

Melatonin, its role in health maintenance, and the effects of EMFs on melatonin production

Melatonin, or 5-methoxy-N-acetyltryptamine, is a hormone found in all living creatures, at levels that vary in a daily cycle. A study by Burgess & Fogg ([2008](#)) found that in the 170 people they studied, lifestyle and behavioural variables were only able to explain about 15% of the individual variability in the amount of melatonin secretion, which they attributed to a substantial genetic influence on the levels of melatonin secretion.

Melatonin, and its by-products (Reiter [2008](#)), are extremely powerful antioxidants with a particular role in protecting DNA. It reduces experimental cataractogenesis, traumatic injury to the spinal cord and brain, and protects against oxidative damage to neurons and ganglia in models of stroke, Parkinsonism and Alzheimer's disease (Reiter [2008](#)). It is naturally synthesized from the amino acid tryptophan via synthesis of serotonin.

Melatonin represents one of the most important immune enhancing substances in our body, and, as a free radical scavenger, protects all body and brain cells against genetic damage considered to be a precursor to cancer (Gulcin [2008](#)). Serotonin acts as a messenger for the nervous system and in the brain as a mood hormone. A reduced serotonin level is associated with depression, lethargy and listlessness, inner agitation and many psychiatric disturbances.

Melatonin regulates chronobiological and reproductive systems and mammary gland functions. Its other functions include free radical scavenging and DNA repair via immunomodulation, body weight control and the promotion of wound healing to the coupling of environmental cues to circadian clock gene expression and the modulation of secondary endocrine signalling (e.g. prolactin release, oestrogen receptor-mediated signalling). Mammalian skin and hair follicles are not only melatonin targets, but also sites of extrapineal melatonin synthesis (Fischer [2008](#)).

Melatonin (as well as 3 other hormones, which are also implicated in antitumour action, Lissoni [2003](#)) is produced primarily in the pineal gland, which is located in the brain, and the production is dependant on the light-dark cycle, being produced primarily during the night. Secretion of melatonin, and its level in the blood, peaks in the middle of the night, and gradually falls during the second half of the night, with normal variations in timing according to the individual. High-fat diets significantly decrease nocturnal pineal melatonin synthesis (Cano [2008](#)).

Melatonin is also produced to a lesser extent, in the bone marrow cells, lymphocytes and epithelial cells. Melatonin concentration in these cells is much higher than that found in the blood but it does not seem to be regulated by the photoperiod.

Until recent history, humans in temperate climates were exposed to up to 18 hours of darkness in the winter. In the modern world, artificial lighting reduces this to typically eight hours or less per day all year round. Even low light levels inhibit melatonin production to some extent, but over-illumination can create significant reduction in melatonin production.

Studies in human populations have shown that magnetic fields, such as those from powerlines and other powerfrequency EMFs, are capable of disrupting the night-time production of the important hormone melatonin in the pineal gland, especially polarised fields, in combination

with the earth's geomagnetic field disturbances ([Burch 1999](#), [2000](#)), and in exposed workers ([Burch 1998](#), [1999](#)).

Corona ions emitted by powerlines produce highly variable disturbances in the atmospheric electric field down wind. It is hypothesised ([Henshaw 2008](#)) that these random disturbances can result in the disruption of nocturnal melatonin synthesis and related circadian rhythms leading to an increased risk of a number of adverse effects.

Dr Yves Primault, Honorary Professor at the University of Milan suggested that exposure to magnetic field levels of more than 0.1 microtesla can stop overnight production of melatonin. The batteries from a mobile phone will exceed this level at the user's head.

A study by the Citizens Initiative Kempten West (in Germany) found that a mobile phone transmitter affected levels of melatonin and serotonin. 'Before' and 'after' blood samples were taken from residents near a newly installed mobile phone mast. The participants had removed other RF sources such as DECT phones and WLANs from their homes. Measured microwave fields showed a several fold increase in RF exposure. 84% of participants reacted with a massive decrease in serotonin level when the new mast became operational. Nearby residents nearly all experienced increases in depressive mood disturbances, lethargy and listlessness, appetite disturbances, inner agitation and reduced quality of life. There was also a fairly steep nightly melatonin decrease for 56% of the group. More than half the group reported sleep disturbances, many complaining of waking between 2 and 4 a.m. and had difficulty getting back to sleep again. Sleep disturbance is increasingly being seen as a cancer promoting risk factor. They also found a displacement in time of melatonin excretion, when getting up rather than earlier in the morning. This results in feeling very tired on getting up, and consequent tiredness, irritability, loss of concentration during the day.

