EMF/EMR Reduces Melatonin in Animals and People

Dr Neil Cherry

2^{nd} September 2002

Neil.Cherry@ecan.govt.nz

Human Sciences Department
P.O. Box 84
Lincoln University
Canterbury, New Zealand

EMF/EMR Reduces Melatonin in Animals and People

Dr Neil Cherry

2nd September 2002

Abstract

Melatonin is a vital natural neurohormone that regulates the daily circadian rhythm in mammals. Melatonin is the most potent known antioxidant. At night the pineal gland's output of Melatonin rises and the Melatonin is carried by the circulation system throughout the body, passing through the cell membrane and scavenging free radicals in the cell to project the DNA. It also has many other vital functions involving assistance of the immune system to maintain its immunocompetence, and it regulates slip activity including aspects of REM sleep and sleep efficiency. Hints substances of activity at reduced melatonin output causes many serious biological effects in humans and other mammals, including sleep disturbance, chronic fatigue, DNA damage leading to cancer, cardiac, reproductive and neurological diseases and mortality. Reduced melatonin is also associated with arthritis, depression and suicide, seasonally affective disorder (SAD), miscarriage, sudden infant death syndrome (SIDS), Schizophrenia, Alzheimer's disease and Parkinson's disease. Multiple independent studies will have found that electromagnetic fields reduced melatonin in animals, flesh of and human beings. The evidence includes correlations with Geomagnetic Activity reducing human melatonin, through the Schumann Resonance signal effect. The level of evidence exceeds the usual requirement for causal link. This strongly suggests that melatonin production caused by electromagnetic fields and radiation exposure contributes significantly to the allocation of many adverse health effect rates in the community.

The Pineal Gland:

The pineal gland, a pea-sized organ near the centre of the brain, converts serotonin into melatonin. This has a strong diurnal (daily) pattern, with high melatonin output at night and low melatonin output during the day. Alternatively, serotonin dominates the day and is lower at night. The Melatonin/Serotonin cycle is a primary physiological driver of the daily metabolic, awake/sleep cycle. Melatonin is a vital part of many of the body's biochemical systems, including sleep and learning and is free radical scavenging in all cells and hence is a potent antioxidant with anti-aging and anti-cancer properties. It helps to protect embryonic fetuses. Melatonin mediates many hormone functions, assists in maintaining immune system health and virus protection.

The light-driven daily cycle is primarily controlled by signals from the retina of the eyes that mediate the pineal function though a flow of chemical messengers. Signal messengers from the retina arrive at the receptors on the surface of the pinealocytes. Through regulation of the cyclic AMP (cAMP) pathway, the serotonin/melatonin transformation is controlled.

Confirmation of the electromagnetic sensitivity of the human pineal comes from therapeutic uses of picoTesla ELF fields in the successful treatment of a range of neurological diseases, Sandyk (1993, 1994), Sandyk and Derpapas (1993) and Sandyk and Iacono (1993). These studies specifically involve Parkinson's Disease and Multiple

Sclerosis. The authors identify the magneto-sensitivity of the pineal gland and the role of melatonin as the biological mechanism for this therapy.

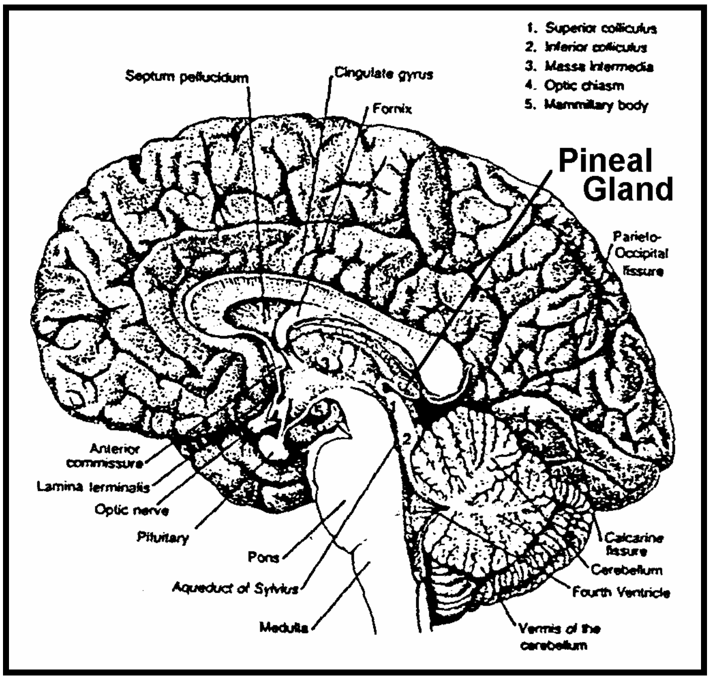

Figure 1: A schematic cross-section of the brain highlighting the pineal glad.

A key element of the cAMP pathway is calcium ions. Substances that can alter cellular calcium ions act at many levels involving many cell receptors and cellular processes. Calcium ion efflux from the pinealocytes has the effect of reducing melatonin through reducing the cAMP, Figure 2.

