

# **“Investigation of mechanisms of action in cells exposed to the high frequency electromagnetic fields of mobile telephone technology. B. pineal gland”**

Prof. Alexander Lerchl’s contribution to the German Mobile Telecommunication Research Programme (DMF) about the effect of RF electromagnetic fields on the synthesis of melatonin in isolated pineal glands of dwarf hamsters

*A critical commentary by Franz Adlkofer*

The pineal gland, whose size varies greatly among mammals, is located in the diencephalon at the posterior wall of the third ventricle. This gland produces melatonin whose synthesis is controlled by the circadian clock of the suprachiasmatic nucleus (SCN). The function of the SCN as a *zeitgeber* depends on the exposure of the eye’s retina to light. Melatonin synthesis and its pulsatile release occur at night and are responsible for the deep sleep cycle. During daylight exposure, the synthesis and secretion of melatonin is suppressed. Melatonin is a neurohormone, which is responsible for the circadian-rhythm processes in the body. The large number of mechanisms through which it modulates the physiology and molecular biology is striking. Many, but not all of these actions are mediated by melatonin receptors. Intracellular processes are also impacted by the capacity of melatonin to trap free oxygen radicals before they can exert their harmful effects. Overall, melatonin plays an important role in the maintenance of the physiological functioning of cells and organs. A lack of melatonin, therefore, is to be expected to cause adverse effects on human health.

## **A. Prof. Lerchl’s final report within the DMF**

That cell phone radiation may cause sleep disorders as well as other disorders in humans due to a suppression of the synthesis and release of melatonin is an assumption that is frequently adopted, but not yet proven. With the term “melatonin hypothesis,” this assumption found its way into the scientific literature. In order to test this connection, Prof. Lerchl examined whether the melatonin synthesis in isolated pineal glands of dwarf hamsters is affected by RF electromagnetic fields. In the final report of his research project<sup>1</sup>, he summarizes his findings as follows:

*The aim of the study was to determine if electromagnetic fields used for telecommunication purposes can affect the synthesis of the pineal hormone melatonin. Isolated pineal organs of Djungarian hamsters (*Phodopus sungorus*) were continuously perfused by Krebs-Ringer buffer, stimulated with the beta-adrenergic receptor agonist isoproterenol to induce melatonin synthesis, and exposed for 7 h to a 1800 MHz continuous-wave (CW) or pulsed GSM-modulated electromagnetic signal at specific absorption rate (SAR) rates of 8, 80, 800, and 2700 mW/kg. Experiments were performed in a blinded fashion. Perfusate samples were collected every hour, and melatonin concentrations were measured by a specific radioimmunoassay. Both types of signal significantly enhanced melatonin release at 800 mW/kg SAR, while at 2700 mW/kg SAR, melatonin levels were elevated in the CW, but suppressed in the GSM-exposed pineal glands. Since at 2700 mW/kg SAR a temperature rise of approximately 1.2 °C was measured, effects at this level are thermal. With regard to RF-EMF, the data do not support the “melatonin hypothesis” according to which non-thermal exposure suppresses melatonin synthesis.*

The research approach is explained as follows<sup>2</sup>:

*In order to reach a definite conclusion of whether or not cellular fields have an effect on the production of this hormone, the effects of diurnal rhythm have to be excluded. This is only possible in experiments using isolated pineal organs (in vitro).*

### **Basic objections to Prof. Lerchl's research project**

Prof. Lerchl's research approach lacks any connection to reality. This even holds true when the difference between the biological systems of humans and dwarf hamsters — which most probably exists, but was barely acknowledged by Prof. Lerchl — is not taken into account. Under physiological conditions, the melatonin synthesis in the pineal organ is controlled by several control (steering) centers outside the location of its production. The study on isolated pineal glands ignores the dependence of melatonin synthesis on these regulatory mechanisms. The assumption that the coupling to the circadian rhythm can only be stopped by the above-described method is not true. The decoupling of the circadian rhythm could also be achieved by creating suitable conditions in the keeping of the animals. Without considering the entire regulatory system as a whole, however, the question as to whether electromagnetic fields affect melatonin synthesis and thus prove or disprove the "melatonin hypothesis" cannot be answered. This fact alone is sufficient to show that the design of Prof. Lerchl's research project is to be regarded as flawed and its result as meaningless.