The levels of melatonin in the body rise in the evening and this increase promotes the ability to fall asleep. Melatonin supplementation has been associated with an improved ability to get to sleep and also to stay asleep. This has long been known to sufferers of jet lag, who synchronise their body clocks by the judicious use of melatonin to re-assert proper sleeping habits. The Food and Drug Administration in America has approved a drug containing melatonin and it is prescribed for the treatment of insomnia in children and the elderly ([Reynoldson 2008](#)). Any disruption in the quality of sleep with the accompanying cellular repair processes will clearly impact on many areas of health.

Sleep is a thalamic function and it is assisted by melatonin which acts by promoting spindle formation. In this way, melatonin has a modulatory influence on sleep onset and maintenance ([Jan 2008](#)).

Some foods and drink help increase melatonin consumption; red wine, bananas, oats, fruit vegetables and cereals. Melatonin is present in many plants, possibly to protect against UV light. Purslane has 10-20 times more melatonin than any other edible plant, followed by St John's Wort, sage and feverfew. Melatonin supplementation may disrupt circadian rhythms, if taken during the day rather than night-time.

The peak production time of melatonin can be shifted by careful environmental manipulation to increase its production in night shift workers. Some of these changes include intermittent bright light pulses during night shifts, wearing dark glasses when outside, sleeping in dark bedrooms at scheduled times after night shifts and on days off, and receiving outdoor light exposure upon

awakening from sleep (Smith [2008](#)). These changes helped study subjects to perform better than their colleagues on a reaction time task.

Once you pass 65, your body will be able to make only about 10% of the melatonin you did when you were 30.

Age-related biological changes

Aging has been proposed as the major risk factor in most neurodegenerative disorders. A study by Akbulut ([2008](#)) concluded that exogenous melatonin had a potential role for retardation of age-related oxidative events. Oztürk ([2008](#)) found melatonin increased levels of Zinc, which reduces with age, in some parts of the body.

Asthma

People who are asthmatic at night (nocturnal asthma) may have higher than normal melatonin levels. This may indicate an adverse effect of melatonin with nocturnal asthmatics. (Sutherland [2002](#), [2003](#), [2005](#))

Autism

People who suffer from autism have half as much melatonin in their blood as the rest of the population. This may be exacerbated by their irregular sleep patterns, which prevent their bodies from making the hormone efficiently.

Blood Brain barrier

Melatonin can easily cross cell membranes and the blood-brain barrier (Hardeland [2005](#)).

Blood flow (restriction and restoration)

Maternal melatonin administration appeared to prevent problems with bloodflow and DNA damage in the foetal rat brain (Wakatsuki [1999](#), [2001](#), Watanabe [2004](#)), and prevented placental DNA damage and fetal growth restriction (Nagai [2008](#)).

Melatonin also prevented liver tissue damage (Okatani [2003](#)) and testicular damage (Duru [2008](#)) due to restricted, then restored, blood flow.

Brain damage

There are mixed results as to the effectiveness of melatonin after intracerebral haemorrhage. One study (Hartman [2008](#)) found no effect, whereas Rojas ([2008](#)) found melatonin reduced oxidative stress, but it did not change the extent of brain oedema or neurologic deficits.

Melatonin was found to reduce oxidative damage in the brain caused by exposure to mobile phone radiation (Sokolovic [2008](#)).

Cancer

Melatonin is a particularly powerful antioxidant, 5 times more potent than vitamin C, which acts as a natural anti-cancer agent in the body ([Sánchez-Barceló 2003](#), Pauley [2004](#)). It is highly protective of oxidative damage to human blood cells (Vijayalaxmi [1995](#), [1996](#), [1999](#), [Badr 1999](#), [Juutilainen 2006](#)) - the sort of damage that could lead to leukaemia ([Blackman 2001](#), [Henshaw 2005](#)), and can prevent damage to DNA (Karbownik [2001](#)).

In a paper as long ago as 1990 Kerenyi, discussing the role of the pineal gland (and subsequent serum melatonin levels), proposed that melatonin may have a direct effect on breast tumours, especially oestrogen-dependent tumours (Maganhin [2008](#)), the melatonin receptors being the probable sites of interaction between melatonin and the tumour cell. Merklinger-Gruchala ([2008](#)) reported that sleep variation may influence endogenous oestrogens, and therefore risk of breast cancer. An estimated 45-80% of breast cancer patients use antioxidant supplements after diagnosis, and the use of antioxidant supplements during breast cancer treatment is common. In a review of 22 articles, Greenlee ([2008](#)) suggested that melatonin could enhance tumour response during treatment, but that the trials did not have sufficient statistical significance to be conclusive.

It was felt that increased light exposure of different types (e.g. fluorescent) may be responsible (Blask [2005](#)), at least in part, especially as blind women have a lower incidence of breast cancer. Pukkala ([2006](#)) also found that breast cancer risk in females decreased according to the amount of visual impairment. There was a similar but less consistent trend for prostate cancer in males.