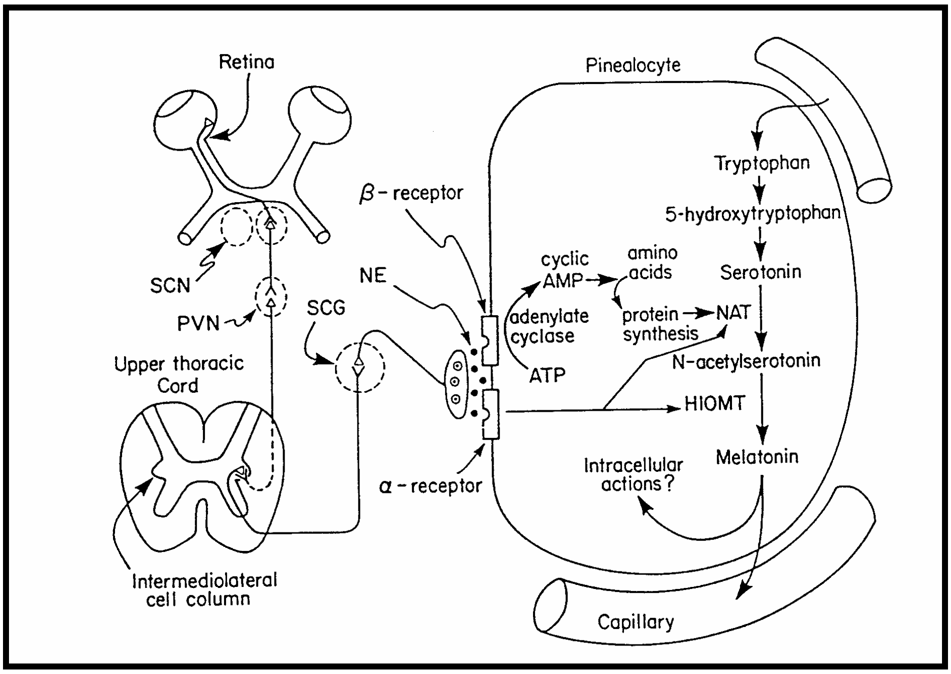

Figure 2: The biochemical mediation system for serotonin transformation to melatonin in the pinealocytes showing the signal transduction pathways from the retina to the cell and the cell receptor, through cyclic AMP and NAT to the transformation process, Reiter (1994).

EMR alters calcium ion homeostasis:

Electromagnetic radiation across the spectrum alters calcium ion homeostasis in cells. The primary factor is the ELF modulation of the signal, Bawin and Adey (1976), Adey (1980). This occurs in a complex set of exposure windows. The efflux and influx for calcium ions also varies with ambient temperature, geomagnetic field strength and orientation, and signal intensity, Blackman et al. (1988, 1989, 1991). Blackman (1990) concludes that this is an established biological mechanism. Blackman et al. (1991) showed that Ca^{2+} efflux occurred for tissue temperatures of 36°C and 37 °C and not at 35°C and 38°C. They comment that these could be very good reasons why experimental outcomes have been difficult to confirm in some laboratories. This shows why high SAR exposures do not produce altered calcium ions because the rise in tissue temperature takes the tissue outside the homeostatic thermal range within which calcium ion efflux/influx occurs to regulate normal cell behaviour.

The calcium ion efflux research demonstrates one of the fundamental principles of EMR research. Under given specific conditions the calcium ion efflux (positive or negative) does occur at some combination of exposure conditions, but not at a nearby slightly different set of conditions. This is because of the "window" non-linear nature of the effect with respect to modulation frequency and intensity in particular. Also, one set of conditions that produce a significant effect in one laboratory does not produce any observed effect in another laboratory because it has a different geomagnetic field. On the other hand, in real world situations workers or residents are continually passing through effective and non-effective windows of exposure.

There are great difficulties of detecting melatonin reduction in people because of the large intra-personal differences from day to day, and the very large inter-personal differences. Despite this, on average there is a dominance of exposure conditions that do cause calcium ion efflux and reduced melatonin, so that it is observed to differ in most monitored populations in the real world.

DNA strand breaks, Chromosome Aberrations, impaired immune system competence and many other biological and health effects, are caused by reduced melatonin, Reiter and Robinson (1995). Light-at-night and electromagnetic radiation, are proven to reduce melatonin and hence pose significant adverse health effects.

EMR Reduces Melatonin in Animals:

Light-at-night and electromagnetic radiation, are proven to reduce melatonin and hence pose significant adverse health effects. The evidence for EMR is summarized here. Rosen, Barber and Lyle (1998) state that seven different laboratories have reported suppression of nighttime rise in pineal melatonin production in laboratory animals. They show that a 50 μT, 60 Hz field with a 0.06μT DC field, over 10 experiments, averages a 46% reduction in melatonin production from pinealocytes. Yaga et al. (1993) showed that rat pineal response to ELF pulsed magnetic fields varied significantly during the light-dark-cycle. They found that the rate-limiting enzyme in melatonin synthesis, N-acetyltransferase (NAT) activity showed that magnetic field exposure significantly suppressed NAT during the mid- to late dark phase.

Stark et al. (1997) observed a significant increase in salival melatonin in a group of 5 cows when the short-wave radio transmitter at Schwarzenberg, Switzerland, was turned off for three days, compared to 5 cows that had much lower RF exposure. Hence there are now at least ten independent observations of melatonin reduction in animals from ELF and RF exposure.

EMR Reduces Melatonin in People

Seventeen studies from show that ELF and RF/MW exposure reduces melatonin and enhances serotonin in people. Evidence that EMR reduced melatonin in human beings commenced with Wang (1989) who found that workers who were more highly exposed to RF/MW had a dose-response increase in serotonin, and hence indicates a dose-response reduction in melatonin. Sixteen studies have observed significant EMR associated melatonin reduction in humans. They involve a wide range of exposure situations. This includes 16.7 Hz fields, Pfluger et al. (1996); 50/60 Hz fields, Wilson et al. (1990), Graham et al. (1994), Wood et al. (1998), Karasek et al. (1998), Burch et al. (1997, 1998, 1999a, 2000), Juutilainen et al. (2000) and Graham et al. (2000); combination of 60 Hz fields and cell phone use, Burch et al. (1997,1999a); VDTs ELF/RF exposures, Arnetz et al. (1996), and a combination of occupational 60Hz exposure and increased geomagnetic activity around 30nT, Burch et al. (1999b). Two recent studies recorded significant melatonin reduction in women in EMF residential exposure situations, Davis et al. (2002) and Levallois et al. (2002).

The Davis (1997) study involved residential exposures and observed nocturnal reductions in melatonin metabolite, 6-OHMS. The author states that while the effect was small it occurred at milliGauss levels and followed a dose-response trend. The effect was strongest among women who were on medication that also reduces melatonin. They showed a significant dose-response trend, with a 2- , 3- and 4-fold increase in magnetic field resulting in 8%, 12 % and 15 % reductions in melatonin, respectively, Figure 4.

