



Do Electric and Magnetic fields from the electricity supply cause adverse health effects?

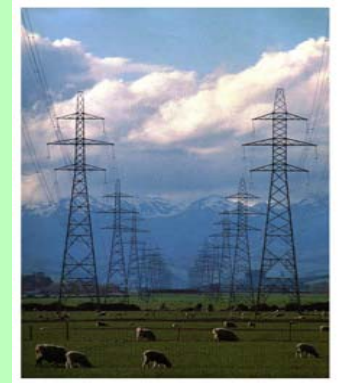
**Denis L Henshaw
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University of Bristol**

Magnetic field exposure and increased risk of childhood leukaemia

1. Chronic exposures

Average home levels $0.05 \mu\text{T}$

Levels under powerlines can be several μT or evens tens of μT



2. Short-term exposures

High magnetic fields are found near appliances:

e. g. Microwaves, vacuum cleaners, hairdryers, shavers

– can be tens of μT close to



Epidemiological case-control studies have demonstrated a doubling of the risk of childhood leukaemia associated with magnetic field exposures **above $0.3/0.4 \mu\text{T}$** .

Childhood leukaemia: key epidemiological findings

- Ahlbom *et al.* (2000) and Greenland *et al.* (2000)
- International Agency for Research on Cancer (IARC) 2001 declares magnetic fields a *possible carcinogen*
- 2001: Schuz *et al.*: CL risk is even greater with night time exposure to MFs (3.21-fold increased risk)
- 31st March 2004: UK Government sets up the Stakeholder Advisory Group on EMF or **SAGE**
- June 2005: Draper *et al.* find increased risk of CL near powerlines in England & Wales
- Autumn 2005: Japanese national study reports an MF/CL link

Review bodies' assessments of EMF causation of various diseases.

Disease	IARC 2001 2B	NIEHS 1999 2B	Calif 2002 2B	Calif 2002 % Degree of C
1. Childhood Leukaemia	Yes	Yes	Yes	72
2. Adult Leukaemia		Yes	Yes	57
3. Adult Brain Cancer			Yes	64
4. Miscarriage			Yes	56
5. ALS			Yes	54
6. Childhood Brain Cancer				25
7. Female Breast Cancer				28
8. Male Breast Cancer				35
9. Alzheimer's Disease				26
10. Suicide				46
11. Heart Disease				33
12. Depression				- (other)
13. Electro-sensitivity				- (other)
14. Universal Carcinogen				3 (SBN)
15. Other reproductive				5 (SBN)

Numbers of reviewed epidemiological studies and of positive and significant results.

Disease	Number of Studies	Positive studies: number, p value*	Significant positives: number, p value*	Meta-analytic OR (95% CI)
1. CL	19	16 0.0014	3 0.01	1.3 (1.0 – 1.7)
2. Adult L	43	32 0.0007	11.5 <<0.00001	1.2 (1.12 – 1.24)
3. A Brain C	32	25 0.0007	6 0.0001	1.2 (1.1 – 1.3)
4. Miscarriage	37	27.5 0.0015	9 <<0.00001	
5. ALS	7	6 0.06	3 0.004	1.5 (1.2 – 1.7)
6. C Brain C	12	6 >0.5	2 0.04	
7. F Breast C	24	17.5 0.012	5.5 0.0001	
8. M Breast C	16	11.5 0.04	no data	
9. Alzheimer's	6	4 0.34	2.5 0.001	
10. Suicide	8	6.5 0.02	3 0.0007	
11. Heart Disease	8	6.5 0.02	5.5 <<0.00001	

*Null hypothesis, result occurs by chance

Illnesses associated with EMFs – Is there a common factor?

- Childhood leukaemia
- Adult brain cancer
- Adult leukaemia
- ALS
- Depression
- Suicide
- Miscarriage
- Breast cancer

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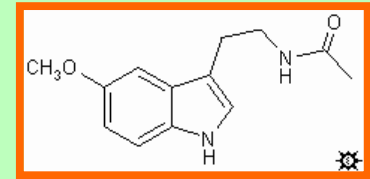
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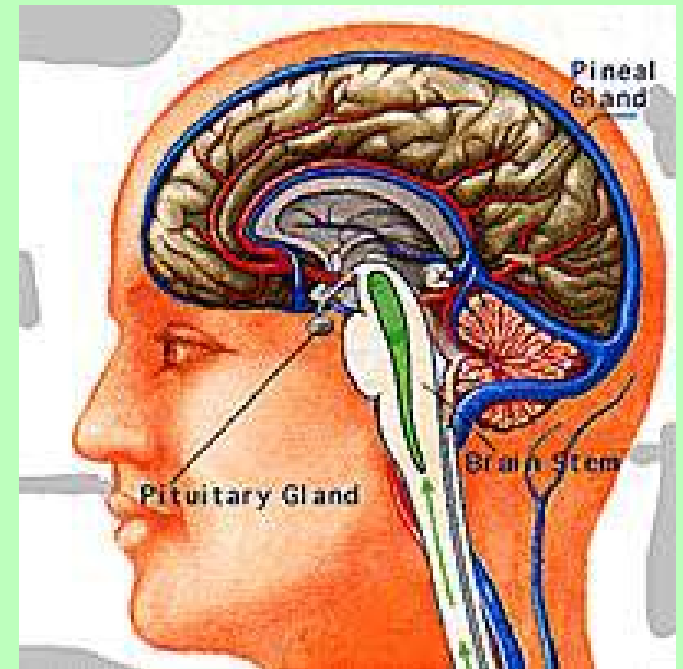
**Disruption of
Melatonin**

Melatonin

(N-acetyl-5-methoxytryptamine)



- Melatonin is a hormone produced in the pineal gland mainly at night
- Highly protective of oxidative damage to the human haemopoietic system
- Reduced levels of melatonin are associated with (i) increased cancer risk in animals and in humans, (ii) with depression and possibly miscarriage



