

# Forskning kring elektromagnetisk påverkan på biologiskt liv

## Växter

Denna sammanställning har gjorts via sökningar i världens största medicinska databas PubMed, innefattande forskningsstudier som är vetenskapligt granskade (peer-reviewed) och publicerade i olika tidskrifter. Sökningar via internet har också fått fram andra publicerade studier. I denna sammanställning har enbart studier specifikt på växter och växtmaterial medtagits.

Det totala antalet funna och listade artiklar inom området elektromagnetiska fälts påverkan på växter, uppgår till 64 st. Av dessa har samtliga (100%), funnit någon typ av påverkan. Ingen studie hittades alltså som rapporterade att växten var opåverkad av de elektromagnetiska fälten.

**J-** Ja, har funnit påverkan negativ för organismen

**J+** Ja, har funnit påverkan positiv för organismen

**J?** Ja, men inte möjligt att avgöra om påverkan var negativ eller positiv

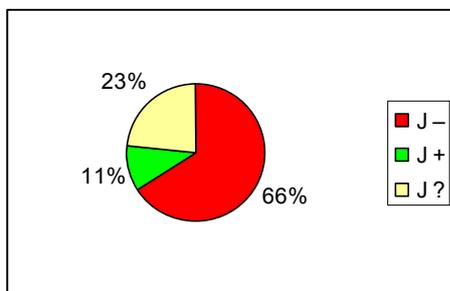
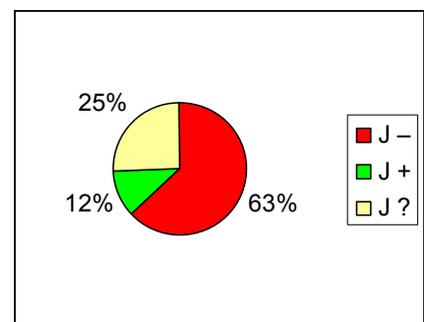
**N** Nej, har inte funnit någon påverkan alls

De studier som funnit positiv påverkan av kort tids exponering, men negativ påverkan av lång tids exponering har räknats till gruppen **J-**, då långtidsexponering är det faktiska förhållandet i samhället från hushållsel, kraftledningar, mobilbasstationer (master och sändare), trådlösa DECT-telefoner, trådlösa nätverk (wlan) och trådlöst internet (wifi/wimax).

Svårigheterna att bedöma resultaten i gruppen **J?** beror i huvudsak på språkbarriärer och att ingen ytterligare information om upplägg och resultat funnits tillgänglig.

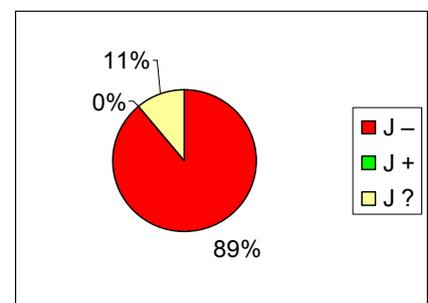
## Analys av funna studier som granskat påverkan från olika typer av elektromagnetiska fält (EMF)

Av de 59 rapporter som hittats i databasen PubMed, har 37 (63%) funnit påverkan som varit skadlig för den undersökta växten, 7 (12%) har funnit positiv påverkan och för 15 (25%) av dem har det inte kunnat avgöras om påverkan varit negativ eller positiv. **Exempel på negativa effekter var påverkan på cellmembran, kalciumnivåer, klorofyllnivåer och antioxidativa försvarssystem, minskad grobarhet, kromosomskador, stressrespons, tillväxtminskning, förtidigt åldrande och död.**



Av samtliga 64 publicerade rapporter har 42 (66%) funnit negativ påverkan, 7 (11%) positiv påverkan och för 15 (23%) har inga slutsatser kunnat dras.

Av de totalt 64 rapporterna, avsåg 18 st<sup>1</sup> radiofrekvent elektromagnetisk strålning, dvs de frekvensområden som mobiltelefoni och andra



trådlösa system använder. Av dessa 18 fann 16 (89%) negativa effekter, ingen fann positiva effekter (0%) och för 2 (11%) kunde inga slutsatser dras.

**De negativa effekterna sågs även på nivåer motsvarande tusendelar av våra gränsvärden.**

<sup>1</sup> Studie 1, 2, 4, 14, 16, 22, 25, 29, 36, 43, 46, 50, 59, 60, 61, 62, 63, 64

## Vetenskapligt validerade och publicerade studier i databasen PubMed

|  |   |   |   |
|--|---|---|---|
| <p>1</p>    | <p><a href="#">Roux D</a> et al<br/>         Université Blaise Pascal,<br/>         Frankrike<br/>         Publ: <a href="#">Planta</a>. 2007 Nov 20</p>  | <p>'High frequency (900 MHz) low amplitude (5 V m(-1)) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato.'</p> | <p>Tomatplantor exponerades i 10 min för 900MHz, 5V m(-1). Inom några minuter ackumulerades stress-relaterade mRNA (calmodulin, calciumberoende protein kinas och proteinas-hämmare) på ett sätt som är typiskt för en miljörelaterad stressrespons. Likheten med respons på sårskada tyder på att växter uppfattar denna strålning som ett skadligt stimulus.</p> <p>Using an especially-designed facility, the Mode Stirred Reverberation Chamber, we exposed tomato plants (<i>Lycopersicon esculentum</i> Mill. VFN8) to low level (900 MHz, 5 V m(-1)) electromagnetic fields for a short period (10 min) and measured changes in abundance of three specific mRNA soon after exposure. Within minutes of electromagnetic stimulation, stress-related mRNA (calmodulin, calcium-dependent protein kinase and proteinase inhibitor) accumulated in a rapid, large and 3-phase manner typical of an environmental stress response. Accumulation of these transcripts into the polysomal RNA also took place (indicating that the encoded proteins were translated) but was delayed (indicating that newly-synthesized mRNA was not immediately recruited into polysomes). Transcript accumulation was maximal at normal Ca(2+) levels and was depressed at higher Ca(2+), especially for those encoding calcium-binding proteins. Removal of Ca(2+) (by addition of chelating agents or Ca(2+) channel blocker) led to total suppression of mRNA accumulation. Finally, 30 min after the electromagnetic treatment, ATP concentration and adenylate energy charge were transiently decreased, while transcript accumulation was totally prevented by application of the uncoupling reagent, CCCP. These responses occur very soon after exposure, strongly suggesting that they are the direct consequence of application of radio-frequency fields and their similarities to wound responses strongly suggests that this radiation is perceived by plants as an injurious stimulus.</p> |
| <p>2</p>  | <p><a href="#">Tkalec M</a> et al.<br/>         Department of Botany, Division of Biology, Faculty of Science, University of Zagreb, Croatia.<br/>         Publ: <a href="#">Sci Total Environ</a>. 2007 Dec 15;388(1-3):78-89.<br/>         Epub 2007 Sep 7.</p> | <p>'Exposure to radiofrequency radiation induces oxidative stress in duckweed <i>Lemna minor</i> L.'</p>  | <p>Resultaten visade att icke-termisk exponering av växten <i>Andmat</i> orsakade oxidativ stress såväl som ospecifika stressreaktioner, speciellt avseende antioxidativa enzymer. De observerade effekterna varierade markant mellan olika frekvenser samt andra parametrar som fältstyrka, modulation och exponeringstid.</p> <p>Widespread use of radiofrequency radiation emitting devices increased the exposure to electromagnetic fields (EMFs) from 300 MHz to 300 GHz. Various biological effects of exposure to these fields have been documented so far, but very little work has been carried out on plants. The aim of the present work was to investigate the physiological responses of the plant <i>Lemna minor</i> after exposure to radiofrequency EMFs, and in particular, to clarify the possible role of oxidative stress in the observed effects. Duckweed was exposed for 2 h to EMFs of 400 and 900 MHz at field strengths of 10, 23, 41 and 120 V m(-1). The effect of a longer</p>  |

