-gallate. *Int. J. Radiat. Biol.* **86**, 935-945 (2010).
- Simkó, M. *et al.* Hsp70 expression and free radical release after exposure to non-thermal radio-frequency electromagnetic fields and ultrafine particles in human Mono Mac 6 cells. *Toxicol. Lett.* **161**, 73-82 (2006).
- \*† Sokolovic, D. *et al.* Melatonin reduces oxidative stress induced by chronic exposure of microwave radiation from mobile phones in rat brain. *J. Radiat. Res.* **49**, 579-586 (2008).
- \* Tomruk, A., Guler, G. & Dincel, A.S. The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits. *Cell. Biochem. Biophys.* **56**, 39-47 (2010).



\*Yao, K. *et al.* Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. *Mol. Vis.* **14**, 964-969 (2008).

(\* Article retracted; listed here but not included in the data. Yao, K. *et al.* Effect of superposed electromagnetic noise on DNA damage of lens epithelial cells induced by microwave radiation. *Invest. Ophthalmol. Vis. Sci.* **49**, 2009-2015 (2008).

**79% (61/77) of studies listed above which could have been included in the AGNIR report on ROS or oxidative stress (with AGNIR restriction to English language) found evidence of increased ROS or oxidative stress in response to radiofrequency radiation.**

### References for male fertility

\*Indicates evidence for adverse effect on male fertility or altered male testosterone concentrations.

**Male fertility studies omitted from the AGNIR report** (AGNIR restriction to English language). 77%, of papers (17/22) found adverse effects on sperm, male reproductive organs or changes in male testosterone concentrations.

\*Aghdam Shahryar, H., Lotfi, A.R., Bahoib, M. & Karami, A.R. Effects of Electromagnetic Fields of Cellular Phone on Cortisol and Testosterone Hormones Rate in Syrian Hamsters (*Mesocricetus auratus*). *Int. J. Zool. Res.* **4**, 230-233 (2008).

\*Avendaño, C., Mata, A., Sanchez Sarmiento, C.A. & Doncel, G.F. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. *Fertil. Steril.* **97**, 39-45 (2012, Epub 2011).

Chaturvedi, C.M. *et al.* 2.45 GHz (CW) microwave irradiation alters circadian organization, spatial memory, DNA structure in the brain cells and blood cell counts of male mice, *Mus musculus*. *Prog. Electromagn. Res. B* **29**, 23-42 (2011).

Dasdag, S., *et al.* Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes. *Bioelectromagnetics* **24**, 182-188 (2003).

Djeridane, Y., Touitou, Y. & de Seze, R. Influence of electromagnetic fields emitted by GSM-900 cellular telephones on the circadian patterns of gonadal, adrenal and pituitary hormones in men. *Radiat. Res.* **169**, 337-343 (2008).

\*Esmekaya, M.A., Ozer, C. & Seyhan, N. 900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues. *Gen. Physiol. Biophys.* **30**, 84-89 (2011).

\*Falzone, N., Huyser, C., Becker, P., Leszczynski, D. & Franken, D.R. 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 (2011).



- \*Forgács, Z. et al. Effect of whole-body 1800MHz GSM-like microwave exposure on testicular steroidogenesis and histology in mice. *Reprod. Toxicol.* **22**, 111-117 (2006).
- \*Gutschi, T., Mohamad, Al-Ali B., Shamloul, R., Pummer, K. & Trummer, H. Impact of cell phone use on men's semen parameters. *Andrologia* **43**, 312-316 (2011).
- Imai, N. et al. Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones. *Syst. Biol. Reprod. Med.* **57**, 204-209 (2011).
- \*Kesari, K.K. & Behari, J. Effects of microwave at 2.45 GHz radiations on reproductive system of male rats. *Toxicol. Environ. Chem.* **92**, 1135-1147 (2010).
- \*Kesari, K.K., Kumar, S. & Behari, J. Mobile phone usage and male infertility in Wistar rats. *Indian J. Exp. Biol.* **48**, 987-992 (2010).
- \*Kesari, K.K., Kumar, S. & Behari, J. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. *Appl. Biochem. Biotechnol.* **164**, 546-559 (2011).
- \*Kilgallon, S.J. & Simmons, L.W. Image content influences men's semen quality. *Biol. Lett.* **1**, 253-255 (2005).
- \*Kumar, S., Kesari, K.K. & Behari, J. 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**, 1237-1245 (2011).
- Lee, H.J. et al. The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function. *Bioelectromagnetics* **33**, 356-364 (2012, Epub 2011).
- \*Lukac, N. et al. In vitro effects of radiofrequency electromagnetic waves on bovine spermatozoa motility. *J. Environ. Sci. Health A. Tox. Hazard Subst. Environ. Eng.* **46**, 1417-1423 (2011).
- \*Meo, S.A. et al. Hypospermatogenesis and spermatozoa maturation arrest in rats induced by mobile phone radiation. *J. Coll. Physicians Surg. Pak.* **21**, 262-265 (2011).
- \*Oni, M.O., Amuda, D.B. & Gilbert, C.E. Effects of radiofrequency radiation from WiFi devices on human ejaculated semen. *Int. J. Recent Res. Appl. Stud.* **9**, 292-294 (2011).
- \*Sarookhani, M.R., Asiabanha Rezaei, M., Safari, A., Zaroushani, V. & Ziaeiha, M. The influence of 950 MHz magnetic field (mobile phone radiation) on sex organ and adrenal functions of male rabbits. *Afr. J. Biochem. Res.* **5**, 65-68 (2011).
- \*Saygin, M. et al. Testicular apoptosis and histopathological changes induced by a 2.45 GHz electromagnetic field. *Toxicol. Ind. Health* **27**, 455-463 (2011).
- \*Wdowiak, A., Wdowiak, L. & Wiktor, H. Evaluation of the effect of using mobile phones on male fertility. *Ann. Agric. Environ. Med.* **14**, 169-172 (2007).