Stevens ([1992](#), [1993a](#), [1993b](#), [1996](#), [2006](#)), Schernhammer ([2004](#), [2005](#)) Srinivasan ([2007](#)), also suggest that light at night reduces melatonin production. A Russian article (Russian b 2008) found that constant lighting increased tumour growth, whereas light deprivation slowed down growth.

It may be that people may sleep less when their work patterns are different. Some research (Verkasalo [2005](#)) has shown a decreased risk of breast cancer in long sleepers.

Cardiovascular support

Melatonin may play a role in preventing cardiac arrhythmia. Grossman ([2006](#)) found that melatonin supplementation reduced night blood pressure in patients with nocturnal hypertension. A Russian review of the literature found evidence of therapeutic effects of melatonin in the treatment of arterial hypertension and cardiac ischemic disease (Russian a [2008](#)). Reiter ([2008](#)) suggested that melatonin may be an effective treatment for hypertension.

Oral melatonin seemed to have the effect of reducing systolic blood pressure in one small study (Yildiz [2006](#)).

Nicotine exposure depletes myocardial antioxidant enzymes and increases free radicals and lipid peroxidation products. Baykan ([2008](#)) found that melatonin prevents the nicotine-induced cardiac injury.

Dementia

Rodriguez ([2007](#)) at the University of Granada in Spain suggested that the melatonin's antioxidant abilities may help reduce the severity of Alzheimer's which involves inflammation

and free radical damage in the brain. Masilamoni ([2008](#)) also found that melatonin was protective against the sort of cellular changes in the brain found in patients with Alzheimer's disease.

A study by Dowling ([2008](#)) found that the combination of bright light and melatonin could slow the progression of dementia by 5%. There was also a change in activity levels from night time to day time which would result in an easier management regimen for carers.

Diabetes

An experiment on diabetic rats (Gül [2008](#)) found that the administration of melatonin reduced corneal injury.

Drug dependency

In an experiment on morphine-induced conditioned 'place preference' in mice, injected melatonin was found to reverse the effect (Han [2008](#)).

Eye problems

In one study (Sande [2008](#)), melatonin was found to prevent the clinical, biochemical, histological, ultrastructural and functional consequences of experimental uveitis (inflammation of the interior of the eye).

Fibromyalgia

Fibromyalgia is a painful syndrome, that is experienced by many people as a precursor to ES. It has been suggested that melatonin supplementation may be effective in treating the pain associated with fibromyalgia, as well as addressing the sleep problems common in this syndrome (Reiter [2007](#)).

Fracture risk

Experimental evidence suggests that light at night (including nightshift work) acts through endocrine disruption likely mediated by melatonin. Osteoporotic fractures are highly sensitive to sex steroids. Feskanich ([2008](#)) found that 20+ years of nightshift work was associated with a significantly increased risk of wrist and hip fractures. The risk was strongest for women with a lower body mass index and those who had never used hormone replacement therapy.

Immune system

While it is clear that melatonin interacts with the immune system (Arushanian [2002](#), Carrillo-Vico [2005](#)) the details of those interactions are unclear. There have been few trials designed to judge the effectiveness of melatonin in disease treatment. Most existing data are based on small, incomplete, clinical trials.

Increased life span

Melatonin has been shown to increase the average life span of mice by 20% in some studies (Oaknin-Bendahan [1995](#), Anisimov [2003](#), Rodriguez [2007](#)). It restored some of the aging effects in mice (Morioka [1999](#), Okatani [2002](#), [2003](#), Gutierrez-Cuesta [2008](#)).

Irritable Bowel Syndrome (IBS) and other gastric problems

It was found that melatonin may be a promising candidate for the future research of agents that can modulate bowel motility and other IBS symptoms, in two studies by Lu ([2005](#), [2008](#)).

Gastric ulceration can be induced in rats by an administration of 15% hydrogen peroxide. Mohamadin ([2008](#)) found that the administration of melatonin 30 minutes before the hydrogen peroxide reduced the development of gastric lesions. The higher the dose, the greater the reduction.

Melatonin pretreatment significantly reduced haemorrhagic lesions and decreased oesophageal lipid peroxidation aggravated by Reflux Esophagitis (RE). Melatonin's free radical scavenging properties and antioxidant effects resulted in the improvement of oesophageal defence mechanisms (Lahiri [2008](#)).

Kidneys

Melatonin treatment had a protective effect on kidney damage induced in rats by 900 MHz phone radiation (simulating the sort of damage that can occur by attaching a mobile phone on standby to the belt) (Oktem [2005](#)).

Mood control and depression

Serotonin, from which melatonin is derived, is involved in mood control and changes in melatonin levels may be the mechanism behind the links between EMFs and chronic fatigue, depression and suicide.