|         |   |   |  |
|---------|---|---|--|
|         |   |   | <p>exposure time (4 h) and modulation was also investigated. After exposure, parameters of oxidative stress, such as lipid peroxidation, H<sub>2</sub>O<sub>2</sub> content, activities and isoenzyme pattern of antioxidative enzymes as well as HSP70 expression were evaluated. At 400 MHz, lipid peroxidation and H<sub>2</sub>O<sub>2</sub> content were significantly enhanced in duckweed exposed to EMFs of 23 and 120 V m<sup>-1</sup> while other exposure treatments did not have an effect. Compared to the controls, the activities of antioxidative enzymes showed different behaviour: catalase (CAT) activity increased after most exposure treatments while pyrogallol (PPX) and ascorbate peroxidase (APX) activities were not changed. Exceptions were reduced PPX and APX activity after longer exposure at 23 V m<sup>-1</sup> and increased PPX activity after exposures at 10 and 120 V m<sup>-1</sup>. By contrast, at 900 MHz almost all exposure treatments significantly increased level of lipid peroxidation and H<sub>2</sub>O<sub>2</sub> content but mostly decreased PPX activity and did not affect CAT activity. Exceptions were exposures to a modulated field and to the field of 120 V m<sup>-1</sup> which increased PPX and CAT activity. At this frequency APX activity was significantly decreased after exposure at 10 V m<sup>-1</sup> and longer exposure at 23 V m<sup>-1</sup> but it increased after a shorter exposure at 23 V m<sup>-1</sup>. At both frequencies no differences in isoenzyme patterns of antioxidative enzymes or HSP70 level were found between control and exposed plants. Our results showed that non-thermal exposure to investigated radiofrequency fields induced oxidative stress in duckweed as well as unspecific stress responses, especially of antioxidative enzymes. However, the observed effects markedly depended on the field frequencies applied as well as on other exposure parameters (strength, modulation and exposure time). Enhanced lipid peroxidation and H<sub>2</sub>O<sub>2</sub> content accompanied by diminished antioxidative enzymes activity caused by exposure to investigated EMFs, especially at 900 MHz, indicate that oxidative stress could partly be due to changed activities of antioxidative enzymes.</p> |
| 3<br>J? | <p><a href="#">Rochalska M.</a><br/>Szkola Główna Gospodarstwa Wiejskiego, Warszawa.<br/>Publ: <a href="#">Med Pr.</a> 2007;58(1):37-48</p>                 | <p>'The effect of electromagnetic fields on living organisms: plants, birds and animals'<br/>Artikeln på polska</p>   | <p>Electromagnetic fields, constant and alternating, are a static element of the environment. They originate from both natural and man-made sources. Depending on the type of the field, its intensity and time of activity, they exert different effects on the natural world (plants and animals). Some animals utilize magnetic field of the earth for their own purposes.</p>  |
| 4<br>J- | <p><a href="#">Beaubois E</a> et al<br/>Université Blaise Pascal Equipe, Frankrike<br/>Publ: <a href="#">Plant Cell Environ.</a> 2007 Jul;30(7):834-44.</p> | <p>'Intercellular communication in plants: evidence for two rapidly transmitted systemic signals generated in response to electromagnetic field stimulation in tomato.'</p> | <p>Vildtomater som exponerades för radiofrekventa elektromagnetiska fält (RF EMF) 900 MHz 5 V/m under 10 minuter, reagerade på ett sätt som mycket liknade respons på sårskada.<br/>Exposing all of a wild-type tomato plant to electromagnetic radiation evoked rapid and substantial accumulation of basic leucine-zipper transcription factor (bZIP) mRNA in the terminal leaf (#4) with kinetics very similar to that seen in response to wounding, while in the abscisic acid (ABA) mutant (Sitiens), the response was more rapid, but transient. Submitting just the oldest</p>  |

|   |  |   |  |
|---|--|---|--|
|   |  |   | <p>leaf (#1) of a wild-type plant to irradiation evoked bZIP mRNA accumulation both locally in the exposed leaf and systemically in the unexposed (distant) leaf #4, although systemic accumulation was delayed somewhat. Accumulation of Pin2 mRNA was less than bZIP in both the exposed and distant leaves in wild type, but there was no delay in the systemic response. In Sitiens, bZIP mRNA accumulation was far less than in wild type in both local and distant leaves, while Pin2 mRNA accumulation was stronger in the exposed leaf, but totally prevented in the systemic leaf. In the jasmonic acid (JA) mutant (JL-5) and in wild-type plants treated with the ABA biosynthesis inhibitor, naproxen, responses were similar to those in the ABA mutant, while treatment of the exposed leaf with calcium antagonists totally abolished both local and systemic increases in bZIP transcript accumulation.</p>  |
| 5 | <p><b>J-</b> <a href="#">Aksenov SI</a> et al<br/>Ryssland<br/>Publ: <a href="#">Biofizika</a>. 2007 Mar-Apr;52(2):332-8.</p>  | <p>'On the mechanisms of stimulation and inhibition during germination of wheat seeds in extremely low frequency electromagnetic fields'</p> <p>Artikeln på ryska</p> | <p>It has been shown that the effects of stimulation of germination of wheat seeds by electromagnetic field depend on the degree of membrane tension during imbibition of seeds in sucrose solutions. This provides further confirmation of the influence of electromagnetic fields on the release of proteins from the bound state on the membranes. The prolonged treatment with electromagnetic fields during the imbibition of seeds leads not only to the inhibition of germination of sprouts but also to a decrease in their germinability, which can be as strong as twofold for seeds with the initial low germinability. This is related to the desynchronization of germination processes, caused by the stimulation of the release of proteins and inhibition of another stage during the cell division, the assembly of complex structures. It is noted that the activation of the release of proteins and inhibition of their binding by the action of electromagnetic fields must elevate the cell excitability. The presumably, the excitability of cells determines the effects of magnetic storms and high solar activity on the physiological state of organisms.</p> |
| 6 | <p><b>J-</b> <a href="#">Solov'yov IA</a> et al<br/>Frankfurt Institute for Advanced Studies, Johann Wolfgang Goethe University, Frankfurt am Main, Germany<br/>Publ: <a href="#">Biophys J</a>. 2007 Apr 15;92(8):2711-26. Epub 2007 Jan 26</p> | <p>'Magnetic field effects in Arabidopsis thaliana cryptochrome-1'</p>  | <p>The ability of some animals, most notably migratory birds, to sense magnetic fields is still poorly understood. It has been suggested that this "magnetic sense" may be mediated by the blue light receptor protein cryptochrome, which is known to be localized in the retinas of migratory birds. Cryptochromes are a class of photoreceptor signaling proteins that are found in a wide variety of organisms and that primarily perform regulatory functions, such as the entrainment of circadian rhythm in mammals and the inhibition of hypocotyl growth in plants. Recent experiments have shown that the activity of cryptochrome-1 in Arabidopsis thaliana is enhanced by the presence of a weak external magnetic field, confirming the ability of cryptochrome to mediate magnetic field responses. Cryptochrome's signaling is tied to the photoreduction of an internally bound chromophore, flavin adenine dinucleotide. The spin chemistry of this photoreduction process, which involves electron transfer from a chain of</p>  |

|          |  |  |  |
|----------|--|--|--|
|          |  |  | three tryptophans, can be modulated by the presence of a magnetic field in an effect known as the radical-pair mechanism. Here we present and analyze a model of the flavin-adenine-dinucleotide-tryptophan chain system that incorporates realistic hyperfine coupling constants and reaction rate constants. Our calculations show that the radical-pair mechanism in cryptochrome can produce an increase in the protein's signaling activity of approximately 10% for magnetic fields on the order of 5 G, which is consistent with experimental results. These calculations, in view of the similarity between bird and plant cryptochromes, provide further support for a cryptochrome-based model of avian magnetoreception.  |
| 7<br>J+  | <a href="#">Trebbi G</a> et al<br>Dipartimento di Scienze e<br>Tecnologie Agroambientali,<br>Università di Bologna, Italy<br>Publ: <a href="#">Bioelectromagnetics</a> . 2007<br>Apr;28(3):214-23                  | 'Extremely low frequency<br>weak magnetic fields enhance<br>resistance of NN tobacco<br>plants to tobacco mosaic<br>virus and elicit stress-related<br>biochemical activities' | Increasing evidence has accumulated concerning the biological effects of extremely low frequency magnetic fields (ELF-MFs) in different plant models. In the present study, effects of ELF-MFs in tobacco plants reacting to tobacco mosaic virus (TMV) with a hypersensitive response (HR) were evaluated. Plants were exposed for 8 or 24 h (either before or after TMV inoculation) to a static MF, at either -17 or 13 microT, combined with a 10 Hz sinusoidal MF with different intensities (25.6 or 28.9 microT). The working variables were the area and number of hypersensitive lesions in leaves. Following ELF-MFs exposure, an increased resistance was detected, particularly after an 8-h treatment, as shown by the decrease in lesion area and number. Moreover, two enzyme activities involved in resistance mechanisms were analyzed: ornithine decarboxylase (ODC) and phenylalanine ammonia-lyase (PAL). Uninoculated leaves previously exposed to ELF-MFs in general showed a significant increase relative to controls in ODC and PAL activities, in particular for 13 microT static MF plus 28.9 microT, 10 Hz sinusoidal MF (24 h) treatment. In conclusion, ELF-MFs seem to influence the HR of tobacco to TMV, as shown by the increased resistance and changes in ODC and PAL activities, indicating the reliability of the present plant model in the study of bioelectromagnetic interactions. (c) 2006 Wiley-Liss, Inc. |
| 8<br>J-  | <a href="#">Sahebamei H</a> et al<br>Department of Biophysics,<br>Faculty of Science, Tarbiat<br>Modarres University (TMU),<br>Tehran, Iran.<br>Publ: <a href="#">Bioelectromagnetics</a> . 2007<br>Jan;28(1):42-7 | 'Effects of magnetic field on<br>the antioxidant enzyme<br>activities of suspension-<br>cultured tobacco cells.'   | Odling av celler från tobaksplanta exponerades för magnetfält (MF) och aktiviteten hos antioxidantenzymerna studerades. Resultaten antyder att MF kan skada växtens antioxidativa försvarssystem.  |
| 9<br>J-  | <a href="#">Ahmad M</a> et al, Université Paris<br>VI, Frankrike.<br>Publ: <a href="#">Planta</a> . 2007<br>Feb;225(3):615-24. Epub 2006<br>Sep 6  | 'Magnetic intensity affects<br>cryptochrome-dependent<br>responses in Arabidopsis<br>thaliana.'  | Växten Backtrav utsattes för magnetfält med ökande intensitet. Man fann påverkan på kryptokrom, en fotoreceptor för blått ljus, vilket i sin tur påverkar växtens tillväxt och utveckling.   |
| 10<br>J- | <a href="#">Demiray H.</a><br>Faculty of Science, Department<br>of Biology, Section of Botany,<br>University of Ege, Bornova-  | 'Effect of static electric fields<br>in root cells of Vicia faba<br>(Fabaceae).'   | Serial electron microscopic sections were prepared from half-ripened meristematic root cells of Vicia faba (Fabaceae) which had been exposed gradually to 700, 1000, 2500, 3500, and 5000 V/m static electric fields   |