**Male fertility studies included in the AGNIR report.** 78%, of papers (18/23) found adverse effects on sperm, male reproductive organs or altered male testosterone concentrations; retracted papers not counted.

\*Agarwal, A., Deepinder, F., Sharma, R.K., Ranga, G. & Li, J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. *Fertil. Steril.* **89**, 124-128 (2008).

\*Agarwal, A. *et al.* 2009. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. *Fertil. Steril.* **92**, 1318-1325 (2009).

\*Aitken, R.J., Bennetts, L.E., Sawyer, D., Wiklendt, A.M. & King, B.V. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. *Int. J. Androl.* **28**, 171-179 (2005).

\*Baste, V., Riise, T. & Moen, B.E. Radiofrequency electromagnetic fields: male infertility and sex ratio of offspring. *Eur. J. Epidemiol.* **23**, 369-377 (2008).

Dasdağ, S., Akdag, M.Z., Ulukaya, E., Uzunlar, A.K. & Yegin, D. Mobile phone exposure does not induce apoptosis on spermatogenesis in rats. *Arch. Med. Res.* **39**, 40-44 (2008).

\*De Iuliis, G.N., Newey, R.J., King, B.V. & Aitken, R.J. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* **4**, e6446 (2009).

\*Erogul, O. *et al.* Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. *Arch. Med. Res.* **37**, 840-843 (2006).

\*Falzone, N. *et al.* In vitro effect of pulsed 900 MHz GSM radiation on mitochondrial membrane potential and motility of human spermatozoa. *Bioelectromagnetics* **29**, 268-276 (2008).

Falzone, N., Huyser, C., Franken, D.R. & Leszczynski, D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. *Radiat. Res.* **174**, 169-176 (2010).

\*Fejes, I. *et al.* Is there a relationship between cell phone use and semen quality? *Arch. Androl.* **51**, 385-393 (2005).

\*Kesari, K.K. & Behari, J. Microwave exposure affecting reproductive system in male rats. *Appl. Biochem. Biotechnol.* **162**, 416-428 (2010).

\*Kumar, S., Kesari, K.K. & Behari, J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. *Indian J. Exp. Biol.* **48**, 586-592 (2010).

\*Kumar, S., Kesari, K.K. & Behari, J. Influence of microwave exposure on fertility of male rats. *Fertil. Steril.* **95**, 1500-1502 (2011).

Lee, H.J. *et al.* The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis. *Bioelectromagnetics* **31**, 528-534 (2010).

\*Mailankot, M., Kunnath, A.P., Jayalekshmi, H., Koduru, B. & Valsalan, R. 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**, 561-565 (2009).

\*Meo, S.A., Al-Drees, A.M., Husain, S., Khan, M.M. & Imran, M.B. Effects of mobile phone radiation on serum testosterone in Wistar albino rats. *Saudi Med. J.* **31**, 869-873 (2010).

\*Møllerløgken, O.J. & Moen, B.E. Is fertility reduced among men exposed to radiofrequency fields in the Norwegian Navy? *Bioelectromagnetics* **29**, 345-352 (2008).

\*Otitoloju, A.A., Obe, I.A., Adewale, O.A., Otubanjo, O.A. & Osunkalu, V.O. Preliminary study on the induction of sperm head abnormalities in mice, *Mus musculus*, exposed to radiofrequency radiations from global system for mobile communication base stations. *Bull. Environ. Contam. Toxicol.* **84**, 51-54 (2010).

\*Ozguner, M. *et al.* Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field. *Saudi Med. J.* **26**, 405-410 (2005).