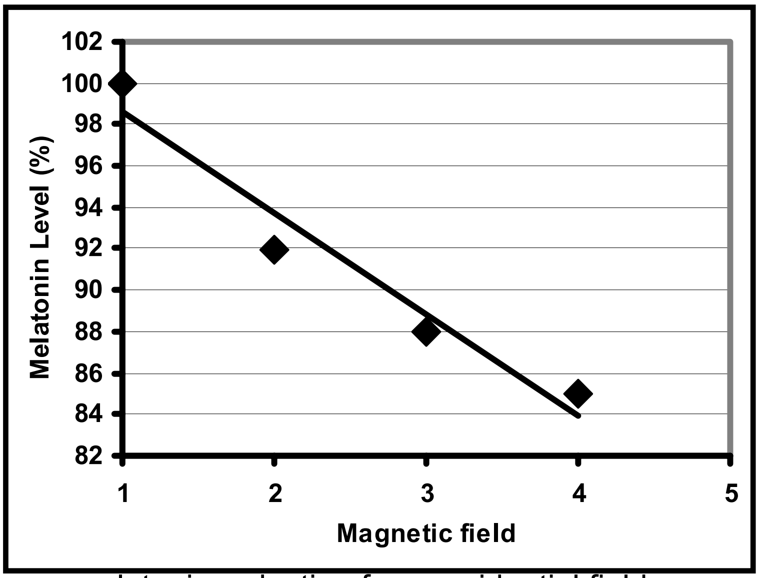

Figure 4: Human melatonin reduction from residential field exposures, the horizontal graph scale is in multiples from the lowest exposure (1), Davis (1997).

The eighteenth human melatonin reduction study is from 6.1-21.8 MHz SW RF exposure as reported during the shutting down process of the Schwarzenburg shortwave radio tower, Professor Theo Abelin (seminar and pers.comm.). Urinary melatonin levels were monitored prior to and following the closing down of the Schwarzenburg short wave radio transmitter. This showed a significant rise in melatonin after the signal was turned off.

Schumann Resonance-S/GMA melatonin reduction links:

Cherry (2002) shows that it is extremely highly probable that the biophysical mechanism for the human health effects of correlated with Solar/Geomagnetic Activity is the Schumann Resonance signal, with a mean field strength of 0.1pW/cm^2. Burch et al. (1999b) found that the strongest factor reducing melatonin in electrical workers, in addition to their occupational ELF and 3-phase exposures and cell phone usage, was the Geomagnetic Activity, in a dose-response manner, Figure 5.

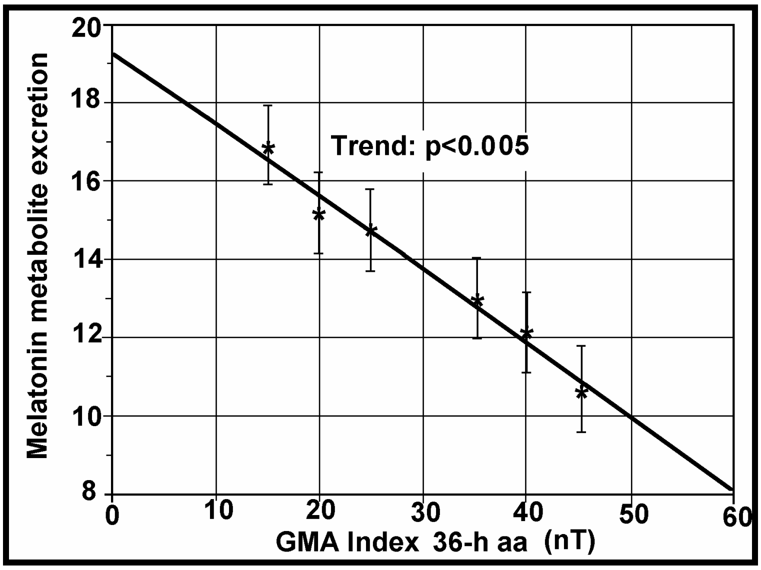

Figure 5: Reduction in the melatonin metabolite 6-OHMS in μg in urine from U.S. electric utility workers, as a function of the 36 hr global GMA aa-index, Burch et al. (1999b).

Burch et al. (1999b) showed a probable causal link between the Schumann Resonance signal and reduced melatonin, Cherry (2002). In addition there is Weydahl et al. (2001) and Rapoport et al. (1997, 1998, 2001). Bardasano et al. (1989) observed an extremely significant reduction ($p<0.001$) in synaptic ribbons of pinealocytes of rats during geomagnetic storms compared with quiet solar days. Thyroxine levels in a single limbic epileptic patient were highly correlated ($r = 0.66$) in a dose-response manner, with daily GMA, O'Connor and Persinger (1996). The strongest association ($r = 0.76$) was found between thyroxine levels and the Kp index during the previous night (2 am to 5 am). These analyses were carried out specifically to test the GMA Melatonin mechanism and they support it.

Hence it is established from multiple, independent studies, that EMR from ELF to RF/MW, including being extremely low intensity natural electromagnetic fields, reduces melatonin in animals and human beings.

The Health Implications of Reduced Melatonin:

Melatonin has many biological effects. The melatonin receptor regulates several second messengers: cAMP, cGMP, diacylglycerol, inositol trisphosphate, arachidonic acid, and intracellular Ca^{2+} concentration ($[Ca^{2+}]_j$). In many cases, its effect is inhibitory and requires previous activation of the cell by a stimulatory agent. Melatonin inhibits cAMP accumulation in most of the cells examined, but the indole effects on other messengers have been often observed only in one type of the cells or tissue, until now. Melatonin also regulates the transcription factors, namely, phosphorylation of cAMP-responsive element binding protein and expression of c-Fos. Molecular mechanisms of the melatonin effects are not clear but may involve at least two parallel transduction pathways, one inhibiting adenylyl cyclase and the other regulating phosphohpide metabolism and $[Ca^{2+}]_j$, Vaneeck (1998).

Professor Russell Reiter, one of the world's leading medical researchers into the effects of melatonin, summarizes melatonin's roles, Reiter and Robinson (1995), as being:

- Vital for healthy sleep, including lowering the body temperature, and assisting in maintaining health sleep states.