The study referred to, above, by the Citizens Initiative Kempten West (in Germany) found that a mobile phone transmitter affected levels of melatonin and serotonin. Some genetic variations (on SLC6A4 and BDNF genes) make people more likely to suffer from depression as a result of environmental stressors, yet other changes in the same gene appear to be protective.

The occurrence of disturbed sleep is one of the principal diagnostic criteria for major depressive disorder (MDD). There is evidence of reciprocity between the two conditions such that, even in the absence of current depressive symptoms, disturbed sleep often predicts their development. It has been suggested that the recently introduced novel melatonin agonist has been very effective in improving the mood of depressed patients because of its ability to improve sleep quality. The use of melatonin is a promising treatment for depression (Pandi-Perumal [2008](#)).

A Turkish study (Ergün [2008](#)) found that the co-administration of the antidepressant imipramine together with melatonin was better than either separately at ameliorating the symptoms of depression, depending on dosage, and there was no interaction between the drugs.

Nitric oxide interaction

Yariktas ([2005](#)) found that exposure to a 900 MHz source increased nitric oxide (NO) levels in the sinus and nasal mucosa. They suggested that increased NO levels may act as a defence mechanism and relate to tissue damage. Melatonin seemed to have a beneficial effect preventing the changes in the mucosa.

Parkinson's disease

Rodriguez ([2007](#)) at the University of Granada in Spain suggested that the melatonin's antioxidant abilities may help reduce the severity of Parkinson's which involves inflammation and free radical damage in the brain.

The antioxidant activity of melatonin may reduce damage caused by some types of Parkinson's disease. A Ukrainian study (2008) found that melatonin blocked the mitochondrial pore openings in nerve cells, helping to prevent neurodegeneration.

Plants

It was found (Chen [2008](#)) that melatonin applied to seedlings stimulated root growth. There were significant windows of dose and seedling age, and had no effect or even an inhibitory effect when given outside these windows.

Pregnancy and reproduction

Human melatonin has an important influence on the female genital system. In fact, melatonin may influence production and action of steroids, modifying cellular signalization on the target tissue (Maganhin [2008](#)).

Daytime melatonin levels in normal pregnancies are low. Night-time melatonin levels increase after 24 weeks gestation, with significantly high levels after 32 weeks. These values decrease to non-pregnant levels on the second day after birth. Night-time melatonin levels are significantly higher in twin pregnancies after 28 weeks gestation. Patients with severe preeclampsia had significantly lower melatonin levels than the women with mild preeclampsia or normal pregnancies after 32 weeks gestation (Nakamura [2001](#)). Melatonin protects against oxidative damage in the placenta caused by restriction of blood flow. It could be useful in treating preeclampsia and possibly other clinical states involving excess free radical production, such as foetal growth restriction and foetal hypoxia (Okatani [2001](#)).

In an experiment by Fujinoki ([2008](#)) melatonin was found to enhance sperm hyperactivation in hamsters.

Radiation side effects

The small intestine is the most radiosensitive gastrointestinal organ and patients receiving radiotherapy directed to the abdomen or pelvis may develop radiation enteritis (Hussein [2008](#)).

Administration of melatonin, or AFMK, a melatonin metabolite, prior to irradiation can protect against the destructive effects of X-rays (Manda [2007](#), Reiter [2008](#)). Manda ([2008](#)) found that melatonin pretreatment combated the delayed side effects of cranial radiotherapy. Shirazi ([2007](#)) suggested not only that melatonin was useful in helping prevent accidental damage to cells in proximity to target cells, but that it may be a useful radioprotector for radiation workers.

Vijayalaxmi, in a review of melatonin as a radioprotective agent ([2004](#)) concluded that it may have a use in protecting individuals from radiation terrorism.

Skin effects

Melatonin is a major skin protectant and its functions may impact on skin biology and pathology (Fischer [2008](#)).

Stress

A melatonin-based antidepressant was found to block the adverse effects of stress on memory (Conboy [2008](#)).

Stroke

Koh ([2008](#)) found that melatonin prevented cell death resulting from ischemic brain injury and suggested the most likely mechanism by which this was occurring.

Toxin Protection

Melatonin was found to protect against damage from formaldehyde-induced oxidative renal damage and neurotoxicity (Zararsiz [2007](#)), tetrachloride-induced changes (Ogeturk [2004](#)), arsenite-induced peripheral neuropathy (Lin [2008](#)), deltamethrin (pesticide) induced nerve cell damage (Guo [2008](#)) and 2-Bromopropane-induced testicular toxicities (Huang [2008](#)). Alonso-Gonzalez ([2008](#)) found that melatonin helped prevent cancers that were dependent on Cadmium contamination. In a review of the effects of melatonin, Reiter ([2008](#)) found that it ameliorated the extensive free radical-mediated damage that ensued following exposure to a wide variety of environmental insults, including toxic prescription drugs, neural toxins, herbicides and metals.