Ribeiro, E.P. *et al.* Effects of subchronic exposure to radio frequency from a conventional cellular telephone on testicular function in adult rats. *J. Urol.* **177**, 395-399 (2007).

(\*) Article retracted; listed here but not included in the data. Salama, N., Kishimoto, T., Kanayama, H.O. & Kagawa, S. The mobile phone decreases fructose but not citrate in rabbit semen: a longitudinal study. *Syst. Biol. Reprod. Med.* **55**, 181-187 (2009).

(\*) Article retracted; listed here but not included in the data. Salama, N., Kishimoto, T. & Kanayama, H.O. Effects of exposure to a mobile phone on testicular function and structure in adult rabbit. *Int. J. Androl.* **33**, 88-94 (2010).

(\*) Article retracted; listed here but not included in the data. Salama, N., Kishimoto, T., Kanayama, H.O. & Kagawa, S. Effects of exposure to a mobile phone on sexual behaviour in adult male rabbit: an observational study. *Int. J. Impot. Res.* **22**, 127-133 (2010).

\*Subbotina, T.I., Tereshkina, O.V., Khadartsev, A.A. & Yashin, A.A. Effect of low-intensity extremely high frequency radiation on reproductive function in Wistar rats. *Bull. Exp. Biol. Med.* **142**, 189-190 (2006).

\*Yan, J.G. *et al.* Effects of cellular phone emissions on sperm motility in rats. *Fertil. Steril.* **88**, 957-964 (2007).

Yilmaz, F., Dasdag, S., Akdag, M.Z. & Kilinc, N. Whole-body exposure of radiation emitted from 900 MHz mobile phones does not seem to affect the levels of anti-apoptotic bcl-2 protein. *Electromagn. Biol. Med.* **27**, 65-72 (2008).

**78% (35/45) of studies listed above which could have been included in the AGNIR report on male fertility (with AGNIR restriction to English language) described effects on sperm, male reproductive organs or male testosterone concentrations in response to radiofrequency radiation.**

## References for genotoxicity

\*Indicates evidence of genotoxicity in response to radiofrequency signal (including DNA or chromosomal damage, micronuclei, decreased DNA repair, potentiation of genotoxic effects of other agents and mutation studies, but not apoptosis or altered gene expression).

†Indicates *in vitro* genotoxicity study.

xIndicates included in report, but not for genotoxicity.

### **Genotoxicity studies included in the AGNIR report.**

46% of papers (36/78) found evidence of genotoxicity (24/54 for *in vitro*).

\*Aitken, R.J., Bennetts, L.E., Sawyer, D., Wiklendt, A.M. & King, B.V. Impact of radiofrequency electromagnetic radiation on DNA integrity in the male germline. *Int. J. Androl.* **28**, 171-179 (2005).

†Agarwal, A. *et al.* Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an *in vitro* pilot study. *Fertil. Steril.* **92**, 1318-1325 (2009).

\*(decreased DNA repair enzyme)Arendash, G.W. *et al.* Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice. *J. Alzheimers Dis.* **19**, 191-210 (2010).

\*†Baohong, W. *et al.* Studying the synergistic damage effects induced by 1.8GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay *in vitro*. *Mutat. Res.* **578**, 149-157 (2005).

†Belloni, F. *et al.* A suitable plane transmission line at 900 MHz rf fields for *E. coli* DNA studies. *Rev. Sci. Instrum.* **76**, 54302 (2005).

\*†xBelyaev, I.Y. *et al.* 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. *Bioelectromagnetics* **26**, 173-184 (2005).

Belyaev, I.Y. *et al.* Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation. *Bioelectromagnetics* **27**, 295-306 (2006).

†Bourthoumieu, S. *et al.* Cytogenetic studies in human cells exposed *in vitro* to GSM -900 MHz radiofrequency radiation using R-banded karyotyping. *Radiat. Res.* **174**, 712-718 (2010).

\*Busljeta, I., Trosic, I. & Milkovic-Kraus, S. Erythropoietic changes in rats after 2.45 GHz nonthermal irradiation. *Int. J. Hyg. Environ. Health* **207**, 549-554 (2004).

\*†Campisi, A. *et al.* Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. *Neurosci. Lett.* **473**, 52-55 (2010).

†‡Chang, S.K. *et al.* Genotoxicity evaluation of electromagnetic fields generated by 835-MHz mobile phone frequency band. *Eur. J. Cancer Prev.* **14**, 175-179 (2005).

†‡xChauhan, V. *et al.* Evaluating the biological effects of intermittent 1.9 GHz pulse-modulated radiofrequency fields in a series of human-derived cell lines. *Radiat. Res.* **167**, 87-93 (2007).