- Reduces cholesterol, with consequent reductions is risk of atherosclerosis and coronary heart disease.

- Reduces blood pressure and the tendency for blood clots, and hence reduces the risk of strokes.

- Scavenger of free radicals. This, along with the above factors, reduces the risk of heart attack, cancer, viral replication. Melatonin plays a vital free radical scavenging role in the brain where, because it is high in iron, has a high production rate of hydroxyl radicals (OH•). Free radical damage is now known to play a formative role in most brain disorders, including Alzheimer' disease, Lou Gehrig's disease, multiple sclerosis and Parkinson's disease. While the Blood Brain Barrier (BBB) denies access to most free radical scavengers, melatonin has free access.

- Enhances the effectiveness of the immune system. Specifically enhancing the T-cells, i.e. the T-helper cells and the T-killer cells. T-helper cells have a receptor for melatonin. When melatonin is received a cascade of events is set in motion including stimulation of Interleukin-4 (IL-4) which then stimulates natural killer cells (NK), B-cells, IgA, phagocytes and T-Cytotoxic cells. The NK cells specialize in attacking cancer cells and virus infected cells.

In Professor Reiter's book, published in 1995, he describes the evidence that EMR/EMF does reduce melatonin as a "Smoking Gun" level of proof. That is, there is considerable scientific evidence but at that time it wasn't sufficient for scientific proof. By considering more recent information, and the extensive results of biometeorological research, and linking the melatonin research to the calcium ion research, the level of proof can be seen as causal. The multiple observations of melatonin reduction in EMR exposed populations means that EMR exposure increases the incidence of all of the conditions identified by Reiter and Robinson above, including impaired immune system, diseases from infections and viruses, arthritis, diabetes, cancer, reproductive, neurological and cardiac disease and/or death. Epidemiological evidence of exposed workers and residential populations confirms all of these, except arthritis, have been identified to occur in EMR exposed human populations.

Sleep disturbance as a melatonin reduction bioindicator:

It is a well-established and brain is a sensitive either electromagnetic organ. One of the most dominant activities is the daily awake/sleep cycle. Melatonin is one of primary regulators of the cycle can regulate the sleep activity. Therefore one of the primary server and surname methods for a non-invasive melatonin tracker is sleep disturbance. Because of the extensive vital rolls of melatonin in many serious health events, the identification of a simple and reliable indicator, such as sleep disturbance may be a simple way of indicating the product is dangerous because of its ability to reduce melatonin is indicated by sleep disturbance.

Sleep Disturbance near a Shortwave Radio Tower, Schwarzenburg, Switzerland:

The Schwarzenburg Study, Alpeter et al. (1995) and Abelin (1999) found a causal relationship of sleep disturbance with exposure to a short-wave radio signal. The effect is assessed as causal because of the significant dose-response relationship, the variation of sleep disturbance in two experiments, one involving changing the beams and one turning the transmitter off, and the identification of significant melatonin reduction. Professor Abelin told seminars in Christchurch that they had measured a significant increase in melatonin after the tower transmission was turned off permanently compared to the levels measured while it was on.

Figure 6 shows the results of the two surveys of sleep disturbance from 1992 and 1996. The first survey was for three groups, A, B and C. For the second survey a third group requested involvement. Their exposure level was between zone B and zone C and their rate of sleep disturbance showed a consistency with the dose-response trends.

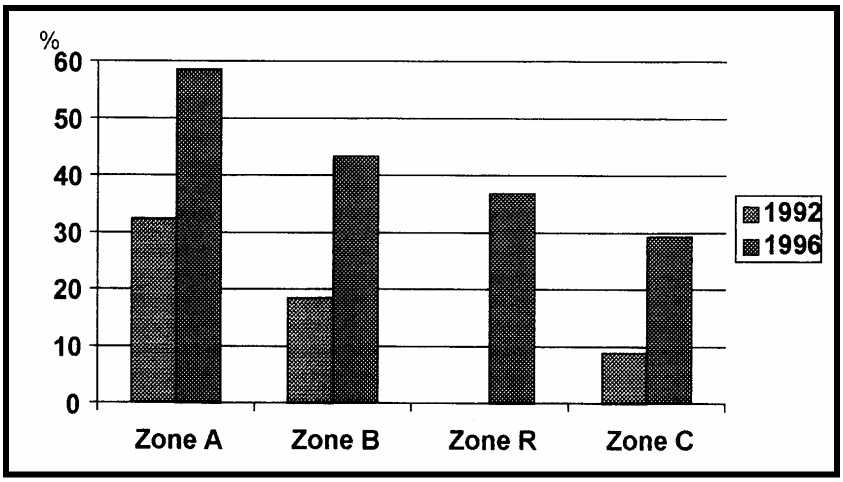

Figure 6: Adult Sleep Disturbance with RF exposure at Schwarzenburg, Switzerland, Abelin (1999).

An extensive measurement survey was carried out and a mean exposure for each zone was determined. These readings are used to create the dose-response graph in Figure 7.

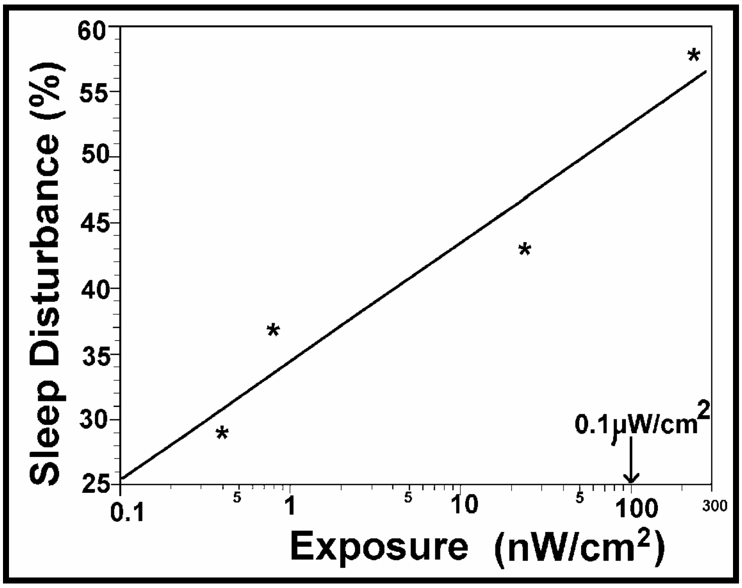

Figure 7: Dose-response relationship for Sleep Disturbance at Schwarzenburg with exposure in nW/cm2. Note: $1nW/cm^2 = 0.001\mu W/cm^2$

Groups B, R and C are all exposed to a mean RF signal of less than $0.1\mu W/cm^2$ and they experienced highly significant sleep disturbance and reduced melatonin. Sleep disruption occurs in a dose-response manner with a threshold below $0.1nW/cm^2$. i.e. very close to zero, Figure 7.