|          |   |   |   |
|----------|---|---|---|
|          | Izmir, Turkey<br>Publ: <a href="#">Electromagn Biol Med.</a> 2006;25(1):53-60   |   | during seven days with and without Zn and Cd electrodes. At the end of five weeks, wall loosening and very small nuclei were observed in those root cells which were exposed to static electric currents from the lower side of the medium without electrodes, while abnormalities in cell formation, e.g., two cells with one nucleus, and GER occurrence were present in an electrolytic (Cd upward and Zn downward) medium. The cells exposed to a static current from the upper side of the medium had small nuclei and abnormal cell divisions in the electrolyte, but in a non-electrolyte very large nuclei and thicker cell walls were observed, the cytoplasm was dense with GER, pinocytosis was seen filled with mitochondria, and protoplast formation with big nuclei was seen in exocytosis.  |
| 11<br>J- | <a href="#">Pazur A</a> et al<br>Department Biologie I<br>Universität München - Bereich<br>Botanik, Tyskland<br>Publ: <a href="#">Biomagn Res Technol.</a> 2006 Feb 3;4:1                                   | 'Growth of etiolated barley plants in weak static and 50 Hz electromagnetic fields tuned to calcium ion cyclotron resonance.'       | Småplantor av Korn exponerades för statiska MF och 50 Hz EMF.<br>De exponerade plantorna blev 15-20% kortare och vägde 10-12% mindre än kontrollerna. Fälten ansågs ha en direkt påverkan på calciumnivåerna (Ca <sup>2+</sup> ).   |
| 12<br>J- | <a href="#">Fatigoni C</a> et al<br>Department of Medical-Surgical<br>Specialities and Public Health,<br>University of Perugia, Italien<br>Publ: <a href="#">Environ Toxicol.</a> 2005<br>Dec;20(6):585-91. | 'Genotoxic effects of extremely low frequency (ELF) magnetic fields (MF) evaluated by the Tradescantia-micronucleus assay.'         | Mikronukleus (mikrokärnor) från växten Tradescantia albiflora (Vandrande jude) exponerades för 50 HZ MF med fältstyrkan 1 mT, vilket hade genotoxiska effekter.   |
| 13<br>J+ | Kalinin LG et al<br>Ryssland<br>Publ: <a href="#">Biofizika.</a> 2005 Mar-Apr;<br>50(2):361-6.  | 'The influence of a low- and high-frequency electromagnetic fields on seeds.'   | Frön exponerades för lågfrekventa elektromagnetiska fält (EMF), vilket ledde till omfattande förändringar i deras fysiologi under groningen. Man konstaterade att låg- och högfrekventa EMF kan ge en biostimulerande effekt.   |
| 14<br>J- | Sandu DD, et al.<br>Faculty of Physics, "Al I Cuza"<br>University, 6600 Iasi, Ungern<br>Publ: <a href="#">Acta Biol Hung.</a> 2005;56 (1-2):109-17.   | 'A preliminary study on ultra high frequency electromagnetic fields effect on black locust chlorophylls. (Robinia pseudoacacia L.)' | Plantor utsattes för 3 veckors daglig exponering för svaga radiofrekventa EMF, 400 MHz (i 1, 2, 3 resp 4 tim). I 2-timmarsgruppen ökade klorofyllnivåerna markant. I samtliga andra grupper minskade klorofyllhalten logaritmiskt i förhållande till exponeringstiden.  |
| 15<br>J? | <a href="#">Amyan A</a> et al<br>UNESCO Chair-Life Sciences<br>International Postgraduate<br>Educational Center, Yerevan,<br>Armenia<br>Publ: <a href="#">Physiol Chem Phys Med NMR.</a> 2004;36(1):69-84   | 'On the modulation effect of pulsing and static magnetic fields and mechanical vibrations on barley seed hydration.'                | The changes of wet and dry weights of barley seed in different periods of swelling were studied in seeds treated with Extremely Low Frequency Electromagnetic Fields (ELF EMF), Static Magnetic Fields (SMF) and Mechanical Vibrations (MV) in cold (4 degrees C) and warm (20 degrees C) distilled water as well as in seeds non-treated (control). The metabolic dependent seed hydration, dry weight loss and water binding in seed were modulated by preliminary EMF, SMF and MV-induced treatment of distilled water. The specific electrical conductivity (SEC) of control and treated distilled water was measured before the seed incubation. Frequency and intensity "windows" (i.e. range of frequency or intensity) for the effect of EMF, MV and SMF (correspondingly) on seed hydration, solubility and water binding in seed were studied. These "windows" were different in various phases of seed |

|          |   |  |  |
|----------|---|--|--|
|          |   |  | swelling. It is suggested that water structure modification is the result of valence angle changes (SMF and EMF) and dipole molecules vibration (EMF and MV) has different effects on the process of hydration, solubility and water binding in seed. These results are important from the point of understanding the mechanisms of the biological effect of EMF, as well as from the point of agriculture.  |
| 16<br>J- | <a href="#">Tkalec M</a> et al.<br>Department of Botany, Faculty of Science, University of Zagreb, Croatia.<br>Publ: <a href="#">Bioelectromagnetics</a> . 2005 Apr;26(3):185-93. | 'Influence of 400, 900, and 1900 MHz electromagnetic fields on Lemna minor (Andmat) growth and peroxidase activity.' | Man fann att EMF kan påverka växterns tillväxt och att påverkan varierar med olika typer av fält. Tillväxten hämmades exempelvis efter 2 tim exponering av fält vid 900 MHz men inte vid 400 MHz, och modulerade fält hämmade mer än omodulerade. Vid längre tids exponering blev dock tillväxten ofta kraftigt hämmad. Vid exponering i 2 tim för 41 V/m vid 900 MHz såg man dock i stället en signifikant tillväxt (41%).  |
| 17<br>J- | <a href="#">Dattilo AM</a> et al, Department of Chemical & Biosystem Sciences and Technologies, University of Siena, Italien  | 'Morphological anomalies in pollen tubes of Actinidia deliciosa (kiwi) exposed to 50 Hz magnetic field'              | Kiwifrukt exponerades för ett växlande 50 Hz MF, vilket påverkade pollineringen negativt. Detta föreföll bero på att jonernas laddning förändrades.  |
| 18<br>J- | <a href="#">Ye H</a> et al<br>Key Laboratory of Optical and Magnetic Resonance Spectroscopy, Kina<br>Publ: <a href="#">Biotechnol Bioeng</a> . 2004 Dec 20;88(6):788-95           | 'Pulsed electric field stimulates plant secondary metabolism in suspension cultures of Taxus chinensis.'             | Cellodling från Idegran exponerades för ett pulsat elektriskt fält (50Hz, 10V/m) i 30 min. Detta inducerade (orsakade) en försvarsreaktion hos cellerna och kan ha förändrat cellmembranens dielektriska egenskaper.   |
| 19<br>J- | <a href="#">Yano A</a> et al<br>Faculty of Life and Environmental Science, Shimane University, Japan<br>Publ: <a href="#">Bioelectromagnetics</a> . 2004 Dec;25(8):572-81.        | 'Effects of a 60 Hz magnetic field on photosynthetic CO2 uptake and early growth of radish seedlings.'               | Frön från Rädisa exponerades för 60Hz ELF MF, vilket ledde till signifikant lägre tillväxt. Effekten av korttidsexponering för dessa MF var dock inte tillräckligt allvarlig för att upptaget av CO2 skulle påverkas negativt  |
| 20<br>J+ | <a href="#">Fischer G</a> et al<br>Institut für Hygiene, Karl-Franzens Universität Graz, Graz, Austria<br>Publ: <a href="#">Bioelectromagnetics</a> . 2004 Dec;25(8):638-41       | , Effects of weak 16 2/3 Hz magnetic fields on growth parameters of young sunflower and wheat seedlings.'            | Previous studies on effects of magnetic fields on plants focussed on the power frequencies (50-60 Hz), but in Austria and Germany electric railways are powered by a frequency of 16 2/3 Hz. In the present study, sunflower and wheat seedlings were exposed to 16 2/3 Hz sinusoidal 20 µT (rms) vertical magnetic fields. Seeds were germinated in a germination roll and grown for 12 days under continued exposure. Seven series with sunflower and six series with wheat were done over 2 years. Sunflower seedlings exposed to experimental magnetic field showed small, but significant increases in total fresh weights, shoot fresh weights, and root fresh weights, whereas dry weights and germination rates remained unaffected. Experimentally treated wheat exhibited marginally (but significantly) higher root fresh and dry weights, total fresh weights, and higher germination rates. 2004 Wiley-Liss, Inc. |
| 21<br>J+ | <a href="#">Kobayashi M</a> et al<br>Department of Electrical and Electronic Engineering, Faculty of Engineering, Ibaraki   | 'Effects of combined DC and AC magnetic fields on germination of hornwort seeds.'                                    | Seeds of hornwort ( <i>Cryptotaenia japonica</i> Hassk) were exposed to sinusoidally time-varying extremely low frequency (ELF) magnetic fields (AC fields) in combination with the local geomagnetic field (DC field).  |