\*†‡De Iuliis, G.N., Newey, R.J., King, B.V. & Aitken, R.J. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* **4**, e6466 (2009).

\*Demsia, G., Vlastos, D. & Matthopoulos, D.P. Effect of 910-MHz electromagnetic field on rat bone marrow. *Scientific World Journal* **4**, 48-54 (2004).

\*†‡Diem, E. Schwarz, C., Adlkofer, F., Jahn, O. & Rüdiger, H. Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro. *Mutat. Res.* **583**, 178-183 (2005).

†‡Falzone, N., Huyser, C., Franken, D.R. & Leszczynski, D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. *Radiat. Res.* **174**, 169-176 (2010).

\*Ferreira, A.R. *et al.* Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. *Life Sci.* **80**, 43-50 (2006).

\*†‡Franzellitti, S. *et al.* Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8 GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline comet assay. *Mutat. Res.* **683**, 35-42 (2010).

\*†‡Gajski, G. & Garaj-Vrhovac, V. 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**, 88-98 (2009).

(\*†‡) Article retracted; listed here but not included in the analysis. Garaj-Vrhovac, V., Gajski, G., Trošić, I. & Pavičić, I. Evaluation of basal damage and oxidative stress in Wistar rat leukocytes after exposure to microwave radiation. *Toxicology* **259**, 107-112 (2009).

Görlitz, B.D. *et al.* Effects of 1-week and 6-week exposure to GSM/DCS radiofrequency radiation on micronucleus formation in B6C3F1 mice. *Radiat. Res.* **164**, 431-439 (2005).

\*Guler, G., Tomruk, A., Ozgur, E. & Seyhan, N. The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. *Gen. Physiol. Biophys.* **29**, 59-66 (2010).

Gurbuz, N. *et al.* Is there any possible genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 MHz GSM-like modulated radio frequency radiation (RFR)? *Electromagn. Biol. Med.* **29**, 98-104 (2010).

† Hansteen, I.L. *et al.* Cytogenetic effects of exposure to 2.3 GHz radiofrequency radiation on human lymphocytes in vitro. *Anticancer Res.* **29**, 4323-4330 (2009).

† Included in AGNIR report, but not included in this data, as it is not a genotoxicity study. Hirose, H. *et al.* Phosphorylation and gene expression of p53 are not affected in human cells exposed to 2.1425 GHz band CW or W-CDMA modulated radiation allocated to mobile radio base stations. *Bioelectromagnetics* **27**, 494-504 (2006.)

† Hirose, H. *et al.* Mobile phone base station radiation does not affect neoplastic transformation in BALB/3T3 cells. *Bioelectromagnetics* **29**, 55-64 (2008).

† Huang, T.Q. *et al.* Characterization of biological effect of 1763 MHz radiofrequency exposure on auditory hair cells. *Int. J. Radiat. Biol.* **84**, 909-915 (2008).

Juutilainen, J., Heikkinen, P., Soikkeli, H. & Mäki-Paakkanen, J. Micronucleus frequency in erythrocytes of mice after long-term exposure to radiofrequency radiation. *Int. J. Radiat. Biol.* **83**, 213-220 (2007).

\* Kesari, K.K., Behari, J. & Kumar, S. Mutagenic response of 2.45 GHz radiation exposure on rat brain. *Int. J. Radiat. Biol.* **86**, 334-343 (2010).

\*† Kim, J.Y. *et al.* In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. *Environ. Toxicol.* **23**, 319-327 (2008).

Kim, T.H. *et al.* Local exposure of 849 MHz and 1763 MHz radiofrequency radiation to mouse heads does not induce cell death or cell proliferation in brain. *Exp. Mol. Med.* **40**, 294-303 (2008).

† Komatsubara, Y. *et al.* Effect of high-frequency electromagnetic fields with a wide range of SARs on chromosomal aberrations in murine m5S cells. *Mutat. Res.* **587**, 114-119 (2005).

† Koyama, S., Isozumi, Y., Suzuki, Y., Taki, M. & Miyakoshi, J. Effects of 2.45-GHz electromagnetic fields with a wide range of SARs on micronucleus formation in CHO-K1 cells. *Scientific World Journal* **4**, 29-40 (2004).

† Koyama, S. *et al.* Effects of 2.45 GHz electromagnetic fields with a wide range of SARs on bacterial and HPRT gene mutations. *J. Radiat. Res.* **48**, 69-75 (2007).

\* Kumar, S., Kesari, K.K. & Behari, J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. *Indian J. Exp. Biol.* **48**, 586-592 (2010).

Lagroye I. *et al.* Measurement of DNA damage after acute exposure to pulsed-wave 2450 MHz microwaves in rat brain cells by two alkaline comet assay methods. *Int. J. Radiat. Biol.* **80**, 11-20 (2004).