This first scientific mistake is compounded by a second one which consists in the fact that due to its central location within the human brain the exposure of the pineal gland to cell phone radiation is very low.<sup>3</sup> It is conceivable that during the use of a cell phone a SAR value of 8 mW/kg may be reached in the pineal gland, e.g. around a two-hundred-fiftieth or perhaps even a slightly higher portion of the partial body limit of 2 W/kg. However, we can rule out with probability that such an exposure level — in compliance with the whole-body limit of 80 mW/kg — is reached when humans are exposed to the radiation of a base station. Provided that the research approach altogether allows for conclusions, they should therefore be limited to the results obtained with 8 mW/kg.

### **Prof. Lerchl's conclusions drawn from his results<sup>1</sup>**

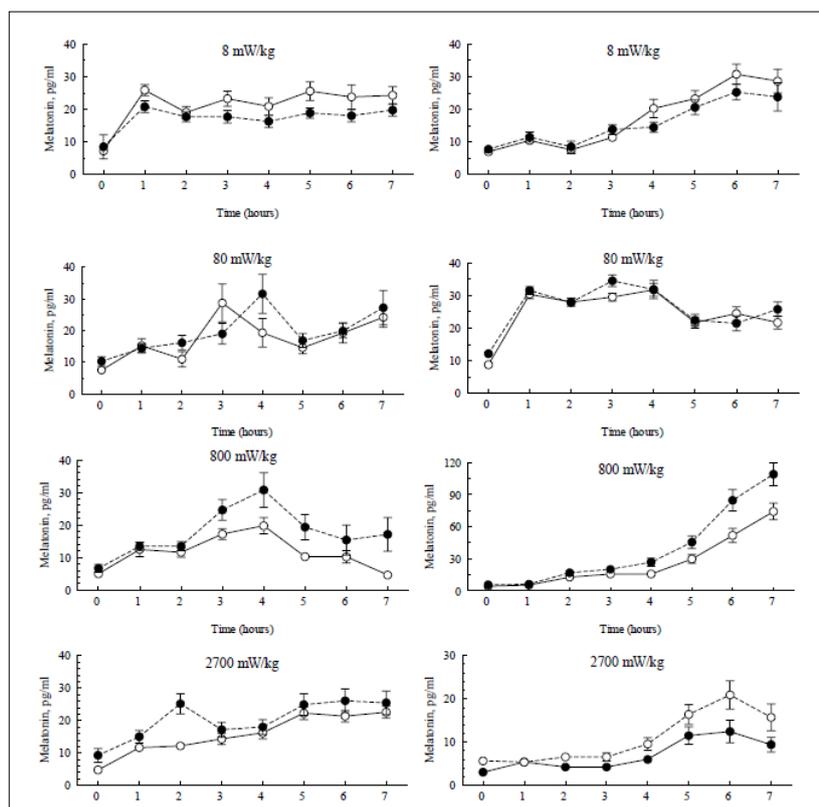
*The study showed that an exposure level within the currently valid whole-body exposure limit (80 mW/kg; 26. BImSchV) does not result in any impairment of the melatonin synthesis in isolated pineal organs. An exposure at 800 mW/kg results in an increase in melatonin levels, at 2700 mW/kg thermal effects become dominant, which are not further discussed here. ... Independent of the potentially fundamental restrictions regarding the comparability of in-vitro studies with human exposures, it should be noted that at a SAR of 800 mW/kg it obviously came to a subthermal response of the pineal organs, regardless of the signal's modulation — at least when the threshold of 1 °C (ultimately arbitrary) serves as the distinguishing criterion for thermal and nonthermal effects. Alternatively, even small differences may have measurable effects in this temperature range. The direction of the response (increase in melatonin synthesis), however, speaks against the melatonin hypothesis according to which melatonin synthesis is assumed to be suppressed after magnetic or electromagnetic field exposures, respectively. Moreover, for an elevated melatonin synthesis no adverse effects are known from animal experiments or clinical studies so that these data in no way suggest the existence of adverse health effects. Yet our finding is of interest insofar as no plausible mechanisms are known to explain it, apart from the potentially minimal-thermal influence. ... Regarding the currently valid exposure limits (whole-body exposure), the above discussed findings provide no basis for a recommendation to lower them. (ed.: translation by Adlkofer)*

