3 精子への影響（奥野、久保田、深津、郭）（奥野分担報告書を参照）

1. 体重および臓器重量における磁場暴露の影響

形態的な異常はすべての項目において見られなかった。体重、肝臓、腎臓、精巣の重量を調べた結果を表１に示した。すべての項目について、有意な差は見られなかった。

2. 精子形成における磁場の影響

オス ICR マウスでは、生後 5～6 週間で精巣上体尾部に精子が出現する。そこで離乳（3 週齢）後 3 週間の間連続的に磁場に暴露し、精子形成における影響を調べた。マウスで射出精子を得ることは難しいため精巣上体尾部を摘出し、そこから出来る限り精子を搾り出して、一定量の希釈液に希釈して精子密度を測りコントロール群と比較することとした。この方法では運動性の悪い精子も多量に混入してくるため、一般の精子調製法に比べると運動率はかなり悪くなる。図 1A は精子密度の測定結果を示している。400μT 暴露ではむしろ磁場暴露の方が高い値を示したが、これはコントロール群に精子数が極端に低い個体がいたためである。標準偏差をとると、有意差は認められなかった。

精子の運動率についても図１Bに示すように、むしろ暴露群のほうが多少高めの値を示したが、有意な差はなかった。これもコントロール群に非常に精子数が少なく運動性も悪い精子がいたためである。今回の結果も、磁場暴露は精子形成に影響を与えないといえるであろう。本研究と比較されるのはKim らの実験（Kim, Y.W., et al., 2009）であるが、彼らの実験に比べると、本実験は磁場の強度は2倍であるが暴露時間がおよそ１/5であった。より長期間の暴露によって影響が出てくる可能性は否定出来ないが、実験スケジュール上長期間暴露ができなかった。

３．磁場のレプチンに対する影響

長期食欲・生殖力の指標として、血中レプチン濃度を測定した。結果を図2に示す。有意な差は得られなかった。今回は3週齢から3週間の曝露実験を行った。この期間、3週齢では乳離れし、6週齢では生殖器がほぼ形成され、精巣上体尾部に精子が出現する時期であり、様々な環境要因に感応しやすい時期である。しかし結果では、400μＴの50Ｈｚ交流磁場はほとんど影響しないことが明らかになった。

表１　体重および各臓器における磁場の影響

	Control		400uT	
	AV	SD	AV	SD
Body weight (g)	32.6	1.4	30.7	1.4
Liver weight (g)	2.1	0.13	1.99	0.14
Kidney weight (mg)	618	28	634	29
Testis weight (mg)	93	22	89	17

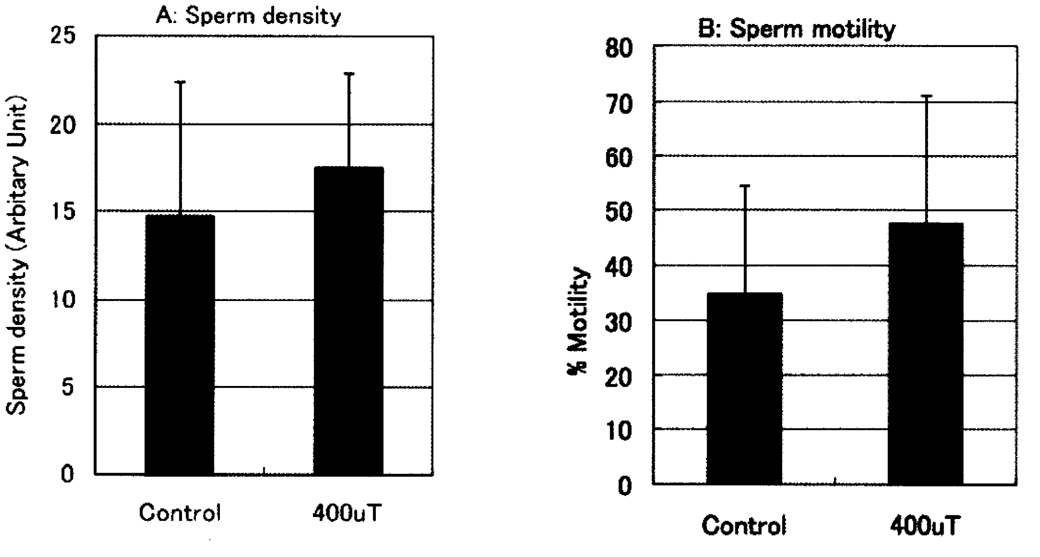

図１　精子形成における低周波数交流磁場（400 μ T）の影響。A：精子の密度における磁場暴露の影響。相対値で表してある。B：精子の運動率における磁場暴露の影響。運動率は％で表してある。N＝4