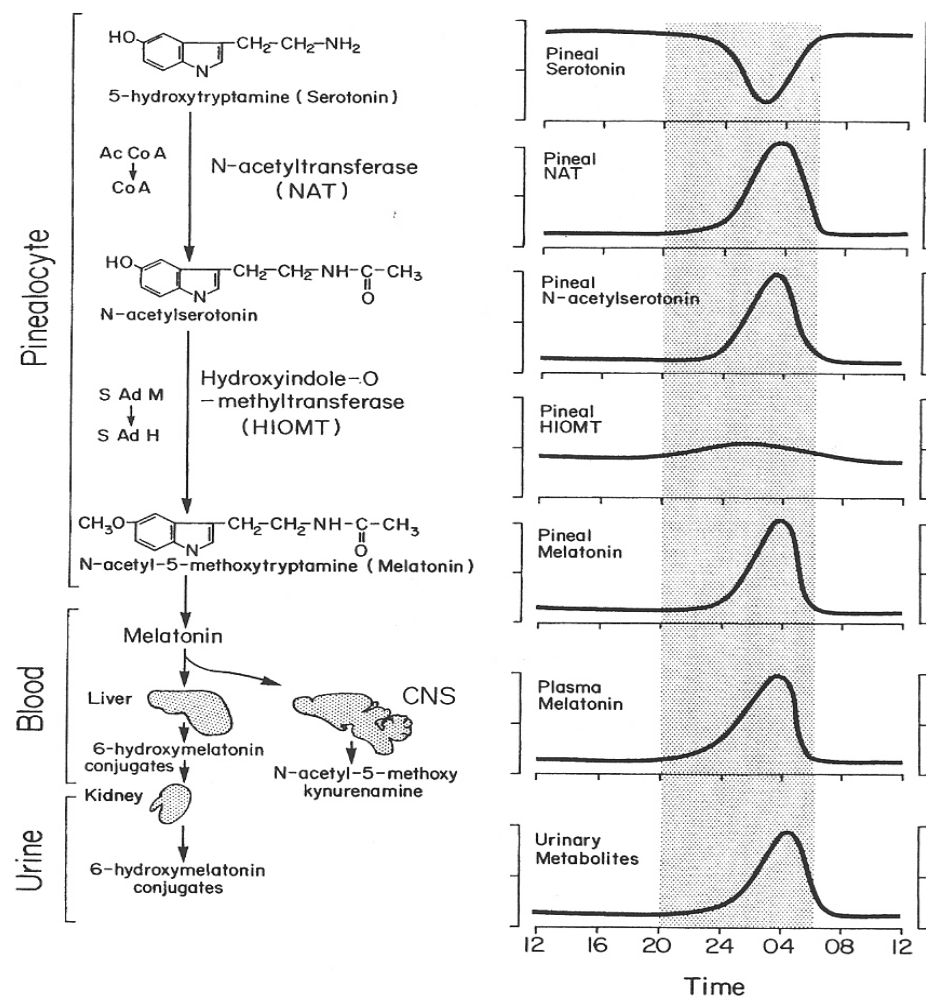


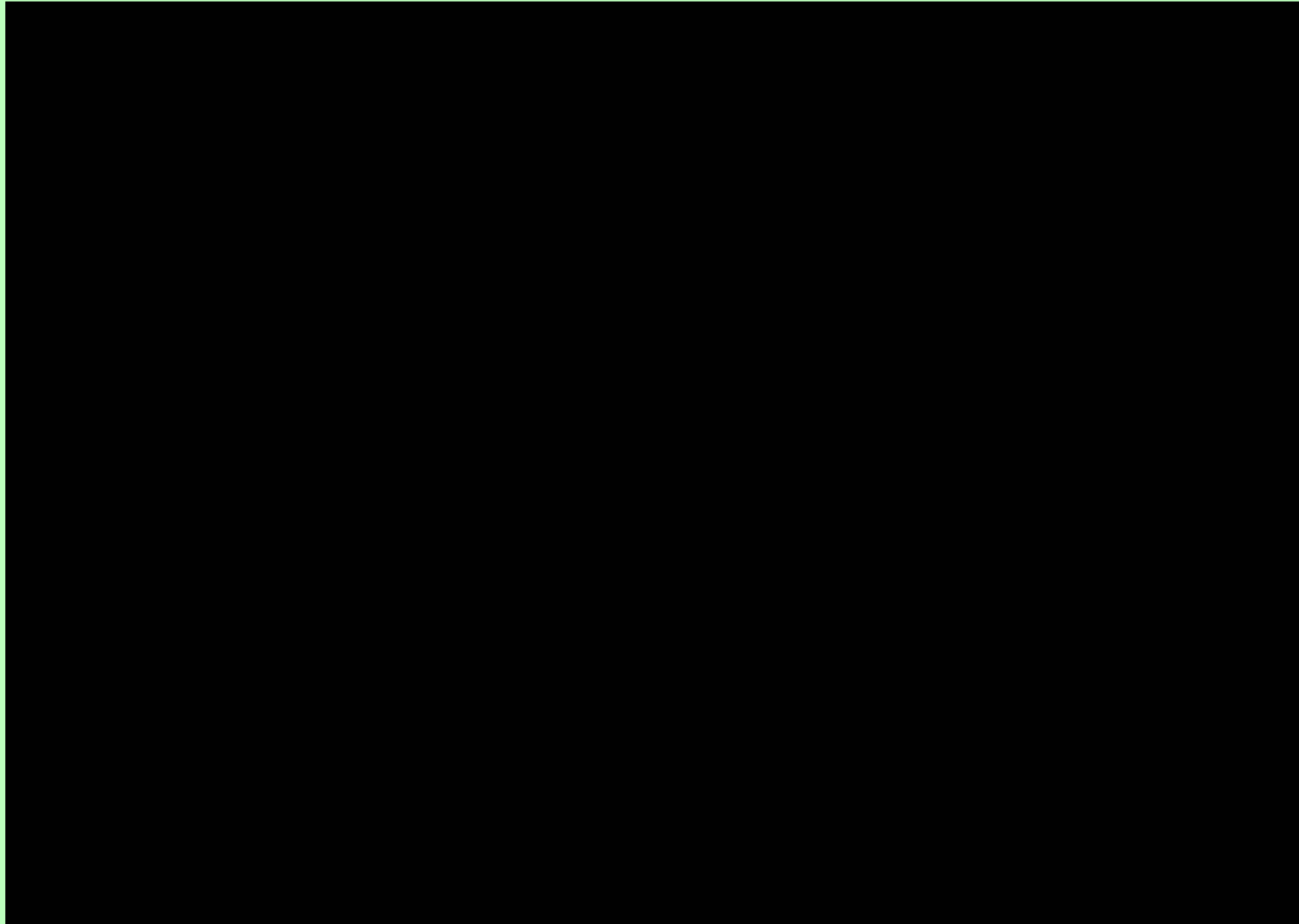
FIG. 2. Metabolism of serotonin to melatonin as it occurs in the pineal gland. After its release from the pineal, melatonin is metabolized in the liver and the brain, with the metabolites being excreted in the urine. On the right are the 24-hour rhythms of each of the constituents; the shaded area represents nighttime. CNS = central nervous system.