|          |   |   |  |
|----------|---|---|--|
|          | University, Hitachi, Ibaraki, Japan<br>Publ: <a href="#">Bioelectromagnetics</a> . 2004 Oct;25(7):552-9   |   | Exposure lasted 24 h/day for 16 days. Three directions of the AC magnetic fields were considered; the vertical (magnetic flux density B ACV, the directions parallel B ACparallel), and perpendicular B ACperpendicular to the direction of total geomagnetic field (magnetic flux density BG) in the geomagnetic plane (GP). Controls consisted of seeds exposed to zero AC magnetic fields in combination with the DC magnetic field. The B ACV in combination with BG effectively promoted the germination of hornwort seeds when applied at 750 microT (RMS) at 7 Hz or 500 microT (RMS) at 14 Hz from among the cases of individual frequencies f = 3.5, 7.0, 10.5, 14.0 Hz at 500 and 750 microT. The B ACparallel promoted the germination of hornwort seeds more effectively than the B ACperpendicular in combination with BG when 500 and 750 microT at 7 Hz were applied. 2004 Wiley-Liss, Inc.   |
| 22<br>J- | <a href="#">Tafforeau M</a> et al<br>Laboratoire des Processus Intégratifs Cellulaires, Université de Rouen, France<br>Publ: <a href="#">Bioelectromagnetics</a> . 2004 Sep;25(6):403-7                                   | 'Plant sensitivity to low intensity 105 GHz electromagnetic radiation.'   | Exposing seedlings of the flax, <i>Linum usitatissimum</i> L., to a variety of weak environmental stresses followed by a 2 day calcium deprivation, triggers the common response of production of epidermal meristems (actively dividing groups of cells) in the hypocotyl, which is the part of the stem between the root and the cotyledons (the pre-existing leaves in the embryo). This production reaches a plateau of 10-20 meristems after a month in the case of mechanical stimulation and cold shock. Recently, we have shown that radiation from a global system for mobile communication (GSM) telephone also triggers production of meristems with a plateau of around six meristems. Here, we show that a single 2 h exposure to radiation emitted at 105 GHz at non-thermal levels by a Gunn oscillator induces meristem production with kinetics similar to that induced by weak environmental stimuli and radiation from GSM telephone. |
| 23<br>J+ | <a href="#">Shang GM</a> et al<br>Department of Pharmaceutical Engineering, School of Chemical Engineering & Technology, Tianjin University, China<br>Publ: <a href="#">Biotechnol Lett</a> . 2004 Jun;26(11):875-8       | 'Improved cell growth and Taxol production of suspension-cultured <i>Taxus chinensis</i> var. <i>mairei</i> in alternating and direct current magnetic fields.' | The growth of suspension cultures of <i>Taxus chinensis</i> var. <i>mairei</i> and Taxol production were promoted both by a sinusoidal alternating current magnetic field (50 Hz, 3.5 mT) and by a direct current magnetic field (3.5 mT). Taxol production increased rapidly from the 4th d with the direct current magnetic field but most slowly with the alternating current magnetic field. The maximal yield of Taxol was 490 microg l(-1) with the direct current magnetic field and 425 microg l(-1) with the alternating current magnetic field after 8 d of culture, which were, respectively, 1.4-fold and 1.2-fold of that without exposure to a magnetic field.   |
| 24<br>J- | <a href="#">Piacentini MP</a> et al<br>Istituto di Chimica Biologica Giorgio Fornaini, Università degli Studi di Urbino, Via Saffi 2, 61029 Urbino, Italy<br>Publ: <a href="#">Biochimie</a> . 2004 Apr-May;86(4-5):343-9 | 'Phospholipase C-dependent phosphoinositide breakdown induced by ELF-EMF in <i>Peganum harmala</i> calli.'  | With the aim of examining the response of plant cells to extremely low frequency (ELF) electromagnetic fields (EMF), we investigated the behaviour of the phosphatidylinositol 4,5 bisphosphate (PtdIns 4,5-P(2)) molecule (the precursor of the phosphoinositide signal transduction cascade) by exposing callus cells from <i>Peganum harmala</i> to 50 Hz, 1 gauss EMF for 10 min and by examining the level and the fatty acid composition of PtdIns 4,5-P(2) after the exposure. Our results evidenced a statistically significant decrease in PtdIns 4,5-P(2) concentrations and a different involvement of the constituting fatty acids in the induced breakdown. The manipulation of the lipid-based signalling pathway  |

|          |  |  |  |
|----------|--|--|--|
|          |  |  | by phosphoinositide-phospholipase C (PI-PLC) inhibitors (i.e., neomycin, U-73122 and ET-18-OCH <sub>3</sub> ) seems to support the hypothesis that, as in animals, also in plants, the cell membrane is the primary impact site of ELF electromagnetic stimulus and that this interaction could probably involve the activation of PI signal transduction pathway including a heterotrimeric G protein.  |
| 25<br>J? | <a href="#">Tordiiia NV</a> et al<br>Ukraina<br>Publ: <a href="#">Tsitol Genet.</a> 2004 Jan-Feb;38(1):63-71   | 'Study of cytoplasm streaming as a cytophysiological method in radiolabeled experiment'<br><br>Article in Ukrainian  | Estimation of influence of ionizing radiation, high-frequency electromagnetic radiation and their combined action on a higher water plant <i>Elodea canadensis</i> has been carried out using cytophysiological method of determination of the cytoplasm streaming rate. It was shown that low-intensive electromagnetic radiation modifies reaction of the differentiated cells on radiolesion. The rate of cytoplasm streaming can be used as an informative characteristic of plant cell state in radiobiological experiment.   |
| 26<br>J? | <a href="#">Es'kov EK</a> et al<br>Russian State Agrarian Correspondence University, ul. Yu. Fuchika 1, Balashikha, Moscow Oblast, 143900 Russia<br>Publ: <a href="#">Izv Akad Nauk Ser Biol.</a> 2003 Sep-Oct;(5):617-22            | 'Effect of high intensity magnetic field on the processes of early growth in plant seeds and development of honeybees'<br><br>Article in Russian   | The influence of magnetic field on the early growth processes in plant seeds and the postembryonic development of honeybees was studied. Some general trends in the effects of magnetic field and differences in the tolerance of plant seeds and developing honeybees to its action were revealed. Some factors that may be responsible for a low reproducibility of magnetobiological effects are discussed.   |
| 27<br>J- | <a href="#">Bauréus Koch CL</a> et al<br>Department of Radiation Physics, Lund University Hospital, Lund, Sweden<br>Publ: <a href="#">Bioelectromagnetics.</a> 2003 Sep;24(6):395-402  | 'Interaction between weak low frequency magnetic fields and cell membranes'  | The question of whether very weak low frequency magnetic fields can affect biological systems, has attracted attention by many research groups for quite some time. Still, today, the theoretical possibility of such an interaction is often questioned and the site of interaction in the cell is unknown. In the present study, the influence of extremely low frequency (ELF) magnetic fields on the transport of Ca <sup>2+</sup> was studied in a biological system consisting of highly purified plasma membrane vesicles. We tested two quantum mechanical theoretical models that assume that biologically active ions can be bound to a channel protein and influence the opening state of the channel. Vesicles were exposed for 30 min at 32 degrees C and the calcium efflux was studied using radioactive ( <sup>45</sup> Ca) as a tracer. Static magnetic fields ranging from 27 to 37 micro T and time varying magnetic fields with frequencies between 7 and 72 Hz and amplitudes between 13 and 114 micro T (peak) were used. We show that suitable combinations of static and time varying magnetic fields directly interact with the Ca <sup>2+</sup> channel protein in the cell membrane, and we could quantitatively confirm the model proposed by Blanchard. Copyright 2003 Wiley-Liss, Inc. |
| 28<br>J? | <a href="#">Frese RN</a> et al<br>Division of Physics and Astronomy, Faculty of Sciences, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands<br>Publ: <a href="#">Biochemistry.</a> 2003 Aug 5;42(30):9205-13 | 'Electric field effects on the chlorophylls, pheophytins, and beta-carotenes in the reaction center of photosystem II'<br><br>Wikipedia:<br>The <b>Stark effect</b> is the shifting and splitting of <a href="#">spectral lines</a> of atoms and molecules due | We present an electric field modulated absorption spectroscopy (Stark effect) study of isolated photosystem II reaction center complexes, including a preparation in which the inactive pheophytin H(B) was exchanged for 13(1)-deoxy-13(1)-hydroxy-pheophytin. The results reveal that the Stark spectrum of the Q(x) and Q(y) transitions of the pheophytins has a second-derivative line shape, indicating that the Stark effect is dominated by differences in the dipole moment between the ground and the electronically excited   |