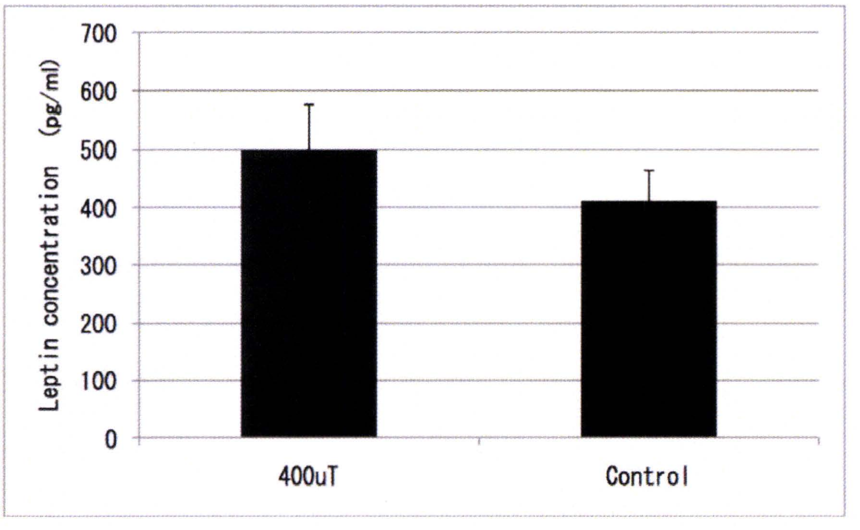

図 2.　3 週齢から 6 週齢までの 3 週間の低周波数交流磁場（400 μ T）曝露によるオスマウスの血中レプチンに対する磁場の影響。N＝4

E. 結論

文献調査１の結論

（牛山分担報告書を参照）

細胞実験および動物実験において検討した。「影響なし」の論文が多く見られた一方で、超低周波磁界、高周波磁界ともに、「影響あり」の論文も散見されたが、多くはガイドラインを大きく越える曝露条件であり、現時点では居住（生活）空間の電磁界強度が健康リスクを発生するという明確な根拠はみられないと考えられた。

文献調査２の結論

（梅景分担報告書を参照）

今回の文献調査および磁場影響の考察からは、日常生活で経験する電磁場での健康障害への明らかな直接的リスクは認められなかった。但し、酵素反応について影響があったとする報告が多く見られ、酵素反応に対する磁場効果の影響については研究継続が必要と考えられる。さらに、電磁界の生体影響について、影響するかどうかの結果が、研究対象の状態（生体側の要因）で異なるとした報告が複数あり、研究条件のきめ細かい設定が重要と思われた。電磁界を用いた臨床応用については、すでに臨床の場で応用されていることも多いが、そのメカニズムは不明なことが多く安全な利用については検討課題として重要である。

細胞レベルの実験の結論

（久保田分担報告書を参照）

１．低周波磁界(50Hz,400μT)の細胞増殖への影響

種々の培養細胞、U251MG(ヒト神経膠腫), U87MG(ヒト神経膠腫), YKG-1(ヒト神経膠腫)、KP2（ヒト膵臓癌）、LC540（ラット精巣腫瘍細胞）、CPAE（ウシ血管内皮細胞）, NSC34（マウス神経細胞), HMY-1（ヒトマラノーマ)、LK2(ヒト肺癌細胞)、U937（ヒト白血病細胞）を低周波磁界(50Hz, 400μT)に曝露し、細胞増殖への影響を解析した結果、顕著な影響は見られなかった。

２.低周波磁界の活性酸素発生への影響

種々の培養細胞を低周波磁界(50Hz,400μT)に１５分間曝露し、細胞外へ放出された過酸化水素発生を解析した。U251MG(ヒト神経膠腫), U87MG(ヒト神経膠腫), YKG-1(ヒト神経膠腫)、E10（ヒト中皮腫)、LC540(ラット精巣腫瘍細胞)、NSC34（マウス神経細胞), HMY-1（ヒトマラノーマ)、LK2(ヒト肺癌細胞)、U937（ヒト白血病細胞)のいずれの細胞においても、低周波磁界の過酸化水素発生への影響はなかった。

動物実験レベルの実験の結論

1. 電気生理学的実験
（村越分担報告書を参照）

ラット生体を低周波均一磁場（50Hz・400μT）に慢性暴露し、これらの動物から作成した帯状回皮質を含む脳スライス標本を用いて、同部位で観察される皮質神経回路シナプス伝達、特に抑制性機能の状態を電気生理学的に評価した。慢性的磁場暴露群において対照群との有意な差は見られなかった。

2. 低周波磁界の生殖系への影響
（久保田分担報告書を参照）
生殖系への影響を明らかにするため、ICR mice（妊娠マウス）（コントロール３匹、曝露群３匹）を低周波磁界(50Hz, 400μT)に16日間曝露し、胎児の生死、奇形の有無および母獣への影響で評価した。実験は２回実施した。その結果、コントロール群と磁界曝露群の間に、胎児死亡の率で有意の差は見られなかった。両群ともに胎児に奇形は見られなかった。
母獣には、下痢は見られず、行動異常も見られなかった。
以上のように、低周波磁界(50Hz, 400μT)に曝露した妊娠マウス及び胎児には影響はなかった。