Light at Night - Europe in the Present



<http://www.ngdc.noaa.gov/dmsp/>

Light at Night - Europe in the Past



<http://www.earthview.mars/safe/>

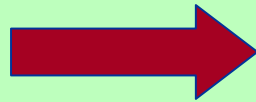
The Melatonin Hypothesis – Richard Stevens

University of Connecticut 1987

- Exposure to Light at night or MFs suppresses nocturnal melatonin leading to increased risk of breast cancer
- Has much support for visible light: evidence that female night shift workers have elevated breast cancer risk
- Women's blood containing normal physiological concentrations of nocturnal melatonin prevents growth of MCF-7 breast tumours transplanted into rats (Blask *et al.* 2005)
- MFs and breast cancer risk controversial – small increased risk at best
- But, populations exposed to neighbourhood EMFs shown melatonin disruption
- For EMFs, the Melatonin Hypothesis has been extended to Childhood Leukaemia – melatonin is highly protective of oxidative damage to the human haemopoietic system and to the fetus in animals (details in Henshaw & Reiter 2005)

Melatonin, EMF and Health:

Large number of
human population
studies

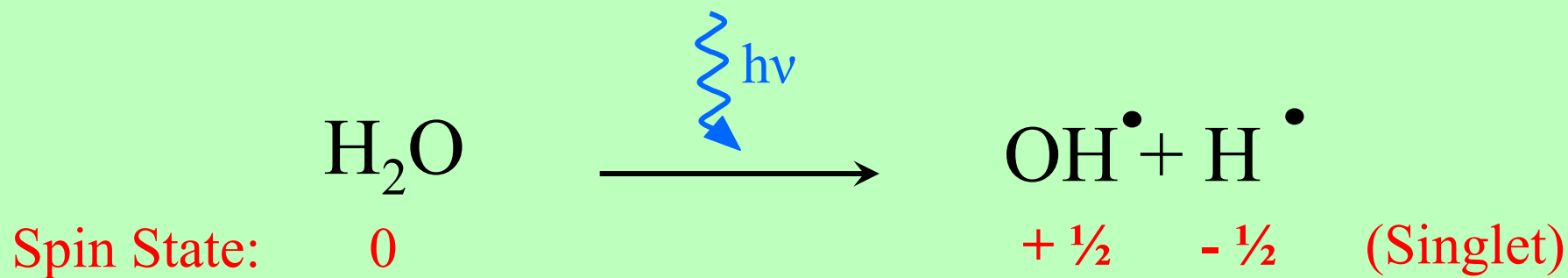


Magnetic fields
 $\geq 0.2 \mu\text{T}$ depress
melatonin production

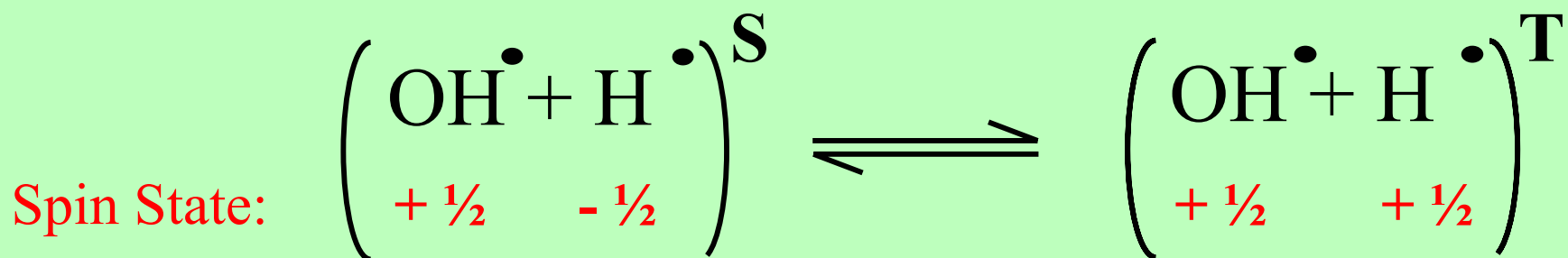
CBA Mice exposed to constant light (which
suppresses melatonin) develop leukaemia