In an experiment the tower was secretly turned off for three days reacts during which the sleep disturbance was being surveyed. Each group showed a significant improvement in sleep quality and a time delay in reaction which increased with distance from the tower. Group A showed a 1 day delay and Group C a two day delay and both showed a highly significant improvement in sleep quality, p< 0.001.

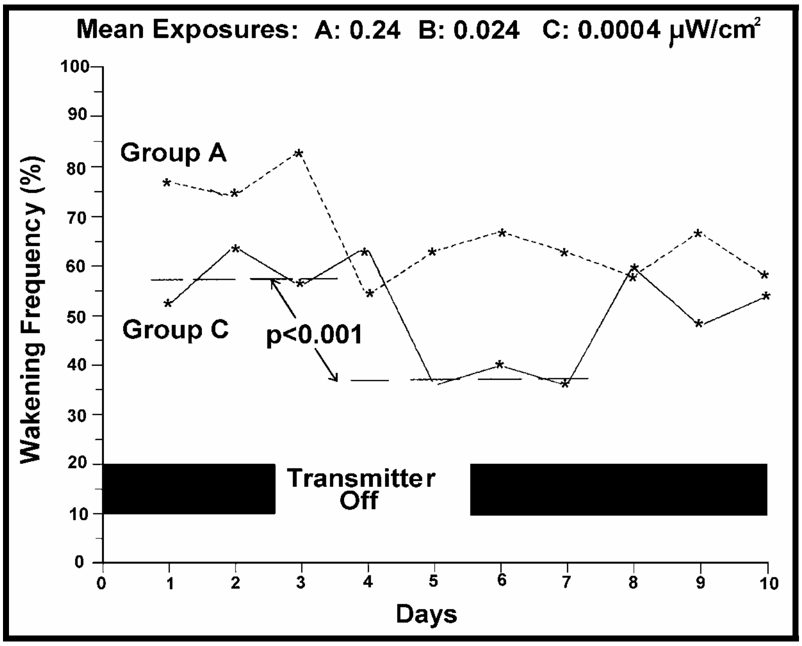

Figure 8: Sleep disturbance in people exposed to a short-wave radio stations which was turned off for three days, Altpeter et al. (1995), showing the highest exposed Group A, and lowest exposed Group C.

The lowest exposed group, 0.0004μW/cm^2 (0.4nW/cm^2), also shows a significant effect of the RF exposure on sleep disturbance confirming that they too have a significant sleep disturbance problem caused by the tower exposure, which was reduced when the tower was briefly turned off and occurred again when it was turned on again.

Since sleep disturbance, Mann and Roschkle (1995), and melatonin reduction, Burch et al. (1997), has been observed with cell phone radiation exposure. Hence these observations also apply to cell phones and cell sites. An investigation of sleep disturbance and a large number of other neurological symptoms was investigated in France, Santini et al. (2001). They found significant elevation of sleep disturbance within 300m of cell sites. The pattern in Figure 9 is closely dose related to the typical cell site radial exposure patterns, Figure 10.

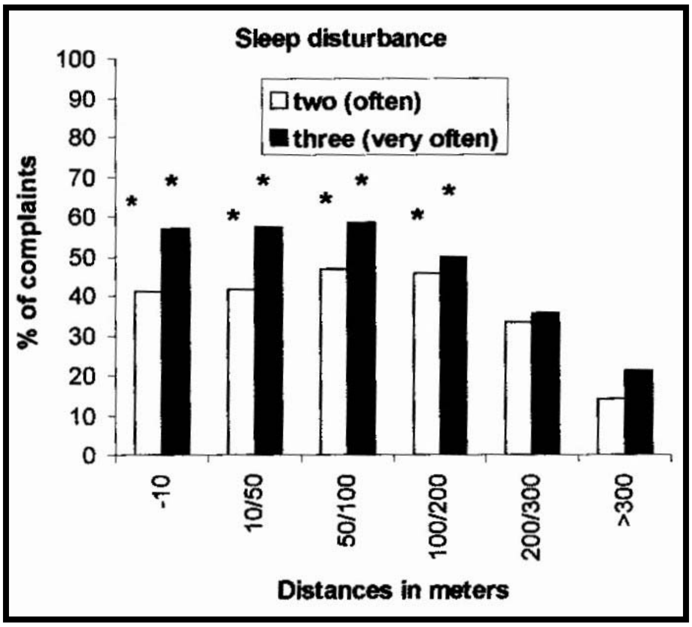

Figure 9: Sleep disturbance in the vicinity of cell sites in France, Santini et al. (2001)

Figure 10 shows a typical cell site exposure pattern along the main beam of the antenna.

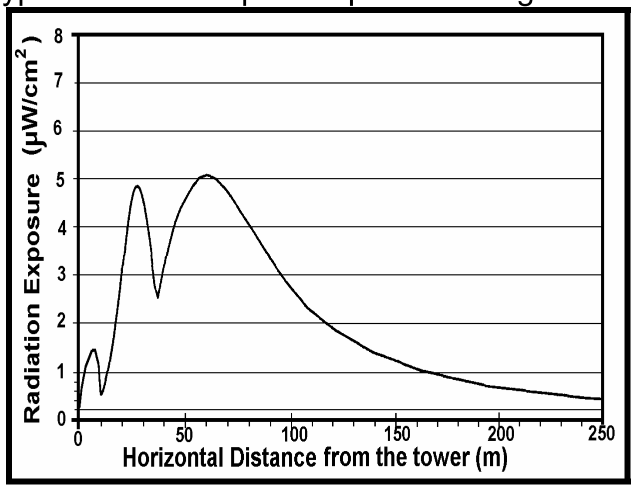

Figure 10: A typical cell site radial center main beam ground level (2m) radiation exposure.