### **Commentary on the study results of Prof. Lerchl**

The reference that results from *in-vitro* studies on pineal glands of dwarf hamsters may not be comparable with those obtained after human exposure is correct and necessary, but it is completely disregarded in the study's conclusions. They are based exclusively on speculation and either show sheer opportunism or a lack of expertise. Some details follow to clarify this point:

- The claim that an exposure below the currently valid whole-body limit (80 mW/kg; 26. BImSchV) does not affect melatonin synthesis in isolated pineal organs is rather questionable and not at all supported by the findings obtained. Figure 3 of the final report (see further below) rather shows that melatonin synthesis is suppressed at a SAR level of 8 mW/kg — thus well below the partial- and whole-body limit — by continuous wave as well as GSM radiation, and this probably even significantly, in any case however with a clear tendency. The original data for further analysis are not available. It is a frequent misunderstanding in the use of statistical methods for which Prof. Lerchl has a tendency, not just in this case, when he considers a significance level of  $p < 0.05$  basically as proof while a level of  $p = 0.06$  is observed as meaningless. This epistemologically questionable

approach ignores the very conventional task to objectively justify the errors one is prepared to accept as part of the statistical testing (alpha and beta errors). In order to definitively rule out the “melatonin hypothesis,” the only option left to Prof. Lerchl was to simply ignore the suppression of the melatonin synthesis at 8 mW/kg, although this is clearly shown in the figure. Otherwise, he would have had to acknowledge also the existence of non-thermal effects of cell phone radiation, which he always strictly denies. On the basis of the presented results one could definitely assume a confirmation of the “melatonin hypothesis”, if the study design as such is not so absurd.



**Fig. 3 of the Final Report:** Effects of electromagnetic fields (1800 MHz: continuous-wave—left, pulsed—right) on melatonin synthesis of isolated pineal organs. Melatonin synthesis was stimulated by isoproterenol for 30 minutes (between hour 0 and 1). ○---○ sham-exposed; ●---● exposed

- However, that Prof. Lerchl regards the increase in melatonin synthesis at a SAR level of 800 mW/kg as an argument against the “melatonin hypothesis” is equally unfounded as his suggestion that in the case of an increase in melatonin synthesis positive effects are more likely to occur than negative ones. Considering the many effects of the neurohormone melatonin, such a statement is most definitely incorrect. According to latest findings, a SAR value of 800 mW/kg, which falls within the partial-body limit of 2 W/kg and exceeds the whole-body limit of 0.08 W/kg by a factor of 10, is never reached in the pineal gland of children or adults during the exposure to GSM radiation at 1800 MHz as long as in compliance with the relevant exposure limits<sup>3</sup>. A sub-thermal response in the pineal gland, which Prof. Lerchl assumes to be the cause of the increase of the melatonin synthesis, is therefore inconceivable. This knowledge, however, undermines also the basis of his most important argument against the “melatonin hypothesis.” Rather obvious throughout the entire final report is the intention to give a reversed interpretation to an assumed — and based on the scientific literature including his own<sup>4</sup> — potential harmful effect of RF radiation in humans.