References

Akbulut KG et al - 2008, *Exogenous melatonin decreases age-induced lipid peroxidation in the brain* Brain Res Aug 16 [Epub ahead of print]

Alonso-Gonzalez C et al - 2008, *Melatonin modulates the cadmium-induced expression of MT-2 and MT-1 metallothioneins in three lines of human tumor cells (MCF-7, MDA-MB-231 and HeLa)* Toxicol Lett Aug 6th [Epub ahead of print]

Arushanian E & E Beier - 2002, *Immunotropic properties of pineal melatonin* Eksp Klin Farmakol 65 (5): 73 - 80

Badr F M et al - 1999, *Radioprotective effect of melatonin assessed by measuring chromosomal damage in mitotic and meiotic cells* Mutation Research 444: 367-372 Pubmed 10521676

- Baykan A et al** – 2008, *The protective effect of melatonin on nicotine-induced myocardial injury in newborn rats whose mothers received nicotine* Anadolu Kardiyol Derg 8(4):243-8
- Blackman CF et al** - 2001, *The influence of 1.2 microT, 60 Hz magnetic fields on melatonin- and tamoxifen-induced inhibition of MCF-7 cell growth* 22(2): 122-8
- Blask DE et al** – 2005, *Melatonin-depleted blood from premenopausal women exposed to light at night stimulates growth of human breast cancer xenografts in nude rats* Cancer Res 65(23): 11174-84
- Burch JB et al** – 1998, *Nocturnal excretion of a urinary melatonin metabolite among electric utility workers* Scand J Work Environ Health 24(3):183-9
- Burch JB et al** – 1999, *Reduced excretion of a melatonin metabolite in workers exposed to 60 Hz magnetic fields* Am J Epidemiol 150(1):27-36
- Burch JB et al** – 1999, *Geomagnetic disturbances are associated with reduced nocturnal excretion of a melatonin metabolite in humans* Neurosci Lett 266(3):209-12
- Burch JB et al** – 2000, *Melatonin metabolite levels in workers exposed to 60Hz magnetic fields; work in substations and with 3 phase conductors.* J Occup Environ Med. 2000 Feb;42(2):136-42
- Burgess HJ & LF Fogg** – 2008, *Individual differences in the amount and timing of salivary melatonin secretion* PLoS ONE 3(8):e3055
- Cano P et al** – 2008, *Effect of a high-fat diet on 24-h pattern of circulating levels of prolactin, luteinizing hormone, testosterone, corticosterone, thyroid-stimulating hormone and glucose, and pineal melatonin content, in rats* Endocrine May 1 [Epub ahead of print]
- Carrillo-Vico A** – 2005, *A review of the multiple actions of melatonin on the immune system* Endocrine 27 (2): 189 – 200
- Chen Q et al** – 2008, *Exogenously applied melatonin stimulates root growth and raises endogenous indoleacetic acid in roots of etiolated seedlings of Brassica juncea* J Plant Physiol Aug 13 [Epub ahead of print]
- Conboy L et al** – 2008, *The antidepressant agomelatine blocks the adverse effects of stress on memory and enables spatial learning to rapidly increase neural cell adhesion molecule (NCAM) expression in the hippocampus of rats* Int J Neuropsychopharmacol Aug 18:1-13 [Epub ahead of print]
- Dowling GA et al** – 2008, *Melatonin and bright-light treatment for rest-activity disruption in institutionalized patients with Alzheimer's disease* J Am Geriatr Soc 56(2):239-46
- Duru FI et al** – 2008, *Brief ischaemia reduces testicular lipid preoxidation following subsequent ischaemia: an evidence for ischaemic preconditioning* Nig Q J Hosp Med 18(3):149-52
- Ergün Y et al** – 2008, *Combination therapy of imipramine and melatonin: Additive antidepressant effect in mouse forced swimming test* Eur J Pharmacol Jun 24 [Epub ahead of print]
- Feskanich D et al** – 2008, *Nightshift work and fracture risk: the Nurses' Health Study* Osteoporos Int Sep 3 [Epub ahead of print]

Fischer TW et al - 2008, *Melatonin as a major skin protectant: from free radical scavenging to DNA damage repair* Exp Dermatol Jul 17 [Epub ahead of print]

Fujinoki M - 2008, *Melatonin-enhanced hyperactivation of hamster sperm* Reproduction Aug 20 [Epub ahead of print]

Greenlee H et al - 2008, *Use of antioxidant supplements during breast cancer treatment: a comprehensive review* Breast Cancer Res Treat Oct 7 [Epub ahead of print]