3. 低周波磁界の精子への影響
（奥野分担報告書を参照）
低周波交流磁場のマウスのオス生殖機能に対する影響を調べた。
形態的な異常はすべての項目において見られなかった。体重、肝臓、腎臓、精巣の重量を調べた結果、すべての項目について、有意な差は見られなかった。
精子密度および精子の運動率についても有意な差は見られなかった。

E 参考文献

文献調査1の参考文献

1. WHO, *Extremely Low Frequency Fields*, in *Environmental Health Criteria Monograph No. 238*2007, World Health Organization Geneva, Switzerland.

2. Szemerszky, R., et al., *Stress-related endocrinological and psychopathological effects of short- and long-term 50Hz electromagnetic field exposure in rats.* Brain Res Bull, 2010. **81**(1): p. 92-99.

3. Sun, H., et al., *Effects of prenatal exposure to a 50-Hz magnetic field on one-trial passive avoidance learning in 1-day-old chicks.* Bioelectromagnetics, 2010. **31**(2): p. 150-155.

4. Gulturk, S., et al., *Effect of exposure to 50 Hz magnetic field with or without insulin on blood-brain barrier permeability in streptozotocin-induced diabetic rats.* Bioelectromagnetics, 2010. **31**(4): p. 262-9.

5. Martinez-Samano, J., et al., *Effects of acute electromagnetic field exposure and movement restraint on antioxidant system in liver, heart, kidney and plasma of Wistar rats: a preliminary report.* Int J Radiat Biol, 2010. **86**(12): p. 1088-94.

6. Rajkovic, V., M. Matavulj, and O. Johansson, *Studies on the synergistic effects of extremely low-frequency magnetic fields and the endocrine-disrupting compound atrazine on the thyroid gland.* Int J Radiat Biol, 2010. **86**(12): p. 1050-60.

7. Reyes-Guerrero, G., et al., *Extremely low-frequency electromagnetic fields differentially regulate estrogen receptor-alpha and -beta expression in the rat olfactory bulb.* Neurosci Lett, 2010. **471**(2): p. 109-13.

8. Tenorio, B.M., et al., *Testicular development evaluation in rats exposed to 60 Hz and 1 mT electromagnetic field.* J Appl Toxicol, 2010. **[Epub ahead of print]**.

9. Bernabo, N., et al., *Extremely low frequency electromagnetic field exposure affects fertilization*

outcome in swine animal model. Theriogenology, 2010. **73**(9): p. 1293-305.
10. Rajkovic, V., M. Matavulj, and O. Johansson, *Combined Exposure of Peripubertal Male Rats to the Endocrine-Disrupting Compound Atrazine and Power-Frequency Electromagnetic Fields Causes Degranulation of Cutaneous Mast Cells: A New Toxic Environmental Hazard?* Arch Environ Contam Toxicol, 2010. **59**(2): p. 334-41.
11. Ulku, R., et al., *Extremely Low-Frequency Magnetic Field Decreased Calcium, Zinc and Magnesium Levels in Costa of Rat.* Biol Trace Elem Res, 2010. **[Epub ahead of print]**.
12. Akdag, M.Z., et al., *Effects of extremely low-frequency magnetic field on caspase activities and oxidative stress values in rat brain.* Biological trace element research, 2010. **138**(1-3): p. 238-49.
13. Mariucci, G., et al., *Brain DNA damage and 70-kDa heat shock protein expression in CD1 mice exposed to extremely low frequency magnetic fields.* Int J Radiat Biol, 2010. **86**(8): p. 701-10.
14. Focke, F., et al., *DNA fragmentation in human fibroblasts under extremely low frequency electromagnetic field exposure.* Mutat Res, 2010. **683**(1-2): p. 74-83.
15. Kaszuba-Zwoinska, J., et al., *Pulsating electromagnetic field stimulation prevents cell death of puromycin treated U937 cell line.* J Physiol Pharmacol, 2010. **61**(2): p. 201-5.
16. Kim, J., et al., *Repetitive exposure to a 60-Hz time-varying magnetic field induces DNA double-strand breaks and apoptosis in human cells.* Biochem Biophys Res Commun, 2010. **400**(4): p. 739-44.
17. Sun, W., et al., *Effects of 50-Hz magnetic field exposure on hormone secretion and apoptosis-related gene expression in human first trimester villous trophoblasts in vitro.* Bioelectromagnetics, 2010. **31**(7): p. 566-72.