A second hypothesis: Radical Pair (RP) mechanism

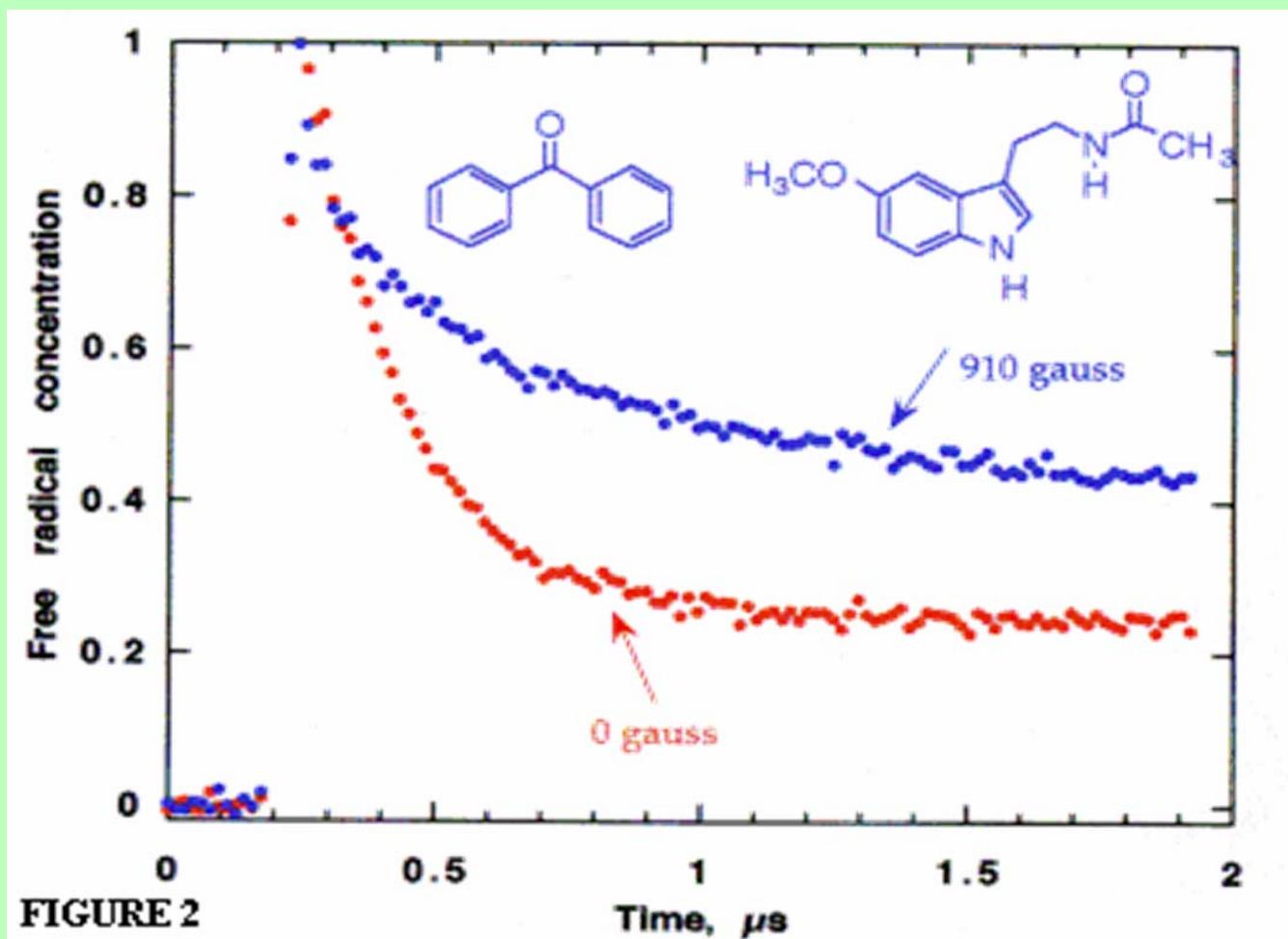
- At low intensity, magnetic fields can increase the lifetime of chemical species known as *free radicals*. This is theoretically possible and has experimental support.



- Magnetic field dependent singlet • triplet interconversion



- LFE = Low Field Effect
- Apply MF, ratio T/S increases
- S lifetime ~ ns
- T lifetime ~ μs



A radical pair, derived from benzophenone and melatonin, is generated in the triplet state. Application of an MF increase the lifetime (Scaiano: J. Pineal Res. 19, 189-195 (1995)).

A second hypothesis: Radical Pair (RP) mechanism

- **Hypothesis:** At low intensity, magnetic fields can increase the lifetime of chemical species known as *free radicals*. This is theoretically possible and has experimental support.
- Studies *in vitro* and in animals show MFs enhance effects of exposure to existing carcinogens – supports RP above 100 μT .

Magnetic fields enhance the effect of environmental carcinogens, *in vivo* and *in vitro*

- Juutilainen & Naarala (*IJRB*, 82(1), 1-12, 2006) carried out a meta-analysis of 65 studies involving both *in vivo* and *in vitro* exposure to MFs and known environmental carcinogens
- Enhanced effects were widely seen when MFs exposure was added; the overall percentage of positive studies was highly significant ($p < 0.001$)
- These results were obtained principally above 100 μT . They support the RPM, but do not address directly the situation at 0.4 μT

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- Studies *in vitro* and in animals show MFs enhance effects of exposure to existing carcinogens – supports RP above 100 μT .
- Birds detect changes in static MFs as low as $\sim 0.08 \mu\text{T}$ for navigation.

Animal navigation:

Robins detect $\sim 0.08 \mu\text{T}$ changes in the Earth's 'static' magnetic field of $50 \mu\text{T}$ using a radical pair mechanism



Ritz *et al* 2004
University of California
(Nature Vol. 429, 177-180)

Animal navigation

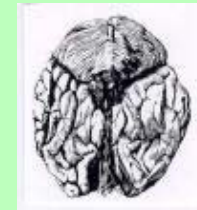
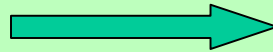
- Many species of animals navigate by detecting tiny changes in the Earth MF – e.g. homing pigeons detect changes at the 10 – 20 nT level.
- In birds both compass and declination information is detected involving both magnetite particles and a RPM.
- The RPM is in the eye; visible light of particular wavelengths is required to create the RPs.
- The RPM appears to use arrays of photo-pigments, cryptochromes, to detect and amplify the MF signal.
- In salamanders, however, the receptors are found in the pineal gland!!

Are the melatonin and RP mechanisms tied together?