Grossman E et al - 2006, *Melatonin reduces night blood pressure in patients with nocturnal hypertension* Am J Med 119(10):898-902

Gulcin I - 2008, *Measurement of antioxidant ability of melatonin and serotonin by the DMPD and CUPRAC methods as trolox equivalent* J Enzyme Inhib Med Chem Jun 2:1 [Epub ahead of print]

Gül M et al - 2008, *Protective effects of melatonin and aminoguanidine on the cornea in streptozotocin-induced diabetic rats* Cornea 27(7):795-801

Guo L et al - 2008, *Effects of melatonin on nerve cell apoptosis and expression of Bcl-2 and cytochrome C genes in rat cerebrum with deltamethrin induction* Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi 26(4):215-8

Gutierrez-Cuesta J et al - 2008, *Evaluation of potential pro-survival pathways regulated by melatonin in a murine senescence model* J Pineal Res Aug 13 [Epub ahead of print]

Han J et al - 2008, *Melatonin reverses the expression of morphine-induced conditioned place preference through its receptors within central nervous system in mice* Eur J Pharmacol Jul 31 [Epub ahead of print]

Hardeland R - 2005, *Antioxidative protection by melatonin: multiplicity of mechanisms from radical detoxification to radical avoidance* Endocrine 27 (2): 119-30.

Hartman RE et al - 2008, *Long-term effects of melatonin after intracerebral hemorrhage in rats* Acta Neurochir Suppl 105:99-100

Henshaw DL & Reiter RJ - 2005, *Do magnetic fields cause increased risk of childhood leukemia via melatonin disruption?* Bioelectromagnetics Suppl 7: S86-97

Henshaw DL et al - 2008, *Can disturbances in the atmospheric electric field created by powerline corona ions disrupt melatonin production in the pineal gland?* J Pineal Res April 1 [Epub ahead of print]

Huang F et al - 2008, *Melatonin pretreatment attenuates 2-bromopropane-induced testicular toxicity in rats* Toxicology Nov 17 [Epub ahead of print]

Hussein MR et al - 2008, *Melatonin and roentgen irradiation-induced acute radiation enteritis in Albino rats: An animal model* Cell Biol Int August 13 [Epub ahead of print]

Jan JE et al - 2008, *The role of the thalamus in sleep, pineal melatonin production, and circadian rhythm sleep disorders* J Pineal Res August 28 [Epub ahead of print]

Juutilainen J & T Kumlin - 2006, *Occupational magnetic field exposure and melatonin: interaction with light-at-night* Bioelectromagnetics 27(5):423-6

- Karbownik M** et al – 2001, *Comparison of the protective effect of melatonin with other antioxidants in the hamster kidney model of estradiol-induced DNA damage* *Mutat Res* 474 (1 – 2): 87 – 92.
- Kerenyi NA** – 1990, *Oncostatic effects of the pineal gland* *Drug Metabol Drug Interact* 8(3-4):313-9
- Koh PO** – 2008, *Melatonin prevents ischemic brain injury through activation of the mTOR/p70S6 kinase signalling pathway* *Neurosci Lett* Aug 14 [Epub ahead of print]
- Lahiri S** et al – 2008, *Melatonin protects against experimental reflux esophagitis* *J Pineal Res* Nov 28 [Epub ahead of print]
- Lin AM** et al – 2008, *Melatonin inhibits arsenite-induced peripheral neurotoxicity* *J Pineal Res* Aug 18 [Epub ahead of print]
- Lissoni P** et al – 2003, *Total pineal endocrine substitution therapy (TPEST) as a new neuroendocrine palliative treatment of untreatable metastatic solid tumor patients: a phase II study* *Neuro Endocrinol Lett* 24(3-4):259-62
- Lu WZ** et al – 2005, *Melatonin improves bowel symptoms in female patients with irritable bowel syndrome: a double-blind placebo-controlled study* *Aliment Pharmacol Ther* 22(10):927-34
- Lu WZ** et al – 2008, *The effects of melatonin on colonic transit time in normal controls and IBS patients* *Dig Dis Sci* Aug 23 [Epub ahead of print]
- Maganhin CC** et al – 2008, *Melatonin effects on the female genital system: a brief review* *Rev Assoc Med Bras* 54(3):267-71
- Manda K** et al – 2007, *AFMK, a melatonin metabolite, attenuates X-ray-induced oxidative damage to DNA, proteins and lipids in mice* *J Pineal Res* 42(4):386-93
- Manda K** et al – 2008, *Cranial irradiation-induced inhibition of neurogenesis in hippocampal dentate gyrus of adult mice: attenuation by melatonin pretreatment* *J Pineal Res* Sep 16 [Epub ahead of print]
- Masilamoni JG** et al – 2008, *The neuroprotective role of melatonin against amyloid beta peptide injected mice* *Free Radi Res* 42(7):661-73
- Merklinger-Gruchala A** et al – 2008, *Low estradiol levels in women of reproductive age having low sleep variation* *Eur J Cancer Prev* 17(5):467-72
- Mohamadin AM** et al – 2008, *Melatonin protects against hydrogen peroxide-induced gastric injury in rats* *Clin Exp Pharmacol Physiol* Oct 15 [Epub ahead of print]
- Morioka N** et al – 1999, *Melatonin protects against age-related DNA damage in the brains of female senescence-accelerated mice* *J Pineal Res* 27(4):202-9
- Nagai R** et al – 2008, *Melatonin preserves fetal growth in rats by protecting against ischemia/reperfusion-induced oxidative/nitrosative mitochondrial damage in the placenta* *J Pineal Res* Mar 26 [Epub ahead of print]
- Nakamura Y** et al – 2001, *Changes of serum melatonin level and its relationship to feto-placental unit during pregnancy* *J Pineal Res* 30(1):29-33