- And Prof. Lerchl does not even try to explain why the results for the exposure to the different types of signals at a SAR level of 2700 mW/kg are opposite. While the continuous-wave radiation caused a slight increase in melatonin synthesis, the GSM-modulated radiation seems to clearly suppress it. Prof. Lerchl is of the opinion that this is about thermal effects, which may indeed be the case. Why, however, this effect is opposite can only be explained by the different signal characteristics of the respective radiation. Probably, Prof. Lerchl did recognize that this is an issue of a highly explosive nature. Yet he prefers to keep silent about it, possibly trying to not draw any attention to a — for the cell phone industry — highly unpleasant issue that belongs in the context of the reliability of the currently valid exposure limits.
- Well-intentioned, but untenable is also Prof. Lerchl's claim that the results of his study support the preventive policy for children by the Federal Office for Radiation Protection (BfS). He, thereby, relies on a supposed worst-case scenario according to which in the center of the head, where the pineal gland is located, SAR values from ca. 0.1 to 0.7 W/kg can occur, depending on age. In his opinion, the highest exposure levels are to be found in small children. This, however, is neither the case for the GSM radiation at 900 MHz to which his worst-case example refers nor for the GSM radiation at 1800 MHz which he used in his study. Because the distance between the pineal gland and the entrance of the radiation at the ear is about the same, the radiation exposure of the pineal gland in children and adults is also about the same.<sup>2</sup>
- It must be conceded, however, that the scientific debate about this issue is not closed yet. Under certain assumptions, it is indeed conceivable that during cell phone use the SAR in children can actually be higher than in adults, thus reaching at least a value of 8 mW/kg or even higher. There could have only been talk about his scientific data supporting the preventive policy of the BfS, if Prof. Lerchl would have been willing to acknowledge the suppression of the melatonin synthesis at 8 mW/kg, which he ignored. Without this admission, the claimed confirmation of the preventive policy is only a friendly gesture he extends to the BfS, but which is untenable from a scientific perspective. There should be no place for such ingratiation in a scientific report.
- Absolutely bizarre is Prof. Lerchl's conclusion that his findings provide no basis for a recommendation to lower the currently valid limits for whole-body exposures. Because his statement contravenes the radiation effects documented both at SAR levels of 8 mW/kg as well as 800 mW/kg, the opposite is more likely. The criticism of Prof. Lerchl's claim, however, is based on rather different considerations, namely that the results of the research project do not allow for direct extrapolation to humans exposed to cell phone radiation: 1) because the pineal gland in humans differs in its function most probably from the one in dwarf hamsters, 2) because the study results of isolated pineal glands disregard the overriding steering system of synthesis and secretion, and 3) because the pineal gland due to its relatively low radiation exposure is pretty much the most unsuitable organ with which the reliability of exposure limits should be verified.

**Thus, in summary, it can be said:** Prof. Lerchl's research project, the approach of which — very obvious to any expert in this research area — could not the least contribute to the clarification of the given issue, is about the inept attempt to rule out doubt about the exposure limits and to refute the "melatonin hypothesis."

**Defending the currently valid exposure limits**, which by now lack a convincing scientific basis, has always been a special concern of Prof. Lerchl. If his research project gives any cause for reflection about exposure limits, the approach would have to be of a fundamental nature. Since exposure limits are only based on the concept of thermal effects and the basic restriction for the localized exposure of the skull only refers to a random 10-g sample of tissue, it is impossible to use them for reliable conclusions regarding the effect in more deeply embedded and possibly more susceptible tissues such as the one of the pineal gland. Should this organ show effects even below a SAR of 2 W/kg, the limit for the localized exposure of the skull, which are regarded as relevant to human health and which actually seem to show a trend at both the 8 mW/kg as well as the 800 mW/kg level, the compliance with the exposure limits does not tell us anything. This would only prove the fact that, in general, the relation between the maximum SAR and the SAR in any part of the skull cannot be determined.

With the **attempt to refute the melatonin hypothesis**, Prof. Lerchl undoubtedly pursues a fundamental interest that appears to coincide with that of the industry. Thus he intends to rule out that people who,

according to their own reports, suffer from sleep disorders because of electromagnetic fields may have the opportunity to ascribe their symptoms to cell phone radiation. From his point of view, these and similar phenomena summarized under the term “electrosensitivity” unnecessarily contribute to uncertainty among the public. Since melatonin being a radical scavenger is suggested to protect from tumor development or at least to be able to slow down such a development, which Prof. Lerchl also refers to, overall adverse health effects would have to be expected in the case of a suppression of melatonin production. Since Prof. Lerchl, however, has allegedly observed only an increase in melatonin synthesis, he even suggests, on the basis of his rather useless results, a positive effect of cell phone radiation on this hormone system — and this is certainly no coincidence.

## **B. Prof. Lerchl’s publication in a peer-reviewed scientific journal**

Independently from the final report within the DMF, Prof. Lerchl together with several co-authors also published his research results with the title *1800 MHz Electromagnetic Field Effects on Melatonin Release from Isolated Pineal Glands* in the *Journal of Pineal Research*.<sup>5</sup> As far as the content is concerned, this renewed publication does not differ from the final report, except for the presentation of the results. What strikes the mind is the fact that instead of 500 dwarf hamsters supposedly only 320 were killed, which are still 320 too many for a useless research project, and that regarding the conclusions drawn from the findings imagination runs even wilder.