|    |   |   |  |
|----|---|---|--|
|    |   | to the presence of an external static <a href="#">electric field</a> .  | states of these transitions ( $\Delta\mu$ ). The $\Delta\mu$ values for the Q(x) and Q(y) transitions of H(B) are small ( $\Delta\mu = 0.6-1.0 D f(-1)$ ), whereas that of the Q(x) transition of the active pheophytin H(A) is remarkably large ( $\Delta\mu = 3 D f(-1)$ ). The Stark spectrum of the red-most absorbing pigments also shows a second-derivative line shape, but this spectrum is considerably red-shifted as compared to the second derivative of the absorption spectrum. This situation is unusual but has been observed before in heterodimer special pair mutants of purple bacterial reaction centers [Moore, L. J., Zhou, H., and Boxer, S. G. (1999) <i>Biochemistry</i> 38, 11949-11960]. The red-shifted Stark spectra can be explained by a mixing of exciton states with a charge-transfer state of about equal energy. We conclude that the charge transfer state involves H(A) and its immediate chlorophyll neighbor (B(A)), and we suggest that this (B(A)( $\delta+$ )H(A)( $\delta-$ )) charge transfer state plays a crucial role in the primary charge separation reaction in photosystem II. In contrast to most other carotenes, the two beta-carotene molecules of the photosystem II reaction center display a very small $\Delta\mu$ , which can most easily be explained by excitonic coupling of both molecules. These results favor a model that locates both beta-carotene molecules at the same side of the complex. |
| 29 | <a href="#">Kalinin LG</a> et al<br>Odessa State Academy of Food Technologies, Odessa, 650023 Ukraine<br>Publ: <a href="#">Biofizika</a> . 2003 Jan-Feb;48(1):122-4   | 'Physical model of the plant tissue response to exposure to the microwave electromagnetic field'<br><br>Article in Russian              | A hypothesis was suggested to explain the effect of biostimulation of seeds exposed to microwave electromagnetic field. It was shown that the assumption on the determining influence of the microwave field on the transport properties of the conducting system of a plant satisfactorily explains the phenomena observed in germinating seeds and growing plants. A physical model of the response of a plant cell to a microwave field is presented, which served as a basis for the method of calculating the maximum possible time of exposure of plant tissue.  |
| 30 | <a href="#">Ben-Izhak Monselise E</a> et al<br>Department of Chemistry, Ben-Gurion University of the Negev, Beer-Sheva, Israel<br>Publ: <a href="#">Biochem Biophys Res Commun</a> . 2003 Mar 7;302(2):427-34 | 'Low-frequency electromagnetic fields induce a stress effect upon higher plants, as evident by the universal stress signal, alanine.'   | <sup>15</sup> N NMR analysis reveals alanine production in Duckweed plants exposed to low intensity sinusoidally varying magnetic fields (SVMF) at 60 and 100Hz, and fed by <sup>15</sup> N-labeled ammonium chloride. Alanine does not accumulate in the absence of SVMF. Addition of vitamin C, a radical scavenger, reduced alanine production by 82%, indicating the roll of free radicals in the process. Alanine accumulation in plants and animals in response to exposure to a variety of stress conditions, including SVMF, is a general phenomenon. It is proposed that alanine is a universal first stress signal expressed by cells.   |
| 31 | <a href="#">Soja G</a> et al<br>ARC Seibersdorf Research, Department of Environmental Research, Seibersdorf, Austria<br>Publ: <a href="#">Bioelectromagnetics</a> . 2003 Feb;24(2):91-102                     | 'Growth and yield of winter wheat ( <i>Triticum aestivum</i> L.) and corn ( <i>Zea mays</i> L.) near a high voltage transmission line.' | The objective of this study was to determine the effects of an electromagnetic field from a high voltage transmission line on the yield of agricultural crops cultivated underneath and near the transmission line. For 5 years, experiments with winter wheat and corn were carried out near the 380 kV transmission line Dürnröhr (Austria)-Slavetice (Czech Republic). Different field strengths were tested by planting the crops at different distances from the transmission line. The   |

|          |   |  |  |
|----------|---|--|--|
|          |   |  | <p>plants were grown in experimental plots (1.77 m<sup>2</sup>), aligned to equal electric field strengths, and were cultivated according to standard agricultural practice. The soil for all plots was homogenized layer-specifically to a depth of 0.5 m to guarantee uniform soil conditions in the plant root environment. The soil was sampled annually for determinations of carbon content and the behavior of microbial biomass. During development of the vegetation, samples were collected at regular intervals for growth rate analyses. At physiological maturity, the plots (n = 8) were harvested for grain and straw yield determinations. The average electric and magnetic field strengths at four distances from the transmission line (nominal distances: 40, 14, 8, and 2 m) were between 0.2 and 4.0 kV/m and between 0.4 and 4.5 micro T, respectively. No effect of the field exposures on soil microbial biomass could be detected. The wheat grain yields were 7% higher (average of 5 years) in the plots with the lowest field exposure than in the plots nearer to the transmission line (P &lt;.10). The responses of the plants were more pronounced in years with drought episodes during grain filling than in humid years. No significant yield differences were found for corn yields. The extent of the yield variations attributed to the distance from the transmission line was small compared to the observed annual variations in climatic or soil specific site characteristics. Copyright 2003 Wiley-Liss, Inc.</p> |
| 32<br>J+ | <p><a href="#">Li AL</a><br/>Institute of Medicinal Plant,<br/>Chinese Academy of Medical<br/>Sciences, Peking Union Medical<br/>University, Beijing, China<br/>Publ: <a href="#">Zhongguo Zhong Yao Za<br/>Zhi</a>. 2000 Jun;25(6):341-3</p> | <p>'Effect of gradient magnetic field on growth of stem pearls of <i>Dioscorea opposita</i> during seedling stage'</p> <p>Article in Chinese</p> | <p>OBJECTIVE: To probe into the bioeffect of gradient magnetic field on the growth and development of medicinal plants. METHODS: Gradient magnetic field with transmission belt was applied to treat the stem pearls of <i>Dioscorea opposita</i> before sowing and an evaluation of the pearl growth during the seedling stage was made. RESULT: Treated with twice gradient magnetic field, the stem pearls grew the best in the seedling stage. Compared with the control, the rate of emergence increased by 38.60%, root number increased by 8%, and the average root length increased by 2.62 cm. By F Test, the average root length was F = 19.98, F0.05 = 6.94 and F0.01 = 18.00. CONCLUSION: Proper magnetic field intensities can promote the growth of medicinal plants</p>   |
| 33<br>J? | <p><a href="#">Stange BC</a> et al<br/>Institute of Molecular<br/>BioSciences, Massey University,<br/>Palmerston North, New Zealand<br/>Publ: <a href="#">Bioelectromagnetics</a>. 2002<br/>Jul;23(5):347-54</p>                              | <p>'ELF magnetic fields increase amino acid uptake into <i>Vicia faba</i> L. roots and alter ion movement across the plasma membrane'</p>        | <p><i>Vicia faba</i> seedlings, subjected to a 10 microT 50 Hz square wave magnetic field for 40 min together with a radioactive pulse, showed a marked increase in amino acid uptake into intact roots. A more modest increase was observed with a 100 microT 50 Hz square wave. An increase in media conductivity at low field intensities from 10 microT 50 Hz square wave, 100 microT 50 Hz sine wave, and 100 microT 60 Hz square wave fields, indicated an alteration in the movement of ions across the plasma membrane, most likely due to an increase in net outflow of ions from the root cells. Similarly, marked elevation in media pH, indicating increased alkalinity, was observed at 10 and 100 microT for both square and sine waves at both 50 and 60 Hz. Our data would indicate that low magnetic field intensities of 10 and</p>  |

|          |  |  |  |
|----------|--|--|--|
|          |  |  | 100 microT at 50 or 60 Hz can alter membrane transport processes in root tips. Copyright 2002 Wiley-Liss, Inc  |
| 34<br>J? | <a href="#">Aksenov SI</a> et al<br>Biological Department,<br>Lomonosov Moscow State<br>University, Vorob'evy Gory,<br>Moscow, 119899 Russia<br>Publ: <a href="#">Biofizika</a> . 2001 Nov-<br>Dec;46(6):1127-32   | 'Characteristics of low<br>frequency magnetic field<br>effect on swelling of wheat<br>seeds at various stages'<br><br>Article in Russian | Low-frequency magnetic field treatment (50 Hz, 30 mT, 15 min) of wheat seeds with a 50% germination efficiency during imbibition at the stage of root formation leads to a statistically significant increase in the number of seeds having sprouts, a still greater increase in the number of seeds having roots, and to an increase in the length of sprouts compared with the control and the seeds treated several hours later. In the last case, an increase in the germinating capacity with a considerably lesser effect on the number of seeds with roots was also observed. Prolonged treatment with the field during the second day of imbibition decreased reliably the length of sprouts with a weaker influence on the number of seeds with sprouts and roots. These data suggest the principal possibility of the effect of electromagnetic fields on the realization of the genetic program during the germination of wheat seeds   |
| 35<br>J- | <a href="#">Zvitov R</a> et al<br>Institute of Biochemistry, Food<br>Science and Nutrition, Faculty<br>of Agricultural, Food and<br>Environmental Quality Sciences,<br>The Hebrew University of<br>Jerusalem, Israel<br>Publ: <a href="#">Biotechnol Prog</a> . 2001<br>Nov-Dec;17(6):1099-106 | 'Physicochemical properties<br>and structural changes in<br>vegetative tissues as affected<br>by a direct current electrical<br>field'   | Cylindrical pieces of potato, sweet potato, kohlrabi, radish, and pear were interposed between a pair of electrodes, and a direct current was applied. A special custom-made apparatus enabled the use of differently shaped electrodes. The electrical field was applied for 1 min at 40 V/cm and caused a reduction in specimen weight by a minimal value of 2.7% of initial weight in sweet potato to a maximum 38.4% in pear. The affected area of the tissue resembled the shape of the electrode. Pores were produced in the tissue (from the anode side), possibly promoting slow release of minerals and other cell components from the contracted specimens. From the cathode side, cell "sealing" could be observed. Weight loss was dependent on the mechanical properties of the nontreated vegetative tissue specimens. After confirmation that all samples pass through induced electrical shrinkage, further work, executed only on potato, demonstrated that after electrical treatment the samples were less brown (higher L values). In addition, a dependence of weight loss on current intensity, electrode diameter, and surface ratio between the electrode and specimen was shown. The reduction in weight loss could be useful for initial drying of vegetative materials. Indirect proof of a decrease in enzyme activity as a result of electrical field application could be beneficial in replacing traditional methods for browning prevention. |
| 36<br>J? | <a href="#">Budagovskii AV</a> et al<br>Michurin All-Russian Research<br>Institute of Fruit Crops Genetics<br>and Breeding, Russia<br>Publ: <a href="#">Biofizika</a> . 2001 Sep-<br>Oct;46(5):894-900   | 'Coherent electromagnetic<br>fields in the remote<br>intercellular interaction'<br><br>Article in Russian                                | The distant interactions various organisms and their communities and the effect of coherent electromagnetic radiation on intercellular relations were studied. The ability of fruit crops male gametophyte to control the germination of pollen tube at the field level (nonchemical) was established. The cooperative character of this process is shown. It is stimulated directly or indirectly, by low-intensity coherent radiation through a bioinductor. The conclusion is made that spontaneous chemiluminescence cannot be considered as an information channel of distant intercellular interaction   |