18. Akan, Z., et al., *Extremely low-frequency electromagnetic fields affect the immune response of monocyte-derived macrophages to pathogens.* Bioelectromagnetics, 2010. **31**(8): p. 603-12.
19. Rodriguez de la Fuente, A.O., et al., *Effect of 60 Hz electromagnetic fields on the activity of hsp70 promoter: an in vitro study.* Cell Biol Int, 2009. **33**(3): p. 419-23.
20. Iorio, R., et al., *Involvement of mitochondrial activity in mediating ELF-EMF stimulatory effect on human sperm motility.* Bioelectromagnetics, 2011. **32**(1): p. 15-27.
21. Morabito, C., et al., *Modulation of redox status and calcium handling by extremely low frequency electromagnetic fields in C2C12 muscle cells: A real-time, single-cell approach.* Free Radic Biol Med, 2010. **48**(4): p. 579-589.
22. Markkanen, A., J. Naarala, and J. Juutilainen, *A Study on the effects of 50 Hz magnetic fields on UV-induced radical reactions in murine fibroblasts.* J Radiat Res (Tokyo), 2010. **51**(5): p. 609-13.
23. Ravera, S., et al., *Sinusoidal ELF magnetic fields affect acetylcholinesterase activity in cerebellum synaptosomal membranes.* Bioelectromagnetics, 2010. **31**(4): p. 270-6.
24. Mannerling, A.C., et al., *Effects of 50-Hz magnetic field exposure on superoxide radical anion formation and HSP70 induction in human K562 cells.* Radiation and environmental biophysics, 2010. **49**(4): p. 731-41.
25. Di Campli, E., et al., *Effects of Extremely Low-Frequency Electromagnetic Fields on Helicobacter pylori Biofilm.* Curr Microbiol, 2009. **60**(6).
26. Magazu, S., E. Calabro, and S. Campo, *FTIR Spectroscopy Studies on the Bioprotective Effectiveness of Trehalose on Human Hemoglobin Aqueous Solutions under 50 Hz Electromagnetic Field Exposure.* J Phys Chem B, 2010. **114**(37): p. 12144-9.
27. Szemerszky, R., et al., *Polluted places or polluted minds? An experimental sham-exposure study on*

background psychological factors of symptom formation in 'Idiophatic Environmental Intolerance attributed to electromagnetic fields'. Int J Hyg Environ Health, 2010. **213**(5): p. 387-94.

28. McNamee, D.A., et al., *The cardiovascular response to an acute 1800-muT, 60-Hz magnetic field exposure in humans.* Int Arch Occup Environ Health, 2009. **83**(4): p. 441-54.

29. McNamee, D.A., et al., *The response of the human circulatory system to an acute 200-muT, 60-Hz magnetic field exposure.* Int Arch Occup Environ Health, 2010. **84**(3): p. 267-77.

30. Auger, N., et al., *The relationship between residential proximity to extremely low frequency power transmission lines and adverse birth outcomes.* J Epidemiol Community Health, 2010. **65**(1): p. 83-5.

31. Kheifets, L., et al., *Pooled analysis of recent studies on magnetic fields and childhood leukaemia.* Br J Cancer, 2010. **103**(7): p. 1128-35.

32. Kheifets, L., et al., *A pooled analysis of extremely low-frequency magnetic fields and childhood brain tumors.* Am J Epidemiol, 2010. **172**(7): p. 752-61.

33. Chen, C., et al., *Extremely low-frequency electromagnetic fields exposure and female breast cancer risk: a meta-analysis based on 24,338 cases and 60,628 controls.* Breast Cancer Res Treat, 2010. **123**(2): p. 569-76.

34. Hug, K., et al., *Parental occupational exposure to extremely low frequency magnetic fields and childhood cancer: a German case-control study.* Am J Epidemiol, 2010. **171**(1): p. 27-35.

35. Behrens, T., et al., *Occupational exposure to electromagnetic fields and sex-differential risk of uveal melanoma.* Occup Environ Med, 2010. **67**(11): p. 751-9.

36. Andel, R., et al., *Work-Related Exposure to Extremely Low-Frequency Magnetic Fields and Dementia: Results from the Population-Based Study of Dementia in Swedish Twins.* J Gerontol A Biol Sci Med Sci, 2010. **65**(11): p. 1220-7.