Light



Newly discovered ganglion cell

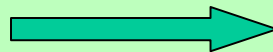


Pineal gland
(regulates melatonin)

MF reception

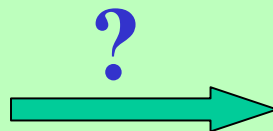


Light dependent radical pair



Brain
(Navigation)

EMF

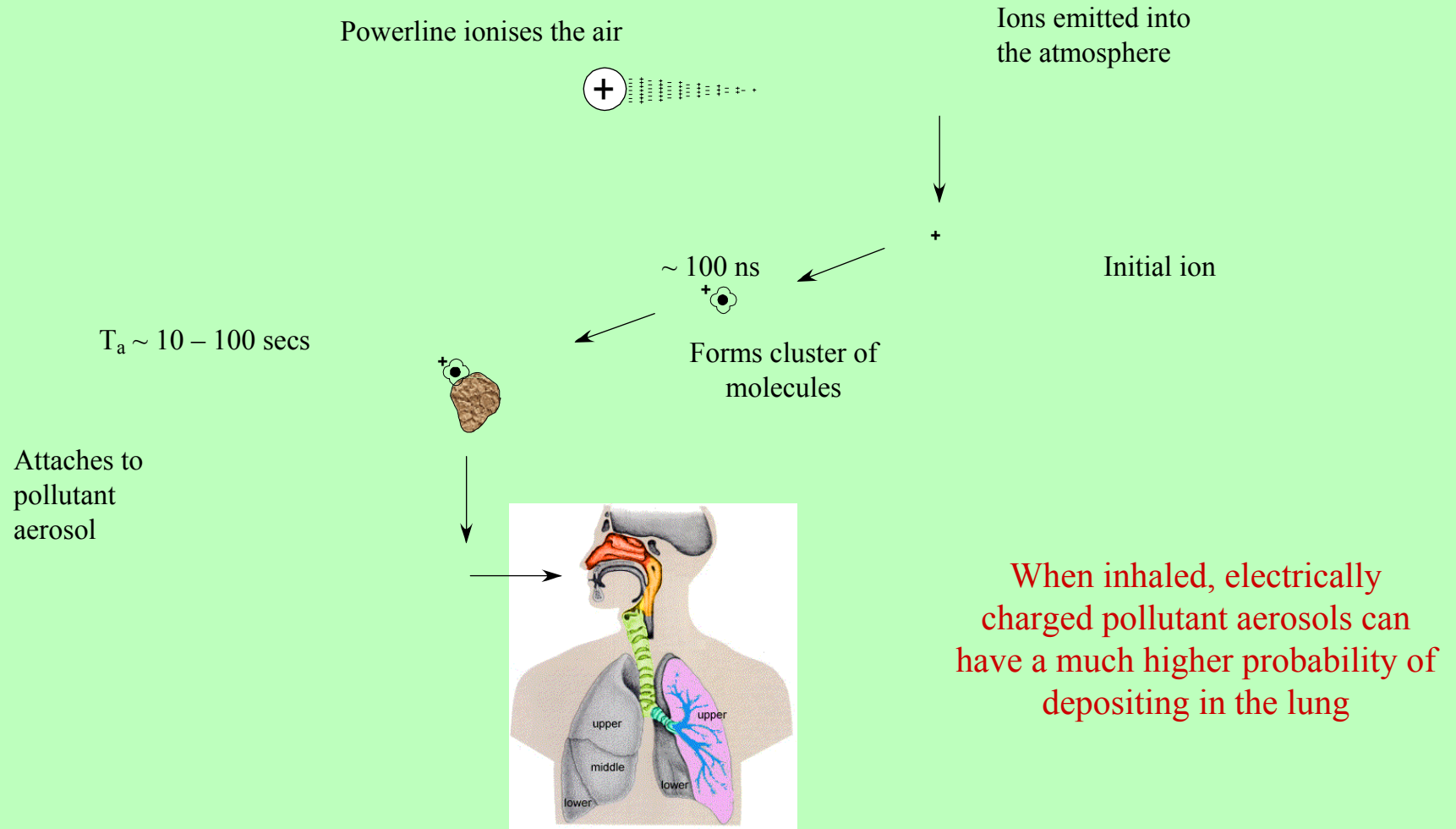


Pineal gland

But for high voltage powerlines:

What about the electric field?