- Ogeturk M** et al – 2004, *Effects of melatonin on carbon tetrachloride-induced changes in rat serum* J Physiol Biochem 60(3):205-10
- Okatani Y** et al – 2001, *Melatonin protects against oxidative mitochondrial damage induced in rat placenta by ischemia and reperfusion* J Pineal Res 31(2):173-8
- Okatani Y** et al – 2002, *Melatonin reduces oxidative damage of neural lipids and proteins in senescence-accelerated mice* Neurobiol Aging 23(4):639-44
- Okatani Y** et al – 2002, *Melatonin protects hepatic mitochondrial respiratory chain activity in senescence-accelerated mice* J Pineal Res 32(3):143-8
- Okatani Y** et al – 2002, *Hepatic mitochondrial dysfunction in senescence-accelerated mice: correction by long-term, orally administered physiological levels of melatonin* J Pineal Res 33(3):127-33
- Okatani Y** et al – 2003, *Protective effect of melatonin against mitochondrial injury induced by ischemia and reperfusion of rat liver* Eur J Pharmacol 469(1-3):145-52
- Okatani Y** et al – 2003, *Acutely administered melatonin restores hepatic mitochondrial physiology in old mice* Int J Biochem Cell Biol 35(3):367-75
- Oktem F** et al – 2005, *Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin* Arch Med Res 36(4):350-5
- Oztürk G** et al – 2008, *Age-related changes in tissue and plasma zinc levels: modulation by exogenously administered melatonin* Exp Aging Res 34(4):453-62
- Pandi-Perumal SR** et al – 2008, *The effect of melatonergic and non-melatonergic antidepressants on sleep: weighing the alternatives* World J Biol Psychiatry Jan 4:1-13 [Epub ahead of print]
- Pauley S** – 2004, *Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue* Med Hypotheses 63 (4): 588-96.
- Pukkala E** et al – 2006, *Does incidence of breast cancer and prostate cancer decrease with increasing degree of visual impairment* Cancer causes Control 17(4):573-6
- Reiter RJ** et al – 2007, *Melatonin therapy in fibromyalgia* Curr Pain Headache Rep 11(5):339-42
- Reiter RJ** et al – 2008, *Biogenic amines in the reduction of oxidative stress: Melatonin and its metabolites* Neuro Endocrinol Lett Aug 2;29(4) [Epub ahead of print]
- Reiter RJ** et al – 2008, *Melatonin reduces oxidative/nitrosative stress due to drugs, toxins, metals, and herbicides* Neuro Endocrinol Lett 29(5):609-613
- Reiter RJ & A Korkmaz** – 2008, *Clinical aspects of melatonin* Saudi Med J 29(11):1537-47
- Reynoldson JN** et al – 2008, *Ramelteon: A novel approach in the treatment of insomnia (CE)*(September) Ann Pharmacother Jul 23 [Epub ahead of print]
- Rodriguez MI** et al – 2007, *Chronic melatonin treatment reduces the age-dependent inflammatory process in senescence-accelerated mice* J Pineal Res 42(3):272-9