|                  |  |  |   |
|------------------|--|--|---|
| <p>37<br/>J-</p> | <p><a href="#">Yano A</a> et al<br/>Graduate School of Science and Technology, Chiba University, Matsudo, Chiba, Japan<br/>Publ: <a href="#">Bioelectromagnetics</a>. 2001 Apr;22(3):194-9</p> | <p>'Induction of primary root curvature in radish seedlings in a static magnetic field'</p>  | <p>Primary roots of radish (<i>Raphanus sativus</i> L.) seedlings were exposed to an inhomogeneous static magnetic field generated by a permanent magnet, during continuous rotation on a 0.06 rpm clinostat, thereby reducing the unilateral influence of gravity. The roots responded tropically to the static magnetic field with the tropism appearing to be negative. These roots responded significantly (<math>P &lt; 0.05</math>) to the south pole of the magnet. The significant tropic response was found for a magnetic flux density of 13-68 mT, for a field gradient of 1.8-14.7 T/m, and for the product of magnetic field and field gradient of 0.023-1.0 T<sup>2</sup>/m. A small, but insignificant, response of the roots to the north pole has also been found.</p>   |
| <p>38<br/>J?</p> | <p><a href="#">Aksenov SI</a> et al<br/>Biological Department, Lomonosov Moscow State University, Russia<br/><a href="#">Biofizika</a>. 2000 Jul-Aug;45(4):737-45</p>                          | <p>'Effect of a low-frequency magnetic field on esterase activity and change in pH in wheat germ during swelling of wheat seeds'</p> <p>Article in Russian</p> | <p>The role of nonsteady phenomena determined by a low velocity of ion movements in a weak external field is considered in relation to their possible nonlinear effects on processes occurring in boundary layers near the membrane, particularly, on the release of membrane-bound proteins and pH value. It is shown that a short-term treatment of wheat seeds with low-frequency magnetic field at the stage of esterase activation during seed swelling enhances the activation of esterases; the effect observed at final stages of activation depends on the time after the treatment with electromagnetic field. Treatment of seeds with electromagnetic field at this stage changed qualitatively the time course of the release of reaction products into the medium: the reaction rate increased initially and then decreased below the control level. At earlier stages of swelling in treated seeds and at all stages in control seeds, the time course of the product release was linear. The retardation of the release of the reaction products at terminal stages of esterase activation is presumably related to the release of proteins and their complexes under the action of electromagnetic field and the resulting restoration of the barrier properties of membranes. Treatment with electromagnetic field also caused a noticeable acceleration of proton flow from the medium, which was judged from pH changes in the bulk medium and in the vicinity of germ surface. The difference between the treated and control samples after 23-24 h of imbibition became statistically significant and was as high as 0.4 pH units. By taking into account the nonsteady phenomena occurring upon action of low-frequency electromagnetic field, it is possible to explain unusual dependences of biological effects on the amplitude of the electromagnetic field, including the atypical enhancement of these effects by the action of weak low-frequency fields'</p> |
| <p>39<br/>J-</p> | <p><a href="#">Freeman DC</a> et al<br/>The University of Chicago<br/>Publ: <a href="#">Int J Plant Sci</a>. 1999 Nov;160(S6):S157-S166</p>  | <p>'Developmental Instability as a Means of Assessing Stress in Plants: A Case Study Using Electromagnetic Fields and Soybeans.'</p>                           | <p>'Developmental instability is often assessed using deviations from perfect bilateral symmetry. Here, we review the literature describing previous studies, suggest mechanisms that may account for both the generation and disruption of bilateral symmetry, and examine the influence of electromagnetic fields on the asymmetry of soybean leaves. Leaves from plants under high-voltage power lines generating pulsed magnetic fields of &lt;3 to &gt;50 mG were more asymmetrical for two</p>  |

|          |   |  |  |
|----------|---|--|--|
|          |   |  | parameters (the terminal leaflet widths and lateral rachilla lengths) than leaves of plants even 50 or 100 m away from power lines. This asymmetry could not be attributed to either size scaling or measurement error.'   |
| 40<br>J- | <a href="#">Isobe S</a> et al<br>National Food Research Institute, Tsukuba, Ibaraki, Japan<br>Publ: <a href="#">Biochim Biophys Acta</a> . 1999 Jan 4;1426(1):17-31 | 'Effect of electric field on physical states of cell-associated water in germinating morning glory seeds observed by 1H-NMR'                           | Morning glory seeds in dry conditions (0.099 g H <sub>2</sub> O/dry wt.) were exposed to electric fields and germinated. The physical state of water in the germinating seeds of both control and exposed groups were examined using 1H-NMR spectroscopy and NMR microscopy. Three water fractions were observed which were characterized by different relaxation times (T1) and chemical shifts. The average region containing long T1 fractions was approximately 50 micrometer in diameter and consisted of half-permeable barriers. The maximum intracellular water transport rate was 2.3x10 <sup>-5</sup> cm <sup>2</sup> /s. The treatment with electric field (500 kV/m for 60 min) increased the fraction with the shortest T1 and decreased that with the longest T1. Because the total water content in the treated seeds (3.4 g H <sub>2</sub> O/dry wt.) was similar to that in the untreated seeds (3.9 g H <sub>2</sub> O/dry wt.), the treated seeds held more water in a condition in restricted motion than the untreated seeds. It is thought that the membrane systems were affected by the electric polarization which led to an unusual accumulation of water and the hydration of stored macromolecules during the imbibition process. This set of events led to excessive swelling of stored macromolecules, resulting in the disruption of membrane systems and irregular organization of tissue structures |
| 41<br>J? | <a href="#">Parkinson WC</a> et al<br>Department of Physics, University of Michigan, USA<br>Publ: <a href="#">Bioelectromagnetics</a> . 1997;18(5):400-1            | 'Comment on "Effects of 60 Hz electromagnetic fields on early growth in three plant species and a replication of previous results" by Mark S. Davies.' | No abstract available  |
| 42<br>J+ | <a href="#">Davies MS</a><br>Ecology Centre, University of Sunderland, Sunderland, U.K<br>Publ: <a href="#">Bioelectromagnetics</a> . 1996;17(2):154-61             | 'Effects of 60 Hz electromagnetic fields on early growth in three plant species and a replication of previous results'                                 | In an attempt to replicate the findings of Smith et al., seeds of <i>Raphanus sativus</i> L. (radish), <i>Sinapsis alba</i> L. (mustard), and <i>Hordeum vulgare</i> L. (barley) were grown for between 9 and 21 days in continuous electromagnetic fields (EMFs) at "ion-cyclotron resonance" conditions for stimulation of Ca(2+) (B(H) = 78.3 mu T, B(HAC) = 40 mu T peak-peak at 60 Hz, B(V) = 0). On harvesting, radish showed results similar to those of Smith et al. Dry stem weight and plant height were both significantly greater (Mann-Whitney tests, Ps < 0.05) in EMF-exposed plants than in control plants in each EMF experiment. Wet root weight was significantly greater in EMF-exposed plants in two out of three experiments, as were dry leaf weight, dry whole weight, and stem diameter. Dry root weight, wet leaf weight, and wet whole weight were significantly greater in EMF-exposed plants in one of three experiments. All significant differences indicated an increase in weight or size in the EMF-exposed plants. In each of the sham experiments, no differences between exposed and control plants were evident. Mustard plants failed to respond to the EMFs in any of the plant parameters measured. In one experiment, barley similarly failed to respond; but in another showed significantly greater  |