Fate of corona ions in the atmosphere

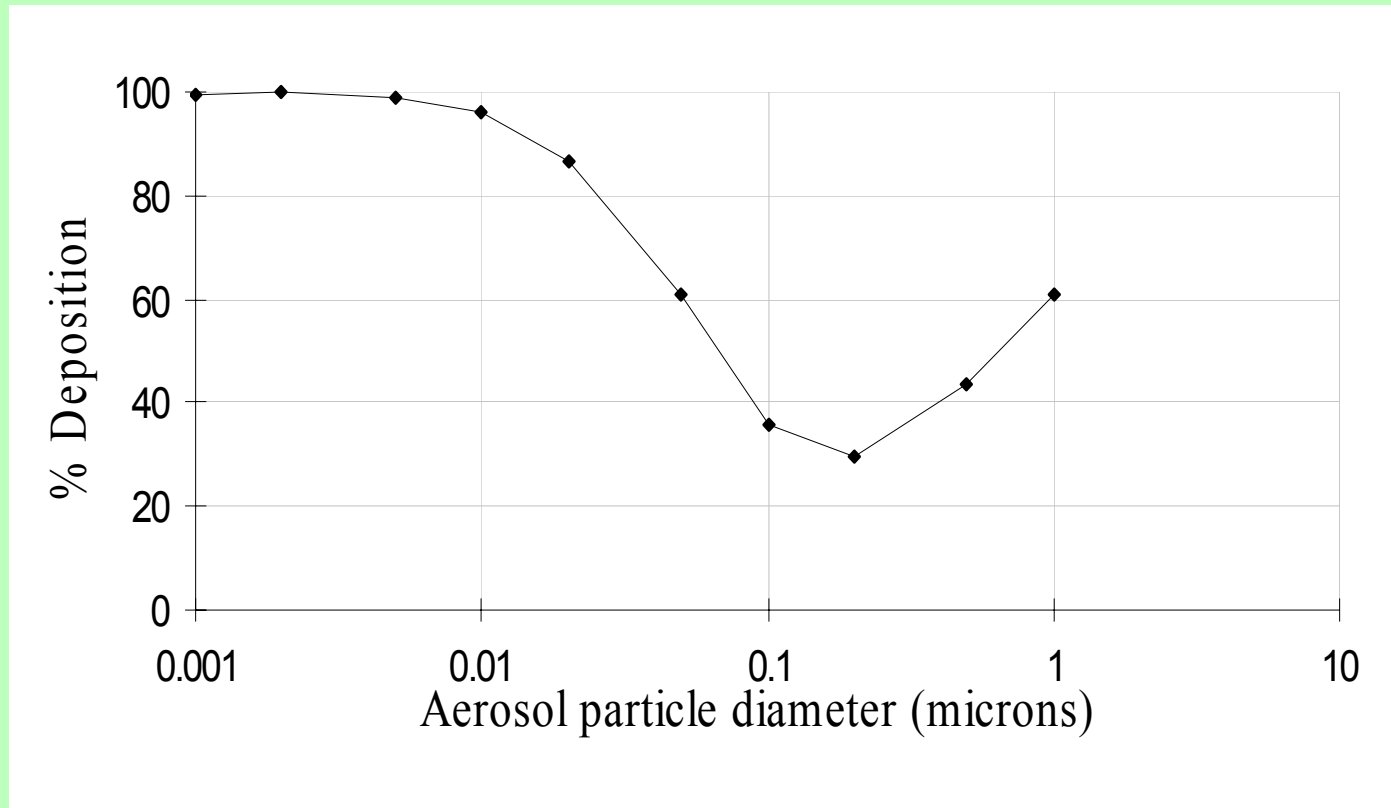


Fews *et al.* 1999, 2002, 2004; Henshaw 2002

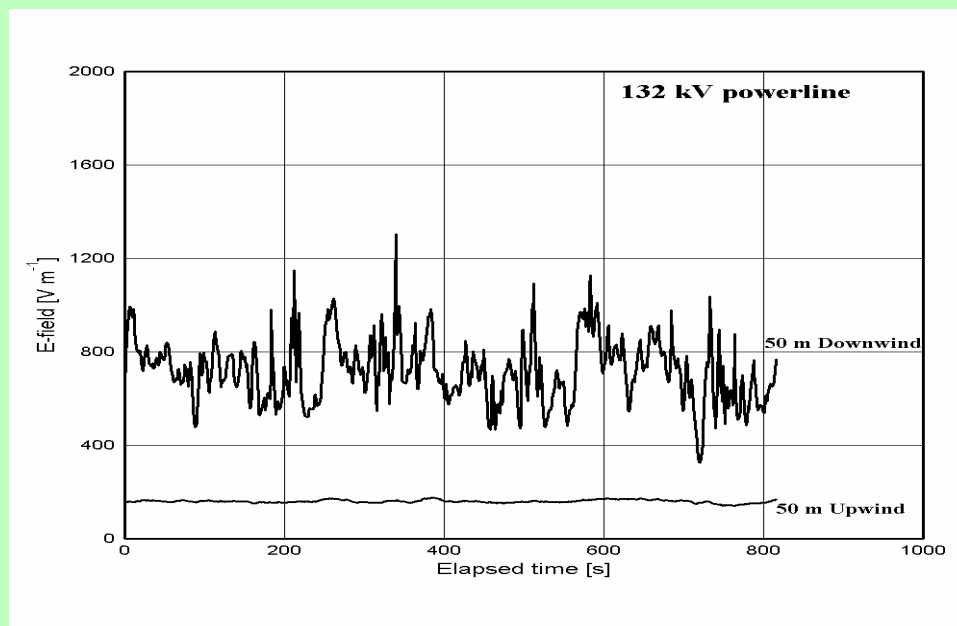
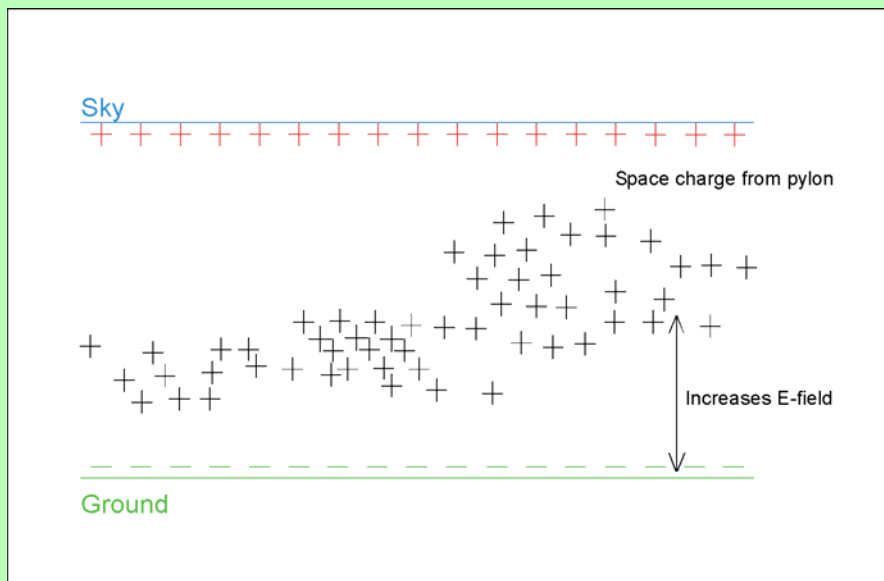
Magnitude of corona losses and transport in the atmosphere

- Losses can be up to 0.1 mA per metre of powerline or up to 6.25×10^{14} charges per metre per second - even if most of these are absorbed by the line, there is potentially a high flux emitted into the atmosphere
- Corona-ion effects can be carried large distances from powerlines – have been detected 5 – 7 km away (Chalmers, Durham 1952; Mühleisen, Weissenau 1953, Bristol today)
- Childhood leukaemia has been firmly linked to air pollution (Knox 2005a & b, 2006)

Total lung deposition according to the ICRP 66 lung model



Positive corona from the 132 kV line at Rangeworthy, South Gloucestershire on 19th October 1999.