\*†Lai, H. & Singh, N.P. Interaction of microwaves and a temporally incoherent magnetic field on single and double strand breaks in rat brain cells. *Electromagn. Biol. Med.* **24**, 23-29 (2005).

\*†‡Lixia S., *et al.* Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. *Mutat. Res.* **602**, 135-142 (2006).

†‡Luukkonen, J. Juutilainen, J. & Naarala, J. 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 (2010).

\*†‡Manti, L. *et al.* Effects of modulated microwave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. *Radiat. Res.* **169**, 575-583 (2008).

\*†‡x Marinelli, F. *et al.* Exposure to 900 MHz electromagnetic field induces an unbalance between pro-apoptotic and pro-survival signals in T-lymphoblastoid leukemia CCRF-CEM cells. *J. Cell. Physiol.* **198**, 324-332 (2004).

\*†‡Markovà, E., Hillert, L., Malmgren, L., Persson, B.R. & Belyaev, I.Y. Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. *Environ. Health Perspect.* **113**, 1172-1177 (2005).

\*†‡Markovà, E., Malmgren, L.O. & Belyaev, I.Y. Microwaves from mobile phones inhibit 53BP1 focus formation in human stem cells more strongly than in differentiated cells: possible mechanistic link to cancer risk. *Environ. Health Perspect.* **118**, 394-399 (2010).

\*†‡Mazor, R. *et al.* Increased levels of numerical chromosome aberrations after in vitro exposure of human peripheral blood lymphocytes to radiofrequency electromagnetic fields for 72 hours. *Radiat. Res.* **169**, 28-37 (2008).

†‡McNamee, J.P. *et al.* No evidence for genotoxic effects from 24h exposure of human leukocytes to 1.9 GHz radiofrequency fields. *Radiat. Res.* **159**, 693-697 (2003).

†‡Miyakoshi, J. *et al.* Effects of high-frequency electromagnetic fields on DNA strand breaks using comet assay method. *Elect. Eng. Jpn.* **141**, 9-15 (2002).

\*†‡x Nikolova, T. *et al.* Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. *FASEB J.* **19**, 1686-1688 (2005).

Ono, T. *et al.* Absence of mutagenic effects of 2.45 GHz radiofrequency exposure in spleen, liver, brain and testis of lacZ-transgenic mouse exposed in utero. *Tohoku J. Exp. Med.* **202**, 93-103 (2004).

\*Paulraj, R. & Behari, J. Single strand DNA breaks in rat brain cells exposed to microwave radiation. *Mutat. Res.* **596**, 76-80 (2006).



- †‡Port, M., Abend M., Römer, B. & Van Beuningen D. Influence of high-frequency electromagnetic fields on different modes of cell death and gene expression. *Int. J. Radiat. Biol.* **79**, 701-708 (2003).
- †‡Sakuma, N. *et al.* DNA strand breaks are not induced in human cells exposed to 2.1425 GHz band CW and W-CDMA modulated radiofrequency fields allocated to mobile radio base stations. *Bioelectromagnetics* **27**, 51-57 (2006).
- †‡Sannino, A. *et al.* Evaluation of cytotoxic and genotoxic effects in human peripheral blood leukocytes following exposure to 1950-MHz modulated signal. *IEEE Trans. Plasma Sci.* **34**, 1441-1448 (2006).
- †‡Sannino, A. *et al.* Human fibroblasts and 900 MHz radiofrequency radiation: evaluation of DNA damage after exposure and co-exposure to 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX). *Radiat. Res.* **171**, 743-751 (2009a).
- †‡Sannino, A. *et al.* Induction of adaptive response in human blood lymphocytes exposed to radiofrequency radiation. *Radiat. Res.* **171**, 735-742 (2009b).
- \*†‡Sarimov, R., Malmgren, L.O.G., Marková, E., Persson, B.R.R. & Belyaev, I.Y. Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock. *IEEE Trans. Plasma Sci.* **32**, 1600-1608 (2004).
- †‡Scarfi, M.R. *et al.* Exposure to radiofrequency radiation (900 MHz, GSM signal) does not affect micronucleus frequency and cell proliferation in human peripheral blood lymphocytes: an interlaboratory study. *Radiat. Res.* **165**, 655-663 (2006).
- \*†‡x Schrader, T., Munter, K., Kleine-Ostmann, T. & Schmid, E. Spindle disturbances in human-hamster hybrid (AL) cells induced by mobile communication frequency range signals. *Bioelectromagnetics* **29**, 626-639 (2008).
- \*†‡Schwarz, C. *et al.* Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not lymphocytes. *Int. Arch. Occup. Environ. Health* **81**, 755-767 (2008).
- \*†‡Shckorbatov, Y.G. *et al.* The influence of differently polarised microwave radiation on chromatin in human cells. *Int. J. Radiat. Biol.* **85**, 322-329 (2009).
- †‡Speit, G., Schütz P. & Hoffmann H. Genotoxic effects of exposure to radiofrequency electromagnetic fields (RF-EMF) in cultured mammalian cells are not independently reproducible. *Mutat. Res.* **626**, 42-47 (2007).
- †‡Stronati, L. *et al.* 935 MHz cellular phone radiation. An in vitro study of genotoxicity in human lymphocytes. *Int. J. Radiat. Biol.* **82**, 339-346 (2006).
- \*†‡Tiwari, R. *et al.* Combinative exposure effect of radio frequency signals from CDMA mobile phones and aphidicolin on DNA integrity. *Electromagn. Biol. Med.* **27**, 418-425 (2008).