The actual mean residential exposures are somewhat less than this because the direct exposure is generally less than at the centre of the main beam and buildings provide significant reductions in exposure levels. Moving around the residential area also smooths out the mean exposures somewhat. Table 1 shows the surveys incidence rates of many neurological symptoms.

Table 1: Incidence of symptoms as a function of the distance from cellphone base stations by 530 people (men and women) as compared to people living more than 300 m for not exposed to base stations.

Symptoms	Distances of subjects from cell phone base stations (m)											
	< 10 m		10 to 50 m		50 to 100 m		100 to 200 m		200 to 300 m		> 300 m …	
	2	3	2	3	2	3	2	3	2	3	2	3
Fatigue	76 *	72 *	63.5*	50.9*	60.6	56.6*	64.2	41.1	66.6*	43.7	40.7	27.2
Irritability	32.8	23.2*	41.7*	25.7*	47.2*	44.1*	25.8	4.1	25	9	18	3.3
Headache	51 *	47.8*	40 *	26.1*	40.6*	36.7*	60.7*	31.2*	19.3	0	15.6	1.8
Nausea	14.5*	6.9	8.4	3	5.7	3.8	2.4	4.6	0	2.3	2.1	1.1
Loss of appetite	20.4*	8.3	8	5.5	5	5	6.9	0	4.2	0	3.3	3.3
Sleep Disturbance	41.3*	57.1*	41.4*	57.5*	46.9*	58.5*	45.8*	50*	33.3	35.5	13.8	21.1
Depression	16.9	26.8*	21.6	19.7*	11.6	24 *	16.2	3.1	13.6	2.5	10.3	3.7
Discomfort	28 *	45.4*	25.2*	18.9	30.6*	12.8	15.7*	0	9.7	5.1	2.4	8.1
Difficulties in concentration	39.3	28.8*	37.5	16.6	34.2	26.4*	25	12.5	43.3	5.5	26.7	7.1
Loss of Memory	27.8	25.4*	29.4	26.6*	37.1*	29 *	25	15.6	17.2	11.1	17.9	5.8
Cutaneous problems	18.1*	17.1*	6.6	10.8	11.1*	11.1	13.9*	7.5	8.7	0	1.2	4.6
Visual Perturbations	14.5	24.3*	23	13.5	22	7.1	2.5	4.9	15	2.8	13.6	4.1
Hearing Difficulties	33.3*	17.4	17.7*	12	8.3	15.5	7.7	7.7	11.6	9.5	5.6	8.7
Vertigo	10	12.5*	17.3*	7.5*	9.6	9.6*	12.2	2.7	7.7	5.2	6.2	0
Moving Difficulties	5.6	7.7*	8.2	1.7	3	3	0	0	2	0	2.9	1
Cardiovascular Problems	10.1*	13 *	15.3*	9.6	12.3*	7.4	8.7	0	8.5	6.5	1	3

* = Chi Squared test Significance ($p < 0.05$) for exposed subjects compared to those living more than 300m from a base station or not exposed. 2 = "often" and 3 = "very often"

Every symptom has at least one significantly elevated incident rate. Most of the symptoms are consistent with reduced melatonin. Several of the seriously elevated symptoms have been identified to increase in a dose-response manner of minutes/day usage of cell phones in Scandinavia, Mild et al. (1998). They include dizziness, discomfort, loss of concentration, memory loss, fatigue, headache and skin reactions of a burning feeling and tingling, Figure 11.

Very strong evidence that sleep disturbance and melatonin reduction had already been associated with a wide range of residential exposure to cellphone radiation and user exposure to cellphone radiation. This confirms the relationship and the usefulness of this and melatonin reduction based bioindicator of approach losing sleep disturbance as the first indicator, or any other melatonin action related health effect that is easy to assess all for which there is already a public database.

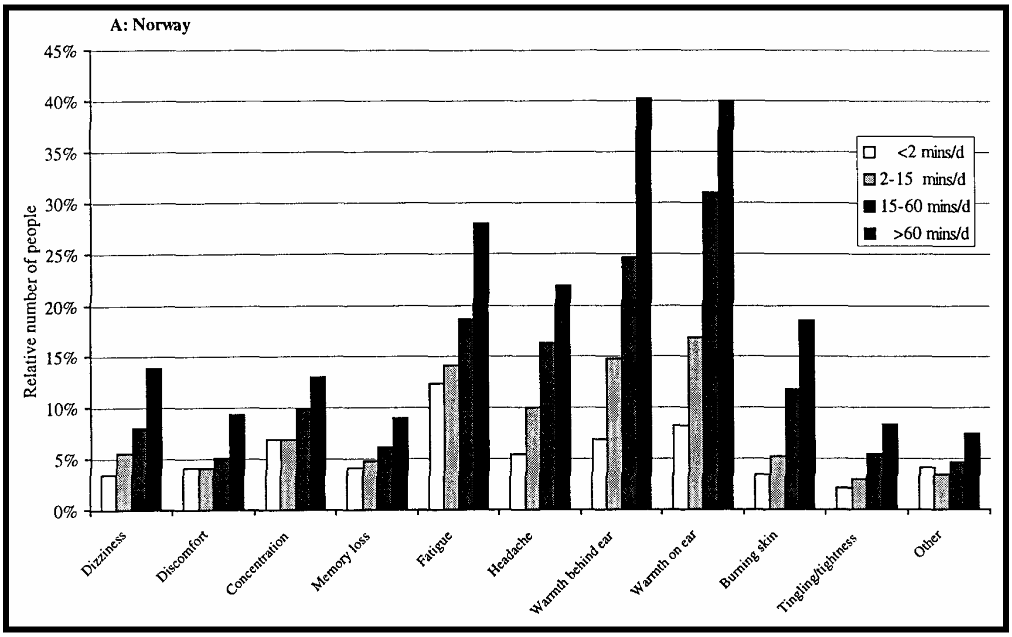

Figure 11: Prevalence of symptoms for Norwegian mobile phone users, mainly analogue, with various categories of length of calling time per day, Mild et al. (1998).