Corona ion effects on ground level atmospheric DC field

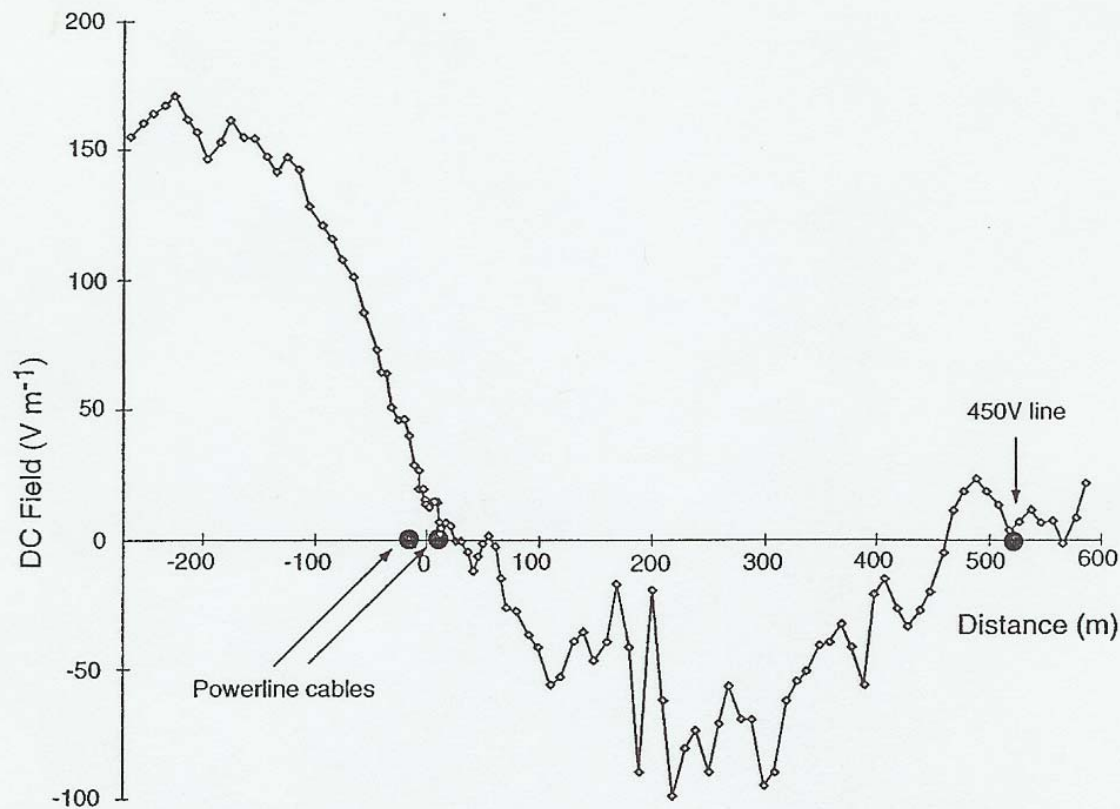
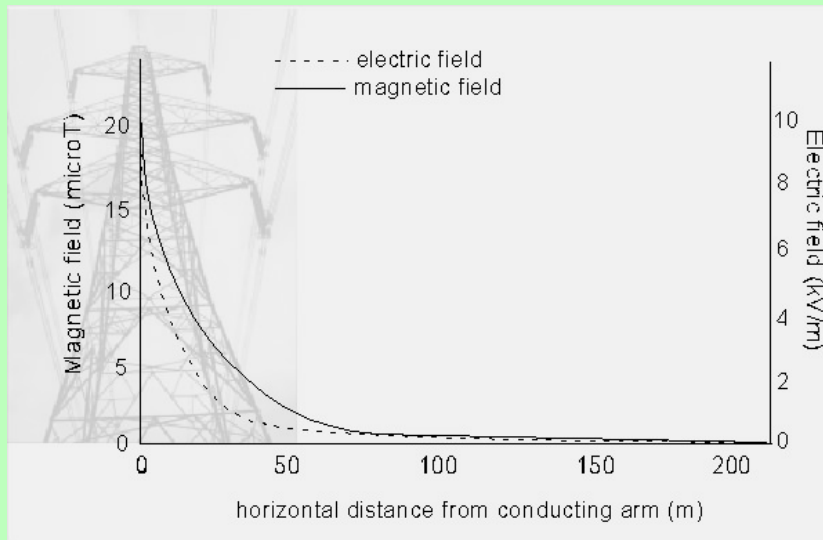
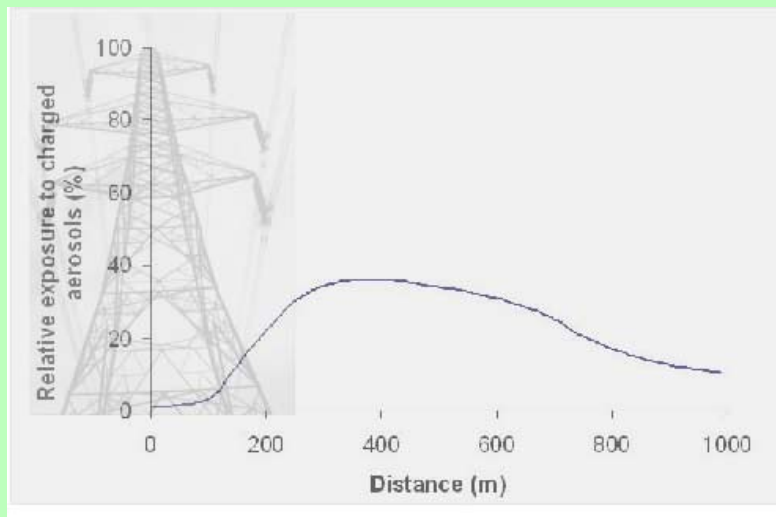


Figure 4. DC field measurements near 275 kV powerline at Oldbury.