Tomruk, A., Guler, G. & Dincel, A.S. The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits. *Cell. Biochem. Biophys.* **56**, 39-47 (2010).

\* Trosic, I., Busljeta, I. & Modlic, B. Investigation of the genotoxic effect of microwave irradiation in rat bone marrow cells: in vivo exposure. *Mutagenesis* **19**, 361-364 (2004).

\* x Trosic, I. & Busljeta, I. Erythropoietic dynamic equilibrium in rats maintained after microwave irradiation. *Exp. Toxicol. Pathol.* **57**, 247-251 (2006).

† Valbonesi, P. *et al.* Evaluation of HSP70 expression and DNA damage in cells of a human trophoblast cell line exposed to 1.8 GHz amplitude-modulated radiofrequency fields. *Radiat. Res.* **169**, 270-279 (2008).

Verschaeve, L. *et al.* Investigation of co-genotoxic effects of radiofrequency electromagnetic fields in vivo. *Radiat. Res.* **165**, 598-607 (2006).

Vijayalaxmi, Sasser, L.B., Morris, J.E., Wilson, B.W. & Anderson, L.E. Genotoxic potential of 1.6 GHz wireless communication signal: in vivo two-year bioassay. *Radiat. Res.* **159**, 558-564 (2003).

Vijayalaxmi, Logani, M.K., Bhanushali, A., Ziskin, M.C. & Prihoda, T.J. Micronuclei in peripheral blood and bone marrow cells of mice exposed to 42 GHz electromagnetic millimetre waves. *Radiat. Res.* **161**, 341-345 (2004).

† Vijayalaxmi. Cytogenetic studies in human blood lymphocytes exposed in vitro to 2.45 GHz or 8.2 GHz radiofrequency radiation. *Radiat. Res.* **166**, 532-538 (2006).

† Wang, J. *et al.* Effects of 2450 MHz electromagnetic fields with a wide range of SARs on methylcholanthrene-induced transformation in C3H10T1/2 cells. *J. Radiat. Res.* **46**, 351-361 (2005).

\* † Xu, S. *et al.* Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons. *Brain Res.* **1311**, 189-196 (2010).

\* † Yao, K. *et al.* Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. *Mol. Vis.* **14**, 964-969 (2008a).

(\* † Article retracted; listed here but not included in the data. Yao, K. *et al.* Effect of superposed electromagnetic noise on DNA damage of lens epithelial cells induced by microwave radiation. *Invest. Ophthalmol. Vis. Sci.* **49**, 2009-2015 (2008b).

† Zeni, O. *et al.* Lack of genotoxic effects (micronucleus induction) in human lymphocytes exposed in vitro to 900 MHz electromagnetic fields. *Radiat. Res.* **160**, 152-158 (2003).

† Zeni, O. *et al.* Evaluation of genotoxic effects in human peripheral blood leukocytes following acute in vitro exposure to 900 MHz radiofrequency fields. *Bioelectromagnetics* **26**, 258-265 (2005).

†Zeni, O. *et al.* Evaluation of genotoxic effects in human leukocytes after in vitro exposure to 1950 MHz UMTS radiofrequency field. *Bioelectromagnetics* **29**, 177-184 (2008).

†Zhijian, C. *et al.* Influence of 1.8-GHz (GSM) radiofrequency radiation (RFR) on DNA damage and repair induced by X-rays in human leukocytes *in vitro*. *Mutat. Res.* **677**, 100-104 (2009).

\*†Zhijian, C. *et al.* Impact of 1.8 GHz radiofrequency radiation (RFR) on DNA damage and repair induced by doxorubicin in human B-cell lymphoblastoid cells. *Mutat. Res.* **695**, 16-21 (2010).

Ziemann C. *et al.* Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz (DCS) wireless communication signals: in vivo two-year bioassay in B6C3F1 mice. *Int. J. Radiat. Biol.* **85**, 454-464 (2009).