37. Tillmann, T., et al., *Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model.* Int J Radiat Biol, 2010. **86**(7): p. 529-41.
38. Sommer, A.M., et al., *Effects of radiofrequency electromagnetic fields (UMTS) on reproduction and development of mice: a multi-generation study.* Radiat Res, 2009. **171**(1): p. 89-95.
39. Chavdoula, E.D., D.J. Panagopoulos, and L.H. Margaritis, *Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: detection of apoptotic cell-death features.* Mutat Res, 2010. **700**(1-2): p. 51-61.
40. Watilliaux, A., et al., *Effect of Exposure to 1,800 MHz Electromagnetic Fields on Heat Shock Proteins and Glial Cells in the Brain of Developing Rats.* Neurotox Res, 2010.
41. Ammari, M., et al., *GFAP expression in the rat brain following sub-chronic exposure to a 900 MHz electromagnetic field signal.* Int J Radiat Biol, 2010. **86**(5): p. 367-75.
42. Imge, E.B., et al., *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, 2010. **86**(12): p. 1044-9.
43. Maskey, D., et al., *Effect of 835 MHz radiofrequency radiation exposure on calcium binding proteins in the hippocampus of the mouse brain.* Brain Res, 2010. **1313**: p. 232-41.
44. Maskey, D., et al., *Chronic 835-MHz radiofrequency exposure to mice hippocampus alters the distribution of calbindin and GFAP immunoreactivity.* Brain Res, 2010. **1346**: p. 237-46.
45. Sonmez, O.F., et al., *Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 Mhz electromagnetic field.* Brain Res, 2010. **1356**: p. 95-101.
46. Ragbetli, M.C., et al., *The effect of mobile phone on the number of Purkinje cells: a stereological study.* Int J Radiat Biol, 2010. **86**(7): p. 548-54.

47. Vorobyov, V., et al., *Repeated exposure to low-level extremely low frequency-modulated microwaves affects cortex-hypothalamus interplay in freely moving rats: EEG study.* Int J Radiat Biol, 2010. **86**(5): p. 376-83.

48. Finnie, J.W., et al., *Microglial activation as a measure of stress in mouse brains exposed acutely (60 minutes) and long-term (2 years) to mobile telephone radiofrequency fields.* Pathology, 2010. **42**(2): p. 151-4.

49. Takahashi, S., et al., *Lack of adverse effects of whole-body exposure to a mobile telecommunication electromagnetic field on the rat fetus.* Radiation research, 2010. **173**(3): p. 362-72.

50. Bartsch, H., et al., *Effect of chronic exposure to a GSM-like signal (mobile phone) on survival of female Sprague-Dawley rats: modulatory effects by month of birth and possibly stage of the solar cycle.* Neuro Endocrinol Lett, 2010. **31**(4): p. 457-73.

51. Esmekaya, M.A., N. Seyhan, and S. Omeroglu, *Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: A light, electron microscopy and immunohistochemical study.* Int J Radiat Biol, 2010. **86**(12): p. 1106-16.

52. Ozgur, E., G. Guler, and N. Seyhan, *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, 2010. **86**(11): p. 935-45.

53. Tomruk, A., G. Guler, and A.S. Dincel, *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, 2009. **56**(1): p. 39-47.

54. Lee, H.J., et al., *Lack of teratogenicity after combined exposure of pregnant mice to CDMA and WCDMA radiofrequency electromagnetic fields.* Radiat Res, 2009. **172**(5): p. 648-52.

55. Yamashita, H., et al., *Short-term exposure to a 1439-MHz TDMA signal exerts no estrogenic effect*

in rats. Bioelectromagnetics, 2010. **31**(7): p. 573-5.

56. Salama, N., et al., *Effects of exposure to a mobile phone on sexual behavior in adult male rabbit: an observational study.* Int J Impot Res, 2009. **22**(2): p. 127-33.

57. Belyaev, I., E. Markova, and L. Malmgren, *Microwaves from Mobile Phones Inhibit 53BP1 Focus Formation in Human Stem Cells Stronger than in Differentiated Cells: Possible Mechanistic Link to Cancer Risk.* Environ Health Perspect, 2010. **118**(3): p. 394-399.

58. Franzellitti, S., et al., *Transient DNA damage induced by high frequency electromagnetic fields (GSM 1.8GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline Comet assay.* Mutat Res, 2010. **683**(1-2): p. 35-42.

59. 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, 2009. **695**(1-2): p. 16-21.

60. Bourthoumieu, S., et al., *Cytogenetic Studies in Human Cells Exposed In Vitro to GSM-900 MHz Radiofrequency Radiation Using R-Banded Karyotyping.* Radiat Res, 2010. **174**(6): p. 712-8.

61. Hintzsche, H. and H. Stopper, *Micronucleus frequency in buccal mucosa cells of mobile phone users.* Toxicol Lett, 2009. **193**(1): p. 124-30.

62. Luukkonen, J., J. Juutilainen, and J. Naarala, *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, 2010. **31**(6): p. 417-24.

63. Gerner, C., et al., *Increased protein synthesis by cells exposed to a 1,800-MHz radio-frequency mobile phone electromagnetic field, detected by proteome profiling.* Int Arch Occup Environ Health, 2010. **83**(6): p. 691-702.

64. Hirose, H., et al., *1950 MHz IMT-2000 field does not activate microglial cells in vitro.* Bioelectromagnetics, 2009.

65. Lee, K.Y., et al., *Effects of combined radiofrequency radiation exposure on the cell cycle and its regulatory proteins.* Bioelectromagnetics, 2010.

66. Nylund, R., N. Kuster, and D. Leszczynski, *Analysis of proteome response to the mobile phone radiation in two types of human primary endothelial cells.* Proteome Sci, 2010. **8**: p. 52.