|          |  |  |   |
|----------|--|--|---|
|          |  |  | wet root weight and significantly smaller stem diameter and dry seed weight at the end of the experiment in exposed plants compared to control plants. Although these results give no clue about the underlying bioelectromagnetic mechanism, they demonstrate that, at least for one EMF-sensitive biosystem, results can be independently replicated in another laboratory. Such replication is crucial in establishing the validity of bioelectromagnetic science.   |
| 43<br>j- | <a href="#">Haider T</a> et al<br>Institute of Environmental Hygiene, University of Vienna, Austria<br>Publ: <a href="#">Mutat Res.</a> 1994 Jun;324(1-2):65-8 | 'Clastogenic effects of radiofrequency radiations on chromosomes of <i>Tradescantia</i> .'   | The clastogenicity of electromagnetic fields (EMF) has so far been studied only under laboratory conditions. We used the <i>Tradescantia</i> -micronucleus (Trad-MCN) bioassay in an in situ experiment to find out whether short-wave electromagnetic fields used for broadcasting (10-21 MHz) may show genotoxic effects. Plant cuttings bearing young flower buds were exposed (30 h) on both sides of a slewable curtain antenna (300/500 kW, 40-170 V/m) and 15 m (90 V/m) and 30 m (70 V/m) distant from a vertical cage antenna (100 kW) as well as at the neighbors living near the broadcasting station (200 m, 1-3 V/m). The exposure at both sides of the slewable curtain antenna was performed simultaneously within cages, one of the Faraday type shielding the field and one non-shielding mesh cage. Laboratory controls were maintained for comparison. Higher MCN frequencies than in laboratory controls were found for all exposure sites in the immediate vicinity of the antennae, where the exposure standards of the electric field strength of the International Radiation Protection Association (IRPA) were exceeded. The results at all exposure sites except one were statistically significant. Since the parallel exposure in a non-shielding and a shielding cage also revealed significant differences in MCN frequencies (the latter showing no significant differences from laboratory controls), the clastogenic effects are clearly attributable to the short-wave radiation from the antennae. |
| 44<br>j- | <a href="#">Bingley MS</a><br>Eaton Farm, Cobham, Surrey, England<br>Publ: <a href="#">Physiol Chem Phys Med NMR.</a> 1994;26(1):5-26                          | 'Some unusual high speed responses to electrical stimulation in <i>Nitella</i> with microscopic observations of electromagnetically induced changes in the cytoplasm.' | <i>Nitella flexilis</i> living in Surrey ponds shows an unusual response to external electrical stimulation. This response is shorter (250 milliseconds) than the normal response (5 seconds), nor does it seem to obey the all-or-none law; decreasing the level of stimulus introduces a delay in its appearance. Microelectrode studies suggest that this response though propagated down the length of the cell is a surface phenomenon as compared to the normal response which is generated across the membrane. Normasky interference microscopic observation of the cytoplasm of those cells exhibiting this response shows large vesicles whose contents rotate, as opposed to those cells showing a normal response which do not show these vesicles. This response is associated with local extinction of groups of <i>Nitella flexilis</i> from ponds in Surrey and a temporary reduction in numbers in certain areas of the New Forest. Electrical excitation itself induces vesicle formation and its associated response in <i>Nitella flexilis</i> , and to a far lesser degree in <i>Nitella translucens</i> . In <i>Nitella translucens</i> alternating electromagnetic fields of low strength induce the formation of vesicles whose   |

|          |   |   |  |
|----------|---|---|--|
|          |   |   | contents actively rotate in some individual cells. These vesicles are always accompanied by distortions in electrical response to stimulation. In its response to electromagnetic fields, <i>Nitella translucens</i> is very variable. <i>Nitella opaca</i> exhibits the same response as <i>Nitella flexilis</i> including the same fragility of survival. Electrical studies may throw light on the contentious problem as to whether <i>Nitella opaca</i> is in reality a separate species from <i>Nitella flexilis</i>   |
| 45<br>J? | <a href="#">McCann J</a> et al<br>ICF Kaiser Engineers, Inc.,<br>Oakland, CA, USA<br>Publ: <a href="#">Mutat Res.</a> 1993<br>Jul;297(1):61-95                        | 'A critical review of the genotoxic potential of electric and magnetic fields'                | 55 published articles were identified which reported results of tests of ELF (extremely low frequency) or static electric or magnetic fields for genotoxic effects. The biological assays used spanned a wide range, including microbial systems, plants, <i>Drosophila</i> , mammalian and human cells in vitro and in vivo. Experimental results were grouped into four exposure categories: ELF Electric; ELF Magnetic; Static Electric; and Static Magnetic. The internal electric fields present in media (for in vitro experiments) and in the torso and extremities (for in vivo experiments) were estimated, providing an index of comparison. All experiments were critically analyzed with respect to basic data quality criteria. Experiments within each exposure category were then compared to determine if results reinforced or contradicted one another. The preponderance of evidence suggests that neither ELF nor static electric or magnetic fields have a clearly demonstrated potential to cause genotoxic effects. However, there may be genotoxic activity from exposure under conditions where phenomena auxiliary to an electric field, such as spark discharges, electrical shocks, or corona can occur. In addition, two unconfirmed reports suggest the genotoxic potential of certain chemical mutagens or ionizing radiation may be affected by co-exposure to electric or magnetic fields. Certain exposure categories are not represented or are under-represented by tests in some genotoxicity test systems that are usually included in minimal test batteries as specified by EPA for chemicals. It is suggested that consideration be given to whether additional genotoxicity testing is warranted to fill these gaps. |
| 46<br>J- | <a href="#">Ellingsrud S</a> et al<br>Department of Physics,<br>University of Trondheim,<br>Norway<br>Publ: <a href="#">Bioelectromagnetics.</a><br>1993;14(3):257-71 | 'Perturbations of plant leaflet rhythms caused by electromagnetic radio-frequency radiation.' | The minute-range up and down rhythms of the lateral leaflets of <i>Desmodium gyrans</i> has been studied when exposed to electromagnetic radiation in the radio-frequency (RF) range. The RF radiation was applied as homogeneous 27.12 MHz fields in specially-designed exposure cells (and in some cases as non-homogeneous radiation of 27 MHz, amplitude modulated by 50 Hz, in front of commercial diathermy equipment). All fields were applied as pulses. We report effects in the leaflet rhythms such as temporary changes in the amplitude, period, and phase. The radiation could also cause temporary or complete cessations of the rhythms. The lowest dose (8 W/cm <sup>2</sup> ) used was still effective.  |
| 47<br>J? | <a href="#">Robertson B</a><br>Biotechnology Division,<br>National Institute of Standards<br>and Technology, Gaithersburg,<br>Maryland                                | 'Interpretation of the effect of an oscillating electric field on membrane enzymes.'          | Theoretical expressions for the frequency and amplitude dependence of the rate of a catalyzed reaction are fitted to the data of Graziana et al. (1990) [Graziana, A., Ranjeva, R., & Teissié, J. (1990) <i>Biochemistry</i> 29, 8313-8318] for Ca <sup>2+</sup> uptake by carrot protoplasts in an  |

|          |  |  |  |
|----------|--|--|--|
|          | Publ: <a href="#">Biochemistry</a> . 1992 Jan 14;31(1):138-41  |  | oscillating electric field. This uptake is a direct (linear) measure of the rate of increase of ATP caused by a plasma membrane enzyme in the oscillating field. The fit gives 20 ms and 33 microseconds for the relaxation times of the enzyme and roughly 3 for the effective number of elementary changes displaced across the membrane by a conformational change of the enzyme in its catalytic cycle. Additional experiments are suggested to define further the mechanism of the enzymatic reaction   |
| 48<br>J- | <a href="#">Azadniv M</a> et al<br>Department of Biophysics,<br>School of Medicine and<br>Dentistry, University of<br>Rochester, New York, USA<br>Publ: <a href="#">Radiat Res</a> . 1990<br>Oct;124(1):62-5   | 'Repetitive pulsed-train "off" duration mitigates reductions in root growth rates of <i>Pisum sativum</i> L. induced by 60-Hz electric field.' | An investigation was undertaken to define a 60-Hz electric field exposure system which would affect a eukaryotic cell system while mitigating a potential thermal rise. The biological effectiveness of pulsed 60-Hz electric fields on a cell system of defined sensitivity to continuous-wave 60-Hz electric fields was sought. Roots of garden pea ( <i>Pisum sativum</i> L.) were exposed to pulsed trains of 60-Hz, 430 V/m electric fields. The "on" time was constant at 1 s and the "off" time varied. The repetitive on:off regimens used were 1:20, 1:50, 1:100, 1:130, 1:200, and 1:300. With continuous or 1:20 pulsed fields the growth response was equivalent (representing a 60% depression in root growth rate). The severity of the growth effect diminished as the off time increased; for the 1:100 regimen, the relative growth rate was depressed by about 30%; for the 1:300 regimen, the relative growth rate was equal to that of the controls  |
| 49<br>J- | <a href="#">Brayman AA</a> et al<br>Department of Biophysics,<br>School of Medicine and<br>Dentistry, University of<br>Rochester, New York, USA<br>Publ: <a href="#">Radiat Res</a> . 1990<br>Jul;123(1):22-31 | '60-Hz electric field exposure inhibits net apparent H(+)-ion excretion from excised roots of <i>Zea mays</i> L.'                              | Plant root model cell systems have provided insight into the biophysical mechanism by which extremely low frequency electric fields (EF; f less than or equal to 100 Hz) affect nonexcitable eukaryotic cells. The evidence indicates that the plasma membrane is the site of interaction with applied extremely low frequency EF, and that cells respond to field exposure via a sensing mechanism involving the induction of extremely low frequency membrane potentials (V <sub>m</sub> ). We suggest a mechanism by which V <sub>m</sub> may be transduced into EF-induced root growth inhibition. Suspensions of excised <i>Zea</i> root tips were used to test the hypothesis that growth-inhibiting extremely low frequency EF exposures inhibit net H <sup>+</sup> excretion from protoplasts, a process mediated by a plasma membrane H(+)-ATPase which is intimately involved in cellular extension. Rates of acidification of root tip suspensions were measured as an analog for net H <sup>+</sup> efflux. The experimental results support this hypothesis. At the apparent threshold for inhibition of H <sup>+</sup> excretion, the associated 60-Hz EF strength was about 220 V.m <sup>-1</sup> (root mean square). Estimates of V <sub>m</sub> associated with inhibition of net H <sup>+</sup> excretion are in agreement with those known to affect Na <sup>+</sup> /K <sup>+</sup> transport in human erythrocytes. |
| 50<br>J- | <a href="#">Chukova IuP</a><br>Russia<br>Publ: <a href="#">Biofizika</a> . 1989 Sep-<br>Oct;34(5):898-900  | 'Dissipative functions of processes of electromagnetic radiation interaction with biological objects'<br><br>Article in Russian                | Entropy generation rate inside the biological systems due to internal irreversible processes of the interaction with electromagnetic radiation is calculated for the processes of chemical free-energy increase. The irreversibility of several processes (photosynthesis in plants, eyesight of man, bioresonance effects of high frequencies of microwaves) is estimated under concrete experimental conditions. It is shown that the irreversible   |