Conclusions and Recommendations:

There is substantial and robust evidence that establish a causal relationship between electromagnetic fields and radiation reduced melatonin. Therefore there is a sound scientific basis for concluding that the melatonin mechanism is one of the established mechanisms between very serious health effects and acute and chronic exposure to electromagnetic fields and radiation. The natural signal, the Schumann Resonance signal, has a radio field intensity of about 0.1pW/cm^2 and sleep disturbance was highly correlated ($p<0.001$) with exposure to the shortwave radio signal measured at 0.4nW/cm^2. Because sleep disturbance and melatonin reduction are causally linked to many other serious health effects, a public protection standard to reduce the incidence of these health effects would need to be somewhat less than 0.1nW/cm^2.

Because of the extreme sensitivity of the brain electromagnetic fields and radiation and the reaction of reduced melatonin, a melatonin based bioindicator mechanism, such as sleep disturbance, can be a very useful tool or showing that electromagnetic signal is causing many other serious health effects, including all of which are linked with reduced melatonin.

References:

Abelin, T., 1999: "Sleep disruption and melatonin reduction from exposure to a shortwave radio signal". Seminar at Canterbury Regional Council, New Zealand. August 1999.

Adey, W.R., 1980: “Frequency and Power windowing in tissue interactions with weak electromagnetic fields”. Proc. IEEE, 68:119-125.

Altpeter, E.S., Krebs, Th., Pfluger, D.H., von Kanel, J., Blattmann, R., et al., 1995: "Study of health effects of Shortwave Transmitter Station of Schwarzenburg, Berne, Switzerland". University of Berne, Institute for Social and Preventative Medicine, August 1995.

Arnetz, B.B. and Berg, M., 1996: "Melatonin and Andrenocorticotropic Hormone levels in video display unit workers during work and leisure. J Occup Med 38(11): 1108-1110.

Bartsch, H., Bartsch, C., Mecke, D. and Lippert, T.H., 1994: "Seasonality of pineal melatonin production in the rat: possible synchronization by the geomagnetic field". Chronobiol Int 11(1):21-26.

Bardasano, J.L., Cos, S. and Picazo, M.L., 1989: "Numerical variation in synaptic ribbons of rat pinealocytes under magnetic storm conditions and on calm days".[In German] J Hirnforsch 30(60: 639-643.

Bawin, S.M. and Adey, W.R., 1976: "Sensitivity of calcium binding in cerebral tissue to weak electric fields oscillating at low frequency". Proc. Natl. Acad. Sci. USA, 73: 1999-2003.

Blackman, C.F., Benane, S.G., Elliott, D.J., and Pollock, M.M., 1988: "Influence of Electromagnetic Fields on the Efflux of Calcium Ions from Brain Tissue in Vitro: A Three-Model Analysis Consistent with the Frequency Response up to 510 Hz". Bioelectromagnetics, 9:215-227.

Blackman, C.F., Kinney, L.S., House, D.E., and Joines, W.T., 1989: "Multiple power-density windows and their possible origin". Bioelectromagnetics, 10: 115-128.

Blackman, C.F., 1990: "ELF effects on calcium homeostasis". In "Extremely low frequency electromagnetic fields: The question of cancer", BW Wilson, RG Stevens, LE Anderson Eds, Publ. Battelle Press Columbus: 1990; 187-208.

Blackman, C.F., Benane, S.G., and House, D.E., 1991: "The influence of temperature during electric- and magnetic-field induced alteration of calcium-ion release from in vitro brain tissue". Bioelectromagnetics, 12: 173-182.

Burch, J.B., Reif, J.S., Pittrat, C.A., Keefe, T.J. and Yost, M.G., 1997: "Cellular telephone use and excretion of a urinary melatonin metabolite". In: Annual review of Research in Biological Effects of electric and magnetic fields from the generation, delivery and use of electricity, San Diego, CA, Nov. 9-13, P-52.

Burch, J.B., Reif, J.S., Yost, M.G., Keefe, T.J. and Pittrat, C.A., 1998: "Nocturnal excretion of urinary melatonin metabolite among utility workers". Scand J Work Environ Health 24(3): 183-189.

Burch, J.B., Reif, J.S., Yost, M.G., Keefe, T.J. and Pittrat, C.A., 1999a: "Reduced excretion of a melatonin metabolite among workers exposed to 60 Hz magnetic fields" Am J Epidemiology 150(1): 27-36.

Burch, J.B., Reif, J.S. and Yost, M.G., 1999b: "Geomagnetic disturbances are associated with reduced nocturnal excretion of melatonin metabolite in humans". Neurosci Lett 266(3):209-212.

Burch, J.B., Reif, J.S., Noonan, C.W. and Yost, M.G., 2000: "Melatonin metabolite levels in workers exposed to 60-Hz magnetic fields: work in substations and with 3-phase conductors". J of Occupational and Environmental Medicine, 42(2): 136-142.

Cherry, N.J., 2002: "Schumann Resonances, a plausible biophysical mechanism for the human health effects of Solar/Geomagnetic Activity". Natural Hazard 26: 279-331.

Davis, S., 1997: "Weak residential Magnetic Fields affect Melatonin in Humans", Microwave News, Nov/Dec 1997.

Graham, C., Cook, M.R., Cohen, H.D. and Gerkovich, M.M., 1994: "A dose response study of human exposure to 60Hz electric and magnetic fields". Bioelectromagnetics 15: 447-463.

Graham, C., Cook, M.R., Sastre, A., Riffle, D.W. and Gerkovich, M.M., 2000: "Multi-night exposure to 60 Hz magnetic fields: effects on melatonin and its enzymatic metabolite". J Pineal Res 28(1): 1-8.