67. Sekijima, M., et al., *2-GHz Band CW and W-CDMA Modulated Radiofrequency Fields Have No Significant Effect on Cell Proliferation and Gene Expression Profile in Human Cells.* J Radiat Res (Tokyo), 2010. **51**(3): p. 277-84.

68. Falzone, N., et al., *Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa.* Radiat Res, 2010. **174**(2): p. 169-76.

69. Xu, S., et al., *Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons.* Brain Res, 2009. **1311**: p. 189-96.

70. Kowalczuk, C., et al., *Absence of nonlinear responses in cells and tissues exposed to RF energy at mobile phone frequencies using a doubly resonant cavity.* Bioelectromagnetics, 2010. **31**(7): p. 556-65.

71. O'Connor, R.P., et al., *Exposure to GSM RF fields does not affect calcium homeostasis in human endothelial cells, rat pheocromocytoma cells or rat hippocampal neurons.* PLoS One, 2010. **5**(7): p. e11828.

72. Bak, M., et al., *Effects of GSM signals during exposure to event related potentials (ERPs).* Int J Occup Med Environ Health, 2010. **23**(2): p. 191-9.

73. Croft, R.J., et al., *Effects of 2G and 3G mobile phones on human alpha rhythms: Resting EEG in adolescents, young adults, and the elderly.* Bioelectromagnetics, 2010. **31**(6): p. 434-44.

74. Lowden, A., et al., *Sleep after mobile phone exposure in subjects with mobile phone-related symptoms.* Bioelectromagnetics, 2010. **32**(1): p. 4-14.

75. Vecchio, F., et al., *Mobile phone emission modulates inter-hemispheric functional coupling of EEG alpha rhythms in elderly compared to young subjects.* Clin Neurophysiol, 2010. **121**(2): p. 163-171.

76. Maganioti, A.E., et al., *Principal component analysis of the P600 waveform: RF and gender effects.* Neurosci Lett, 2010. **478**(1): p. 19-23.

77. Mizuno, Y., et al., *Effects of W-CDMA 1950 MHz EMF emitted by mobile phones on regional cerebral blood flow in humans.* Bioelectromagnetics, 2009. **30**(7): p. 536-44.

78. Kwon, M.S., et al., *No effects of mobile phone electromagnetic field on auditory brainstem response.* Bioelectromagnetics, 2009. **31**(1): p. 48-55.

79. Parazzini, M., et al., *Absence of short-term effects of UMTS exposure on the human auditory system.* Radiat Res, 2010. **173**(1): p. 91-7.

80. Parazzini, M., et al., *Effects of UMTS Cellular Phones on Human Hearing: Results of the European Project "EMFnEAR".* Radiat Res, 2009. **172**(2): p. 244-51.

81. Okano, T., et al., *The effect of electromagnetic field emitted by a mobile phone on the inhibitory control of saccades.* Clin Neurophysiol, 2010. **121**(4): p. 603-11.

82. Sauter, C., et al., *Effects of exposure to electromagnetic fields emitted by GSM 900 and WCDMA mobile phones on cognitive function in young male subjects.* Bioelectromagnetics, 2010.

83. Wallace, D., et al., *Do TETRA (Airwave) Base Station Signals Have a Short-Term Impact on Health and Well-Being? A Randomized Double-Blind Provocation Study.* Environ Health Perspect, 2010. **118**(6): p. 735-41.

84. Riddervold, I.S., et al., *No effect of TETRA hand portable transmission signals on human cognitive function and symptoms.* Bioelectromagnetics, 2010. **31**(5): p. 380-90.

85. Nam, K.C., et al., *Hypersensitivity to RF fields emitted from CDMA cellular phones: A provocation study.* Bioelectromagnetics, 2009.

86. Thomas, S., et al., *Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents.* Eur J Epidemiol, 2010. **25**(2): p. 135-41.
87. Abramson, M.J., et al., *Mobile telephone use is associated with changes in cognitive function in young adolescents.* Bioelectromagnetics, 2009. **30**(8): p. 678-86.
88. Heinrich, S., et al., *Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study.* Environ Health, 2010. **9**: p. 75.
89. Heinrich, S., et al., *The impact of exposure to radio frequency electromagnetic fields on chronic well-being in young people - A cross-sectional study based on personal dosimetry.* Environ Int, 2010. **37**(1): p. 26-30.
90. Thomas, S., et al., *Use of mobile phones and changes in cognitive function in adolescents.* Occupational and environmental medicine, 2010. **67**(12): p. 861-6.
91. Milde-Busch, A., et al., *The association between use of electronic media and prevalence of headache in adolescents: results from a population-based cross-sectional study.* BMC Neurol, 2010. **10**(1): p. 12.
92. Mohler, E., et al., *Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: a cross-sectional study.* Radiat Res, 2010. **174**(3): p. 347-56.
93. Berg-Beckhoff, G., et al., *Mobile phone base stations and adverse health effects: phase 2 of a cross-sectional study with measured radio frequency electromagnetic fields.* Occup Environ Med, 2009. **66**(2): p. 124-30.
94. Hartikka, H., et al., *Mobile phone use and location of glioma: a case-case analysis.* Bioelectromagnetics, 2009. **30**(3): p. 176-82.
95. *Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international*

case-control study. Int J Epidemiol, 2010. **39**(3): p. 675-94.
96. Elliott, P., et al., *Mobile phone base stations and early childhood cancers: case-control study.* BMJ, 2010. **340**: p. c3077.
97. Divan, H.A., et al., *Cell phone use and behavioural problems in young children.* J Epidemiol Community Health, _2010