\*†Zotti-Martelli, L., Peccatori, M., Maggini, V., Ballardin, M. & Barale, R. Individual responsiveness to induction of micronuclei in human lymphocytes after exposure in vitro to 1800-MHz microwave radiation. *Mutat. Res.* **582**, 42-52 (2005).

**Genotoxicity studies omitted from the AGNIR report.** 63% of papers (25/40) found evidence of genotoxicity (55%, 12/22, for *in vitro*).

\*Aweda, M.A., Usikalu, M.R., Wan, J.H., Ding, N. & Zhu, J.Y. Genotoxic effects of low 2.45 GHz microwave radiation exposures on Sprague Dawley rats. *Int. J. Genet. Mol. Biol.* **2**, 189-197 (2010).

\*†Ballardin, M. *et al.* Non-thermal effects of 2.45 GHz microwaves on spindle assembly, mitotic cells and viability of Chinese hamster V-79 cells. *Mutat. Res.* **716**, 1-9 (2011).

\*†Baohong, W. *et al.* Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8 GHz microwaves using comet assay in vitro. *Toxicology* **232**, 311-316 (2007).

\*†Belyaev, I.Y., Markovà, E., Hillert, L., Malmgren, L.O. & Persson, B.R. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. *Bioelectromagnetics* **30**, 129-141 (2009).

†Bourthoumieu, S. *et al.* Aneuploidy studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using FISH. *Int. J. Radiat. Biol.* **87**, 400-408 (2011).

\*Chaturvedi, C.M. *et al.* 2.45 GHz (CW) microwave irradiation alters circadian organization, spatial memory, DNA structure in the brain cells and blood cell counts of male mice, *Mus musculus*. *Prog. Electromagn. Res. B* **29**, 23-42 (2011).

\*†Esmekaya, M.A. *et al.* Mutagenic and morphologic impacts of 1.8GHz radiofrequency radiation on human peripheral blood lymphocytes (hPBLs) and possible protective role of pre-treatment with Ginkgo bilboa (EGb 761). *Sci. Total Environ.* **410-411**, 59-64 (2011).

†Figueiredo, A.B.S., Alves, R.N. & Ramalho, A.T. Cytogenetic analysis of the effects of 2.5 and 10.5 GHz microwaves on human lymphocytes. *Genet. Mol. Biol.* **27**, 460-466 (2004).

\*Gadhia, P.K., Shah, T., Mistry, A., Pithawala, M. & Tamakuwala, D. A preliminary study to assess possible chromosomal damage among users of digital mobile phones. *Electromagn. Biol. Med.* **22**, 149-159 (2003).

\*Gandhi Gursatej, A. Genetic damage in mobile phone users: some preliminary findings. *Indian J. Hum. Genet.* **11**, 99-104 (2005).

\*Gandhi, G. & Singh, P. Cytogenetic damage in mobile phone users: preliminary data. *Int. J. Hum. Genet.* **5**, 259-265 (2005).

\*Garaj-Vrhovac, V. & Orescanin, V. Assessment of DNA sensitivity in peripheral blood leukocytes after occupational exposure to microwave radiation: the alkaline comet assay and chromatid breakage assay. *Cell. Biol. Toxicol.* **25**, 33-43 (2009).

\*Garaj-Vrhovac, V. *et al.* Assessment of cytogenetic damage and oxidative stress in personnel occupationally exposed to the pulsed microwave radiation of marine radar equipment. *Int. J. Hyg. Environ. Health* **214**, 59-65 (2011).

††Hansteen, I.L. *et al.* Cytogenetic effects of 18.0 and 16.5 GHz microwave radiation on human lymphocytes in vitro. *Anticancer Res.* **29**, 2885-2892 (2009).

Hintzsche, H. & Stopper, H. Micronucleus frequency in buccal mucosa cells of mobile phone users. *Toxicol. Lett.* **193**, 124-130 (2010).

††Hintzsche, H. *et al.* Terahertz radiation induces spindle disturbances in human-hamster hybrid cells. *Radiat. Res.* **175**, 569-574 (2011).

†Hook, G.J. *et al.* Measurement of DNA damage and apoptosis in Molt-4 cells after in vitro exposure to radiofrequency radiation. *Radiat. Res.* **161**, 193-200 (2004).

†Huang, T.Q., Lee, M., Oh, E. & Park, W.Y. Molecular responses of Jurkat T-cells to 1763 MHz radiofrequency radiation. *Int. J. Radiat. Biol.* **84**, 734-741 (2008).

\*Ji, S. *et al.* DNA damage of lymphocytes in volunteers after 4 hours use of mobile phone. *J. Prev. Med. Public Health* **37**, 373-380 (2004).

††Karaca, E. *et al.* The genotoxic effect of radiofrequency waves on mouse brain. *J. Neurooncol.* **106**, 53-58 (2012, Epub 2011).