Juutilainen, J., Stevens, R.G., Anderson, L.E., Hansen, N.H., Kilpelainen, M., Laitinen, J.T., Sobel, E. and Wilson, B.W., 2000: "Nocturnal 6-hydroxymelatonin sulphate excretion in female workers exposed to magnetic fields". J Pineal Res 28(2): 97-104.

Karasek, M., Woldanska-Okonska, M., Czernicki, J., Zylinska, K. and Swietoslawski, J., 1998: "Chronic exposure to 2.9 mT, 40 Hz magnetic field reduces melatonin concentrations in humans". J Pineal Research 25(4): 240-244.

Levallois, P., Dumont, M., Touitou, Y., Gingras, S., Masse, B., Gauvin, D., Kroger, E., Bourdages, M. and Douville, P., 2001: “Effects of electric and magnetic fields from high-power lines on female urinary excretion of 6-sulfatoxymelatonin”. Am J Epidemiology 154(7): 601-609.

Mann, K, Roschke, J, 1996: Effects of pulsed high-frequency electromagnetic fields on human sleep. Neuropsychobiology 33(1):41-47.

Mild, K.H., Oftedal, G., Sandstrom, M., Wilen, J., Tynes, T., Haugsdal, B. and Hauger E., 1998: "Comparison of symptoms by users of analogue and digital mobile phones - A Swedish-Norwegian epidemiological study". National Institute for Working Life, 1998:23, Umea, Sweden, 84pp.

O'Connor, R.P. and Persinger, M.A., 1996: Increases in geomagnetic activity associated with increases in thyroxine levels in a single patient: implications for melatonin levels". International Journal of Neuroscience, 88(3-4): 243-247.

Pfluger, D.M. and Minder, C.E., 1996: "Effects of 16.7 Hz magnetic fields on urinary 6-hydroxymelatonin sulfate excretion of Swiss railway workers". J Pineal Research 21(2): 91-100.

Rapoport, S.I., Malinovskaia, N.K., Oraevskii, V.N., Komarov, F.I., Nosovskii, A.M. and Vetterberg, L., 1997: "Effects of disturbances of natural magnetic field of the Earth on melatonin production in patients with coronary heart disease". Klin Med (Mosk) 75(6): 24-26.

Rapoport, S.I., Blodypakova, T.D., Malinovskaia, N.K., Oraevskii, V.N., Meshcheriakova, S.A., Breus, T.K. and Sosnovskii, A.M., 1998: "Magnetic storms as a stress factor". Biofizika 43(4): 632-639.

Rapoport, S.I., Shalalova, A.M., Oraevskii, V.N., Malinovskaia, N.K., and Vetterberg, L., 2001: "Melatonin production in hypertonic patients during magnetic storms". Ter Arkh 73(12): 29-33.

Reiter, R.J., 1994: “Melatonin suppression by static and extremely low frequency electromagnetic fields: relationship to the reported increased incidence of cancer”. Reviews on Environmental Health. 10(3-4): 171-86, 1994.

Reiter, R.J. and Robinson, J, 1995: "Melatonin: Your body's natural wonder drug". Publ. Bantam Books, New York.

Rosen, L.A., Barber, I. and Lyle D.B., 1998: "A 0.5 G, 60 HZ magnetic field suppresses melatonin production in pinealocytes". Bioelectromagnetics 19: 123-127.

Sandyk, R. 1993: "Weak magnetic fields antagonize the effects of melatonin on blood glucose levels in Parkinson's Disease". Int. J. Neuroscience 68(1-2): 85-91.

Sandyk, R. 1994: "Rapid normalization of visual evoked potentials by picoTesla range magnetic fields in chronic progressive multiple sclerosis". Int. J. Neuroscience 77(304): 243-259.

Sandyk, R. and Derpapas, K. 1993: "Further observations on the unique efficacy of picoTesla range magnetic fields in Parkinson's Disease". Int. J. Neuroscience 69(1-4): 167-183.

Sandyk, R. and Iacono, R.P., 1993: "Reversal of visual neglect in Parkinson's Disease by treatment with picoTesla range magnetic fields". Int. J. Neuroscience 73(1-2): 93-107.

Santini R., Santini, P., Seigne, M. and Danze, J.M., 2001: "Symptômes exprimés par des riverains de stations relais de téléphonie mobile". Article accepted as a letter to editor to La Presse Medidale, 10 September 2001.

Stark, K.D.C., Krebs, T., Altpeter, E., Manz, B., Griol, C. and Abelin, T., 1997: "Absence of chronic effect of exposure to short-wave radio broadcast signal on salivary melatonin concentrations in dairy cattle". J Pineal Research 22: 171-176.

Vaneeck, J., 1998: "Cellular Mechanisms of Melatonin Action". Physiol. Rev. 78: 687-721.

Wang, S.G. 1989: "5-HT contents change in peripheral blood of workers exposed to microwave and high frequency radiation". Chung Hua Yu Fang I Hsueh Tsa Chih 23(4): 207-210.

Weydahl A, Sothern RB, Cornelissen G, and Wetterberg L. 2001: “Geomagnetic activity influences the melatonin secretion at latitude 70 degrees N”. Biomed Pharmacother 55 Suppl 1:57s-62s.

Wilson, B.W., Wright, C.W., Morris, J.E., Buschbom, R.L., Brown, D.P., Miller, D.L., Sommers-Flannigan, R. and Anderson, L.E., 1990: "Evidence of an effect of ELF electromagnetic fields on human pineal gland function". J Pineal Research 9(4): 259-269.

Wood, A.W., Armstrong, S.M., Sait, M.L., Devine, L. and Martin, M.J., 1998: "Changes in human plasma melatonin profiles in response to 50 Hz magnetic field exposure". J Pineal Research 25(2): 116-127.

Yaga, K, Reiter, R.J., Manchester, L.C., Nieves, H., Sun, J.H. and Chen, L.D., 1993: "Pineal sensitivity to pulsed magnetic fields changes during the photoperiod. Brain Res Bulletin, 30 (1-2): 153-156.