文献調査２の参考文献

1. Mayer-Wagner S, Passberger A, Sievers B, Aigner J, Summer B, Schiergens TS, Jansson V, Müller PE. Effects of low frequency electromagnetic fields on the chondrogenic differentiation of human mesenchymal stem cells. Bioelectromagnetics. 2010 Dec 22.

2. Roux D, Girard S, Paladian F, Bonnet P, Lalléchère S, Gendraud M, Davies E, Vian A. Human keratinocytes in culture exhibit no response when exposed to short duration, low amplitude, high frequency (900 MHz) electromagnetic fields in a reverberation chamber. Bioelectromagnetics. 2010 Dec 22.

3. Kumar G, Wood AW, Anderson V, McIntosh RL, Chen YY, McKenzie RJ. Evaluation of hematopoietic system effects after in vitro radiofrequency radiation exposure in rats. Int J Radiat Biol. 2010 Nov 10.

4. Kumar G, Wood AW, Anderson V, McIntosh RL, Chen YY, McKenzie RJ. Evaluation of hematopoietic system effects after in vitro radiofrequency radiation exposure in rats. Int J Radiat Biol. 2010 Nov 10.

5. Lee HM, Kwon UH, Kim H, Kim HJ, Kim B, Park JO, Moon ES, Moon SH. Pulsed electromagnetic field stimulates cellular proliferation in human intervertebral disc cells. Yonsei Med J. 2010 Nov 1;51(6):954-9.

6. Heredia-Rojas JA, Rodríguez de la Fuente AO, Alcocer González JM, Rodríguez-Flores LE, Rodríguez-Padilla C, Santoyo-Stephano MA, Castañeda-Garza E, Taméz-Guerra RS. Effect of 60 Hz magnetic fields on the activation of hsp70 promoter in cultured INER-37 and RMA E7 cells. In Vitro Cell Dev Biol Anim. 2010 Oct;46(9):758-63.

7. Garaj-Vrhovac V, Gajski G, Pažanin S, Sarolić A, Domijan AM, Flajs D, Peraica M. 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. 2011 Jan;214(1):59-65.

8. Yang X, He G, Hao Y, Chen C, Li M, Wang Y, Zhang G, Yu Z. The role of the JAK2-STAT3 pathway in pro-inflammatory responses of EMF-stimulated N9 microglial cells. J Neuroinflammation. 2010 Sep 9;7:54.

9. Emre M, Cetiner S, Zencir S, Unlukurt I, Kahraman I, Topcu Z. Oxidative stress and apoptosis in relation to exposure to magnetic field. Cell Biochem Biophys. 2011 Mar;59(2):71-7.

10. Cuccurazzu B, Leone L, Podda MV, Piacentini R, Riccardi E, Ripoli C, Azzena GB, Grassi C. Exposure to extremely low-frequency (50 Hz) electromagnetic fields enhances adult hippocampal neurogenesis in C57BL/6 mice. Exp Neurol. 2010 Nov;226(1):173-82.

11. Kim J, Ha CS, Lee HJ, Song K. Repetitive exposure to a 60-Hz time-varying magnetic field induces DNA double-strand breaks and apoptosis in human cells. Biochem Biophys Res Commun. 2010 Oct 1;400(4):739-44.

12. Collard JF, Mertens B, Hinsenkamp M. In vitro study of the effects of ELF electric fields on gene expression in human epidermal cells. Bioelectromagnetics. 2011 Jan;32(1):28-36.

13. Jansen JH, van der Jagt OP, Punt BJ, Verhaar JA, van Leeuwen JP, Weinans H, Jahr H. Stimulation of osteogenic differentiation in human osteoprogenitor cells by pulsed electromagnetic fields: an in vitro study. BMC Musculoskelet Disord. 2010 Aug 23;11:188.

14: Sun W, Tan Q, Pan Y, Fu Y, Sun H, Chiang H. Effects of 50-Hz magnetic field exposure on hormone secretion and apoptosis-related gene expression in human first trimester villous trophoblasts in vitro. Bioelectromagnetics. 2010 Oct;31(7):566-72.

15. Garip AI, Akan Z. Effect of ELF-EMF on number of apoptotic cells; correlation with reactive oxygen species and HSP. Acta Biol Hung. 2010 Jun;61(2):158-67.