\*Kesari, K.K. & Behari, J. Fifty-gigahertz microwave exposure effect of radiations on rat brain. *Appl. Biochem. Biotechnol.* **158**, 126-139 (2009).

Kesari, K.K., Kumar, S. & Behari, J. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. *Appl. Biochem. Biotechnol.* **164**, 546-559 (2011).

Khalil, A.M., Alshamali, A.M. & Gagaa, M.H. Detection of oxidative stress induced by mobile phone radiation in tissues of mice using 8-Oxo-7, 8-Dihydro-2'-Deoxyguanosine as a biomarker. *Int. J. Biol. Biomol. Agr. Food Biotechnol. Eng.* **5**, 240-245 (2011).

\*†‡ Korenstein-Ilan, A. *et al.* Terahertz radiation increases genomic instability in human lymphocytes. *Radiat. Res.* **170**, 224-234 (2008).

†‡ Koyama, S. *et al.* Effects of high frequency electromagnetic fields on micronucleus formation in CHO-K1 cells. *Mutat. Res.* **541**, 81-89 (2003).

†‡ Kumar, G. *et al.* Evaluation of hematopoietic system effects after in vitro radiofrequency radiation exposure in rats. *Int. J. Radiat. Biol.* **87**, 231-240 (2011).

†‡ Lagroye, I. *et al.* Measurements of alkali-labile DNA damage and protein-DNA crosslinks after 2450 MHz microwave and low-dose gamma irradiation in vitro. *Radiat. Res.* **161**, 201-214 (2004).

\*†‡ (CW but not GSM) Luukkonen, J., Hakulinen, P., Mäki-Paakkanen, J., Juutilainen, J. & Naarala, J. 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**, 54-58 (2009).

Maes, A., Van Gorp, U. & Verschaeve, L. Cytogenetic investigation of subjects professionally exposed to radiofrequency radiation. *Mutagenesis* **21**, 139-142 (2006).

\*†‡ Mashevich, M. *et al.* Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosome instability. *Bioelectromagnetics* **24**, 82-90 (2003).

†‡ Sannino, A. *et al.* Induction of adaptive response in human blood lymphocytes exposed to 900 MHz radiofrequency fields: influence of cell cycle. *Int. J. Radiat. Biol.* **87**, 993-999 (2011).

†‡ Scarfi, M.R. *et al.* THz exposure of whole blood for the study of biological effects on human lymphocytes. *J. Biol. Phys.* **29**, 171-177 (2003).

\*†‡ Schrader, T., Kleine-Ostmann, T., Munter, K., Jastrow, C. & Schmid, E. Spindle disturbances in human-hamster hybrid (A(L)) cells induced by the electrical component of the mobile communication frequency range signal. *Bioelectromagnetics* **32**, 291-301 (2011).

\*†‡ Shckorbatov, Y.G. *et al.* Effects of differently polarized microwave radiation on the microscopic structure of the nuclei in human fibroblasts. *J. Zhejiang Univ. Sci. B* **11**, 801-805 (2010).

\*†‡ Tkalec, M., Malarić, K., Pavlica, M., Pevalek-Kozlina, B. & Vidaković-Cifrek, Z. Effects of radiofrequency electromagnetic fields on seed germination and root meristematic cells of *Allium cepa* L. *Mutat. Res.* **672**, 76-81 (2009).

\*Trosic, I. & Busljeta, I. Frequency of micronucleated erythrocytes in rat bone marrow exposed to 2.45 GHz radiation. *Phys. Scripta*. **2005 T118**, 168-170 (2003).

\*Trosić, I., Pavčić, I., Milković-Kraus, S., Mladinić, M. & Zeljezić, D. Effect of electromagnetic radiofrequency radiation on the rats' brain, liver and kidney cells measured by comet assay. *Coll. Antropol.* **35**, 1259-1264 (2011).

\*Yadav, A.S. & Sharma, M.K. Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile telephone radiations. *Mutat. Res.* **650**, 175-180 (2008).

Yildirim, M.S., Yildirim, A., Zamani, A.G. & Okudan, N. Effect of mobile phone station on micronucleus frequency and chromosomal aberrations in human blood cells. *Genet. Couns.* **21**, 243-251 (2010).

†Zeni, O. *et al.* Cytogenetic observations in human peripheral blood leukocytes following in vitro exposure to THz radiation: a pilot study. *Health Phys.* **92**, 349-357 (2007).

**52% (61/118) of studies listed above which could have been included in the AGNIR report on genotoxicity (with AGNIR restriction to English language) described evidence of genotoxicity in response to radiofrequency radiation.**

**47% (36/76) of *in vitro* studies listed above which could have been included in the AGNIR report on genotoxicity described evidence of genotoxicity.**