Exposure profiles with distance from powerlines



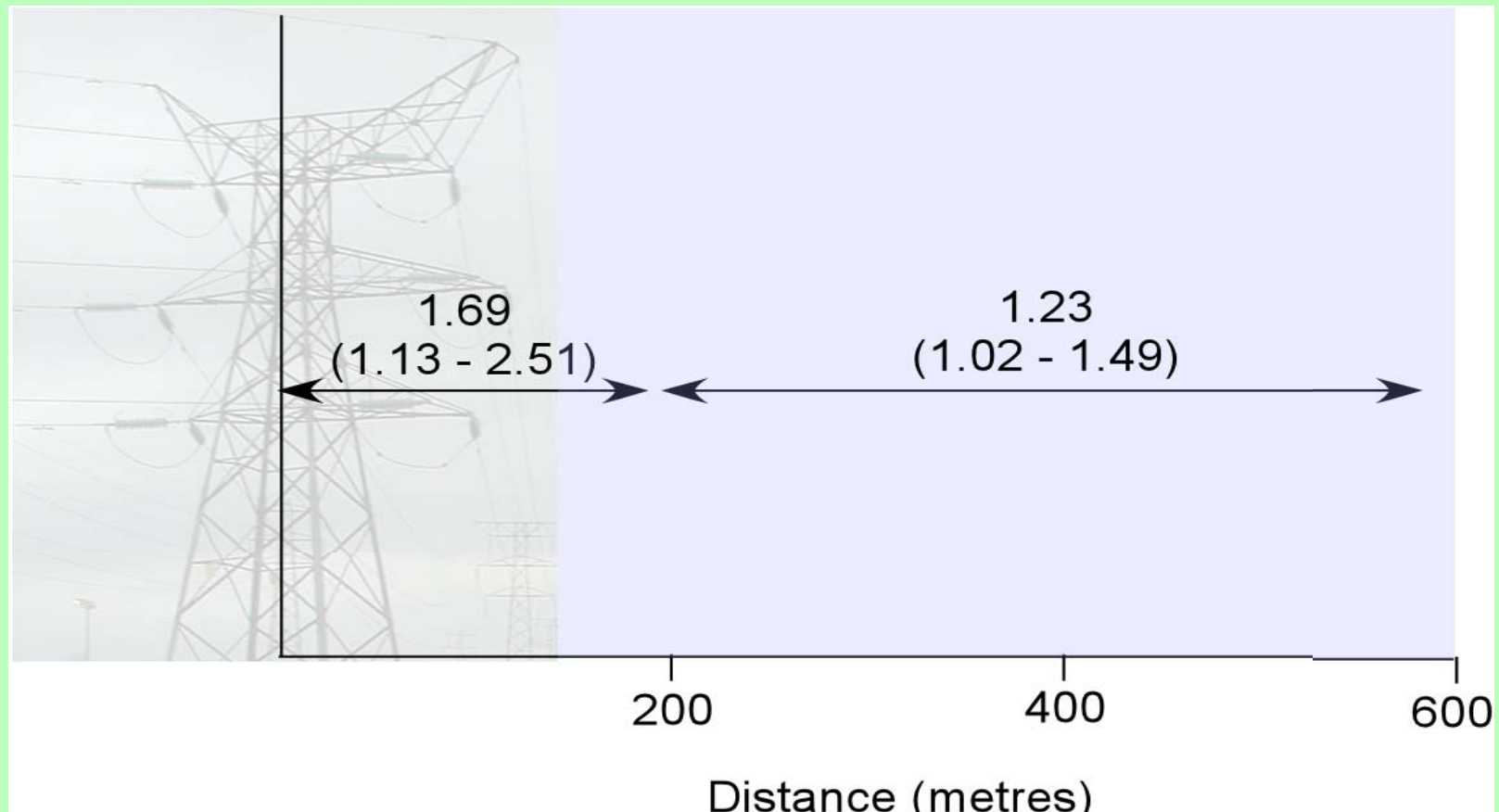
Electric and magnetic fields



Corona ions

Draper *et al.* British Medical Journal 2005; 330: 1290-3

29,081 children with cancer, 9,700 with leukaemia 1962-1995



Conclusions

- There is a robust association between exposure to **magnetic fields** and increased risk of childhood leukaemia and possibly other illnesses. Causal mechanisms are under discussion
- Though much less developed, recent evidence suggests that in the case of high voltage powerlines adverse health effects may extend much further away than from the **direct range** of either the electric or magnetic fields

Acknowledgements

Team members:

Paul Keitch

Julie Close

Liz Ainsbury

Matthew Wright

Jonathan Ward

James Matthews

Alison Buckley

Websites:

www.electric-fields.bris.ac.uk

www.leukaemiaconference.org

Supported by



Causal mechanisms

- Magnetic fields effects on the production and action of pineal melatonin
- Magnetic fields effects on the production and action of pineal melatonin

More about RPs

- Chris Timmell's graph

Other illnesses associated with EMFs:

- **Adult leukaemia & brain tumours:** California Dept of Health Sciences (DHS) EMF Report 2002 cites a body of epidemiological studies clearly indicating an association with EMFs
- **ALS (motor neurone disease):** association agreed by NRPB (HPA) and DHS
- **Depression:** a body of epidemiological studies, including those in the West Midlands by the Wolverhampton GP Dr Steven Perry. Similar evidence for increased **suicide** risk
- **Miscarriage:** a small number of studies which if causal would imply a 5-10% absolute risk of miscarriage linked to MFs above 1.6 μ T (but not principally from powerlines)
- **Breast cancer:** much discussed, at most a small increase in risk