16. Chavdoula ED, Panagopoulos DJ, Margaritis LH. Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: Detection of apoptotic cell-death features. Mutat Res. 2010 Jul

17: Ammari M, Gamez C, Lecomte A, Sakly M, Abdelmelek H, De Seze R. GFAP expression in the rat brain following sub-chronic exposure to a 900 MHz electromagnetic field signal. Int J Radiat Biol. 2010 May;86(5):367-75.

18. Sollazzo V, Palmieri A, Pezzetti F, Massari L, Carinci F. Effects of pulsed electromagnetic fields on human osteoblastlike cells (MG-63): a pilot study. Clin Orthop Relat Res. 2010 Aug;468(8):2260-77.

19. Söderqvist F, Hardell L, Carlberg M, Mild KH. Radiofrequency fields, transthyretin, and Alzheimer's disease. J Alzheimers Dis. 2010;20(2):599-606.

20. Campisi A, Gulino M, Acquaviva R, Bellia P, Raciti G, Grasso R, Musumeci F, Vanella A, Triglia A. Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure

to low intensity microwave electromagnetic field. Neurosci Lett. 2010 Mar 31;473(1):52-5

21. Gerner C, Haudek V, Schandl U, Bayer E, Gundacker N, Hutter HP, Mosgoeller W. Increased protein synthesis by cells exposed to a 1,800-MHz radio-frequency mobile phone electromagnetic field, detected by proteome profiling. Int Arch Occup Environ Health. 2010 Aug;83(6):691-702.

22. Reyes-Guerrero G, Guzmán C, García DE, Camacho-Arroyo I, Vázquez-García M. Extremely low-frequency electromagnetic fields differentially regulate estrogen receptor-alpha and -beta expression in the rat olfactory bulb. Neurosci Lett. 2010 Mar 3;471(2):109-13.

23. Hao Y, Yang X, Chen C, Yuan-Wang, Wang X, Li M, Yu Z. STAT3 signalling pathway is involved in the activation of microglia induced by 2.45 GHz electromagnetic fields. Int J Radiat Biol. 2010 Jan;86(1):27-36.

24. Chen J, He HC, Xia QJ, Huang LQ, Hu YJ, He CQ. Effects of pulsed electromagnetic fields on the mRNA expression of RANK and CAII in ovariectomized rat osteoclast-like cell. Connect Tissue Res. 2010;51(1):1-7.

25. Yang Y, Tao C, Zhao D, Li F, Zhao W, Wu H. EMF acts on rat bone marrow mesenchymal stem cells to promote differentiation to osteoblasts and to inhibit differentiation to adipocytes. Bioelectromagnetics. 2010 May;31(4):277-85.

26. Amara S, Douki T, Garel C, Favier A, Sakly M, Rhouma KB, Abdelmelek H. Effects of static magnetic field exposure on antioxidative enzymes activity and DNA in rat brain. Gen Physiol Biophys. 2009 Sep;28(3):260-5.

27. Hintzsche H, Stopper H. Micronucleus frequency in buccal mucosa cells of mobile phone users. Toxicol Lett. 2010 Mar 1;193(1):124-30. Epub 2009 Dec 29.

28 Di Campli E, Di Bartolomeo S, Grande R, Di Giulio M, Cellini L. Effects of extremely low-frequency electromagnetic fields on Helicobacter pylori biofilm. Curr Microbiol. 2010 Jun;60(6):412-8.

29. Focke F, Schuermann D, Kuster N, Schär P. DNA fragmentation in human fibroblasts under extremely low frequency electromagnetic field exposure. Mutat Res. 2010 Jan 5;683(1-2):74-83.

30. Girgert R, Hanf V, Emons G, Gründker C. Signal transduction of the melatonin receptor MT1 is disrupted in breast cancer cells by electromagnetic fields. Bioelectromagnetics. 2010 Apr;31(3):237-45.

31. Xu S, Zhou Z, Zhang L, Yu Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Zhong M. Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons. Brain Res. 2010 Jan 22;1311:189-96.

32. Sun LY, Hsieh DK, Lin PC, Chiu HT, Chiou TW. Pulsed electromagnetic fields accelerate proliferation and osteogenic gene expression in human bone marrow mesenchymal stem cells during osteogenic differentiation. Bioelectromagnetics. 2010 Apr;31(3):209-19.

細胞レベルの実験　参考文献

1. Kheifets L, Repacholi M, Saunders R, van Deventer E. The sensitivity of children to electromagnetic fields. Pediatrics. 2005 Aug;116(2): 303-13.

2. Schmiedel S, Brüggemeyer H, Philipp J, Wendler J, Merzenich H, Schüz J. An evaluation of exposure metrics in an epidemiologic study on radio and television broadcast transmitters and the risk of childhood leukemia. Bioelectromagnetics. 2009;30(2):81-91.