- Figure 3 of the final report (see above), which shows detailed study results for each hour during the 7-hour exposure period, is dropped from the new publication. This is obviously meant to ensure that nobody notices the clear trend towards a suppression of melatonin synthesis during both continuous wave and GSM exposure at a SAR level of 8 mW/kg. On the one hand, this would be in line with the “melatonin hypothesis,” which is to be refuted, and, on the other hand, confirms the existence of non-thermal effects caused by RF radiation, which supposedly do not exist. Instead of this figure, a table with numbers is presented in which the average values of melatonin synthesis on an hourly basis for the different exposure intensities are calculated from the total synthesis. Through this watering-down of the presentation, it was then possible with the help of an obviously suitable statistical tool to obscure the clear trend toward a suppression of the melatonin synthesis, and thus to achieve the wished-for result. Strangely enough, the data in the table are not consistent with those in figure 3. According to figure 3, the melatonin production during the GSM exposure at 8 mW/kg is most of the time lower than during sham exposure. But in the contrary, the table shows with 111.8 % a higher percentage than in the sham exposure, which seems to be impossible.
- On the basis of the findings obtained at the whole-body limit of 80 mW/kg, the whole-body limit, Prof. Lerchl points out even more clearly than in the final DMF report that disorders of the melatonin synthesis in humans are highly unlikely to be caused by radiation from base stations and that sleep disorders resulting from a lack of melatonin secretion can be ruled out. After all, his research findings rather showed an increase in melatonin synthesis, for which he claims that no adverse effects are to be expected. That cell phone radiation most probably led to a suppression of the melatonin synthesis already at a SAR of 8 mW/kg and as a result the “melatonin hypothesis” rather confirmed, is totally ignored by Prof. Lerchl. In addition, the fact is ignored that the melatonin synthesis is regulated via several steering centres, the effects of which he deliberately excluded in his research approach. Even a well-informed layman must feel the imposition of Prof. Lerchl’s above mentioned arguments.
- Prof. Lerchl draws three important conclusions from his research results. He claims that they suggest that (a) children should use cell phones in emergencies only if possible — just as recommended by the BfS; (b) more base stations should be installed to reduce the transmitting power level of individual base stations—just as desired by industry; and (c) in the future, higher cell phone frequencies should be given preference because their absorption by biological material is lower — just as intended by industry and politicians. To provide, whether right or wrong, industry-friendly recommendations, which are not at all supported by his own research findings, in a scientific paper under the pretext of protecting children, may indeed earn the claim of being quite unusual.

Prof. Lerchl’s motto with which he tends to condemn research results he disapproves goes as follows: “An esoteric can tell more nonsense in only five minutes than a scientist can refute in his entire life

(Vince Ebert).” That he outed himself as an esoteric, who has moved far beyond of what can be established on the basis of his findings, must have escaped him as well as the reviewers from the science journal *Journal of Pineal Research* who accepted his work for publication.

### **C. Statement by the German Commission on Radiological Protection (SSK) on Prof. Lerchl’s research project**

Much to our amazement did we notice that the BfS provided the required funds and the ethics commission — if indeed called in — saw no reason to withhold its approval for the killing of about 500 or 320 dwarf hamsters in such an artificial project. There is no need to point out that failures like these have an impact on the credibility of the DMF altogether.

At least, the enthusiasm of the SSK within the BfS regarding the assessment of the research findings was rather limited. Within the framework of their statement on the DMF from May 13, 2008, it comes to the following conclusion regarding Prof. Lerchl’s research project<sup>6</sup>:

*It is not clear to what extent the results obtained from isolated hamster organs can be transferred to humans, since in humans systemic differences could play a part. In hamsters, however, these differences have been excluded (Lerchl et al. 2007). Overall, these results have not confirmed the melatonin hypothesis”*

From the **first** sentence of the statement, which I agree with, it follows conclusively that the presented findings neither refute nor confirm the “melatonin hypothesis.” Why, nevertheless, the SSK emphasizes in the **last** sentence that the results did not confirm the “melatonin hypothesis,” is probably owing to Prof. Lerchl’s membership in the SKK. Thus the SSK also reveals a type of logic that has nothing to do with science, but should please the cell phone industry. Apart from that, the SSK appears to be content with having been able to advance the dwarf hamster research through the provided funds.