- Rojas H** et al – 2008, *The antioxidant effects of melatonin after intracerebral hemorrhage in rats* Acta Neurochir Suppl 105:19-21
- Russian a** (no authors listed) – 2008, *Significance of melatonin for the activity and pharmacology of cardiovascular system* Eksp Klin Farmakol 71(3):65-71
- Russian b** (no authors listed) – 2008, *Colon carcinogenesis in rat vs. variable light* Vopr Onkol 54(3):332-7
- Sánchez-Barceló EJ** – 2003, *Melatonin and mammary cancer: a short review* Endocr Relat Cancer 10(2): 153-9
- Sande PH** et al – 2008, *Therapeutic effect of melatonin in experimental uveitis* Am J Pathol Nov 13 [Epub ahead of print]
- Schernhammer E** et al - 2004 *Epidemiology of urinary melatonin in women and its relation to other hormones and night work* Cancer Epidemiol Biomarkers Prev 13 (62): 936-43
- Schernhammer ES** & SE Hankinson – 2005, *Urinary melatonin levels and breast cancer risk* J Natl Cancer Inst 97(14):1084-7
- Shirazi A** et al – 2007, *A radiobiological review on melatonin: a novel radioprotector* J Radiat Res (Tokyo) 48(4):263-72
- Smith MR** et al – 2008, *Shaping the light/dark pattern for circadian adaptation to night shift work* Physiol Behav 95(3):449-56
- Sokolovic D** et al – 2008, *Melatonin reduces oxidative stress induced by chronic exposure of microwave radiation from mobile phones in rat brain* J Radiat Res (Tokyo) 49(6):579-86
- Srinivasan V** et al – 2007, *Melatonin, environmental light, and breast cancer* Breast Cancer Res Treat May 31 [Epub ahead of print]
- Stevens RG** et al – 1992, *Electric power, pineal function, and the risk of breast cancer* FASEB 6(3):853-60
- Stevens RG** – 1993a, *Breast cancer and electric power* Biomed Pharmacother 47(10):435-8
- Stevens RG** – 1993b, *Biologically based epidemiological studies of electric power and cancer* Environ Health Perspect 101(S4):93-100
- Stevens RG** & S Davis – 1996, *The melatonin hypothesis: electric power and breast cancer* Environ Health Perspect 104(S1):135-40
- Stevens RG** – 2006, *Artificial lighting in the industrialised world: circadian disruption and breast cancer* Cancer Causes Control 17(4):501-7
- Sutherland ER et al** – 2002, *Immunomodulatory effects of melatonin in asthma* Am J Respir Crit Care Med 166(8):1055-61
- Sutherland ER et al** – 2003, *Elevated serum melatonin is associated with the nocturnal worsening of asthma* J Allergy Clin Immunol 112(3):513-7

- Sutherland ER** – 2005, *Nocturnal asthma* J Allergy Clin Immunol 116(6):1179-86
- Ukrainian study** – 2008, *Antioxidants prevent experimental hemiparkinsonism in rats* Fiziol Zh 54(4):23-9
- Verkasalo PK et al** – 2005, *Sleep duration and breast cancer: a prospective cohort study* Cancer Res 65(20):9595-600
- Vijayalaxmi et al** - 1995, *Marked reduction of radiation-induced micronuclei in human blood lymphocytes pretreated with melatonin* Radiation Research 143: 102-106 Pubmed 7597136
- Vijayalaxmi et al** - 1996, *Melatonin and radioprotection from genetic damage: In vivo/in vitro studies with human volunteers* Mutation Research 371: 221-228 Pubmed 9008723
- Vijayalaxmi et al** - 1999, *Melatonin and protection from whole-body irradiation: survival studies in mice* Mutation Research 425: 21-27 Pubmed 10082913
- Vijayalaxmi et al** - 2004, *Melatonin as a radioprotective agent: a review* Int J Radiat Oncol Biol Phys 59(3):639-53
- Wakatsuki A et al** – 1999, *Melatonin protects against ischemia and reperfusion-induced oxidative lipid and DNA damage in fetal rat brain* J Pineal Res 26(3):147-52
- Wakatsuki A et al** – 2001, *Melatonin protects against ischemia/reperfusion-induced oxidative damage to mitochondria in fetal rat brain* J Pineal Res 31(2):167-72
- Watanabe K et al** – 2004, *Maternally administered melatonin protects against ischemia and reperfusion-induced oxidative mitochondrial damage in premature fetal rat brain* J Pineal Res 37(4):276-80
- Yariktas M et al** – 2005, *Nitric oxide level in the nasal and sinus mucosa after exposure to electromagnetic field* Otolaryngol Head Neck Surg 132(5):713-6
- Yildiz M et al** – 2006, *Acute effects of oral melatonin administration on arterial distensibility, as determined by carotid-femoral pulse wave velocity, in healthy young men* Exp Clin Cardiol 11(4):311-3
- Zararsiz I et al** – 2007, *Melatonin prevents formaldehyde-induced neurotoxicity in prefrontal cortex of rats: an immunohistochemical and biochemical study* Cell Biochem Funct 25(4):413-8
- Zararsiz I et al** – 2007, *Protective effect of melatonin against formaldehyde-induced kidney damage in rats* Toxicol Ind Health 23(10):573-9