### **D. Answering the questions requested by the commissioners of the review**

1. *How do you evaluate the results of Prof. Lerchl’s melatonin project within the framework of the DMF?*
2. *From your perspective, how are the scientific as well as the ethical qualification of Prof. Lerchl to be assessed?*

As to 1: The results of the above research project lack any connection to reality. Since the overriding regulatory system that controls the secretion of melatonin is not included, the “melatonin hypothesis” can neither be confirmed nor refuted on the basis of the research approach. Due to its central location in the human brain, the pineal gland is not sufficiently high exposed to cell phone radiation to trigger thermal effects. But because there are no non-thermal effects for Prof. Lerchl, he can only ignore his own findings — even if they clearly indicate such effects. That one cannot compare the function of the pineal gland in dwarf hamsters with the one in humans, for which their different circadian rhythm is a strong indicator, is indeed mentioned, but not appreciated. These facts alone are sufficient to realize that already the study design of Prof. Lerchl’s research project is flawed and that the execution must be considered useless and the results meaningless. In addition, it becomes clear that the killing of 500 dwarf hamsters — or only 320 as shown in the later publication — even violates the Animal Protection Act.

As to 2: An imposition of a special kind is Prof. Lerchl’s very individual interpretation of his research results. It shows him as a scientist who wants to enforce conclusions seemingly important for him by ignoring and/or reinterpreting findings, no matter if they actually correspond with the obtained data or not. Should Prof. Lerchl be indeed convinced of the reliability of his data and the correctness of their interpretation, would this raise doubts about his qualifications as a scientist. As a consequence, one might classify him as an esoteric according to his above-quoted motto. The cause of events reached certainly a scientific-ethical dimension, if one would have to assume that Prof. Lerchl has been fully aware of the consequences of his – in my view - irresponsible handling of the matter. Ethically questionable would it also be, if Prof. Lerchl should again be appointed chairperson of the Committee

Non-ionizing Radiation at the SSK by the politically responsible authorities, in spite of his scientific and/or scientific-ethical shortcomings

**Overall, it can be said:** Prof. Lerchl's research project on the verification of the "melatonin hypothesis" does not fulfill the standard, which should be expected from scientific research regarding design, execution, and interpretation of the results. The study can serve as further evidence for cell phone research that as a whole is still in pretty bad shape. This situation is the result of industry-controlled accommodation research that has been ongoing for the past six decades and of which Prof. Lerchl is only one more striking example.

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- <sup>1</sup> Lerchl A (2003) Untersuchungen zu Wirkmechanismen an Zellen unter Exposition mit hochfrequenten elektromagnetischen Feldern der Mobilfunktechnologie. B. Pinealdrüse. Abschlussbericht. Deutsches Mobilfunk Forschungsprogramm. [http://www.emf-forschungsprogramm.de/forschung/biologie/biologie\\_abges/bio\\_020.html](http://www.emf-forschungsprogramm.de/forschung/biologie/biologie_abges/bio_020.html)
  - <sup>2</sup> Deutsches Mobilfunk Forschungsprogramm (DMF). English version: Investigation of mechanisms of action in cells exposed to the high frequency electromagnetic fields of mobile telephone technology. B. pineal gland. Objective. [http://www.emf-forschungsprogramm.de/forschung/biologie/biologie\\_abges/bio\\_020.html](http://www.emf-forschungsprogramm.de/forschung/biologie/biologie_abges/bio_020.html)
  - <sup>3</sup> Christ A, Gosselin MC, Christopolou M, Kühn S, Kuster N (2010) Age-dependent tissue-specific exposure of cell phone users. *Phys Med Biol* 55(7):1767-83.
  - <sup>4</sup> Lerchl A (2002) Die Melatonin-Hypothese. Eine Einführung. Edition Wissenschaft der Forschungsgemeinschaft Funk e.V., Ausgabe 16, Juni 2002. [http://www.fgf.de/publikationen/edition-wissenschaft/Edition\\_Wissenschaft\\_Nr16.pdf](http://www.fgf.de/publikationen/edition-wissenschaft/Edition_Wissenschaft_Nr16.pdf)
  - <sup>5</sup> Sukhotina I, Streckert JR, Bitz AK, Hansen VW, Lerchl A (2006) 1800 MHz electromagnetic field effects on melatonin release from isolated pineal glands. *J Pineal Res* 40(1):86-91.
  - <sup>6</sup> Strahlenschutzkommission (2008) German Mobile Telecommunication Research Programme. Statement adopted at the 223rd Session on 13 May 2008:11. <http://www.ssk.de/en/werke/2008/volltext/ssk0804e.pdf>