|                        |  |  |  |
|------------------------|--|--|--|
|                        |  |  | of five biological processes differs very much (by 10(8) times).   |
| <b>51</b><br><b>J-</b> | <a href="#">Brayman AA</a> et al<br>Department of Biophysics,<br>School of Medicine and<br>Dentistry, University of<br>Rochester, New York, USA<br>Publ: <a href="#">Radiat Res.</a> 1989<br>Feb;117(2):207-13 | 'Proportionality of 60-Hz<br>electric field bioeffect<br>severity to average induced<br>transmembrane potential<br>magnitude in a root model<br>system.' | The postulate that electric field-induced bioeffects in the root model system are related to the induction of 60-Hz transmembrane potentials (V <sub>im</sub> ) was quantitatively tested. Root segment growth rate data and the calculated mean 60-Hz V <sub>im</sub> which would arise in the cortical cells of a segment under specified exposure conditions were subjected to regression analysis. Statistically significant correlations between segmental growth rate and segmental-average V <sub>im</sub> were obtained using data analyzed (1) within species at a constant applied field strength, (2) within species and pooled across field exposures, and (3) pooled across both species and exposures. In <i>C. sativus</i> roots, segmental growth is inhibited when segmental-average V <sub>im</sub> attain a value of 3.4-3.6 mV. In <i>C. maxima</i> roots, growth inhibition occurs when V <sub>im</sub> attain or exceed 2.3-2.7 mV. Segmental growth cessation is predicted to occur when segmental-average V <sub>im</sub> exceed 7-9 mV.   |
| <b>52</b><br><b>J?</b> | <a href="#">Hendrickson RC</a><br>Minnesota Environmental<br>Quality Board, Power Plant<br>Siting Program, St. Paul,<br>Minnesota<br>Publ: <a href="#">Bioelectromagnetics.</a><br>1986;7(4):369-79            | 'Space charge drift from a +/-<br>400-kV direct current<br>transmission line.'   | The Minnesota Environmental Quality Board completed a 3-year study of the space charge plume outside the right of way of a bipolar (+/- 400 kV) direct current transmission line in rural west central Minnesota. The purpose of the study was to determine the levels of DC potential gradient and small air ions in the downwind plume to which humans and animals may be exposed. Potential gradient measurements show that a space charge plume is detectable downwind at least 1600 m from the transmission line. Plume relaxation rates indicate that under certain conditions one could detect the plume at twice that distance or more. Net charge in the plume assumes the polarity of the downwind energized transmission line conductor. The bipolar DC line thus electrically bisects the land through which it passes; on one side of the line there is a net positive space charge, on the other side a net negative space charge. Electric charge in the plume resides on aerosols and small air ions. Polar conductivity data substantiate the fact that small air ions of one polarity in the plume are elevated while those of opposite polarity are suppressed compared to background concentrations found in the rural environment. The resulting charge imbalance persists downwind at least 1600 m, though the median small air ion concentrations of plume polarity have adjusted to within the background range by that time with perpendicular wind speed components between 1 and 6 m/sec. |
| <b>53</b><br><b>J-</b> | <a href="#">Inoue M</a> et al<br>Radiation Center of Osaka<br>Prefecture, 593 Shinke, Sakai,<br>Osaka, Japan", m fl<br>Publ: <a href="#">Radiat Environ Biophys.</a><br>1985;24(4):303-14                      | 'The relationship between<br>sensitivity to 60-Hz electric<br>fields and induced<br>transmembrane potentials in<br>plants root cells.'                   | Growth rates and cell diameters were determined from 12 species of plant roots exposed to a 60-Hertz (Hz) electric field of 360 Volts per meter (V/m) in an aqueous inorganic nutrient medium [conductivity: 0.07-0.09 Siemens per meter (S/m)]. The degree of growth depression ranged from zero to nearly 100 percent of control. Cell diameters ranged from 13.5 to 31.8 micron as an averaged value for procambial, cortical, and meristem cells. Sensitivity to the electric field as determined by root growth rate reduction increased with increasing cell size. Sensitivity also increased with   |

|          |   |   |  |
|----------|---|---|--|
|          |   |   | increase in 60 Hz induced transmembrane potentials; the transmembrane potential threshold for growth reduction was about 6.0 mV and the potential for near-complete cessation of growth was about 10-11 mV. Two different hypothetical mechanisms of action by which applied electric fields induce biological effects at the cellular level were tested. The two mechanisms pertain to different possible modes of action of applied electric fields: one mechanism postulates the involvement of the transmembrane field, the other mechanism postulates the tangential electric field as the important factor for inducing biological effects. The data support the transmembrane and not the tangential field mechanism. It is concluded that the effects observed are consistent with a membrane related mechanism and that there is a narrow range (a few mV) between threshold and debilitating induced membrane potentials |
| 54<br>J- | <a href="#">Inoue M</a> et al<br>Department of Radiation Biology and Biophysics, School of Medicine and Dentistry, Rochester, New York m fl<br>Publ: <a href="#">Bioelectromagnetics</a> . 1985;6(3):293-303                                | 'Growth rate and mitotic index analysis of <i>Vicia faba</i> L. roots exposed to 60-Hz electric fields.'                        | Growth, mitotic index, and growth rate recovery were determined for <i>Vicia faba</i> L. roots exposed to 60-Hz electric fields of 200, 290, and 360 V/m in an aqueous inorganic nutrient medium (conductivity 0.07-0.09 S/m). Root growth rate decreased in proportion to the increasing strength; the electric field threshold for a growth rate effect was about 230 V/m. The induced transmembrane potential at the threshold exposure was about 4-7 mV. The mitotic index was not affected by an electric field exposure sufficient to reduce root growth rate to about 35% of control. Root growth rate recovery from 31-96% of control occurred in 4 days after cessation of the 360 V/m exposure. The results support the postulate that the site of action of the applied electric fields is the cell membrane  |
| 55<br>J- | <a href="#">Brulfert A</a> et al<br>Department of Radiation Biology and Biophysics, School of Medicine and Dentistry, The University of Rochester, Rochester, New York m fl<br>Publ: <a href="#">Bioelectromagnetics</a> . 1985;6(3):283-91 | 'A cytohistological analysis of roots whose growth is affected by a 60-Hz electric field.'                                      | Roots of <i>Pisum sativum</i> were exposed for 48 h to 60-Hz electric fields of 430 V/m in an aqueous inorganic growth medium. The growth in length of the exposed roots was 44% of that for control roots. Root tips were analyzed for mitotic index and cell cycle duration. Mature, differentiated root sections from tissue produced after electrode energization were analyzed for cell lengths and number of files. The major reason for the observation that exposed roots are shorter than control roots is that cell elongation in the former is greatly diminished relative to controls.   |
| 56<br>J? | <a href="#">Nikolova L</a> et al<br>Publ: <a href="#">Vopr Kurortol Fizioter Lech Fiz Kult</a> . 1984 May-Jun;(3):19-23   | 'Effect of interference current and low-frequency magnetic field on tissue regeneration.'<br><br>Article in Russian             | No abstract available  |
| 57<br>J? | <a href="#">Sonneveld A</a> et al<br><a href="#">Biochim Biophys Acta</a> . 1981 Jun 12;636(1):39-49  | 'Sub-microsecond chlorophyll a delayed fluorescence from photosystem I. Magnetic field-induced increase of the emission yield.' | (1) In photosystem I (PS I) particles in the presence of dithionite and intense background illumination at 290 K, an external magnetic field (0-0.22 T) induced an increase, $\Delta F$ , of the low chlorophyll a emission yield, $F$ ( $\Delta F/F$ approximately or equal to 1-1.5%). Half the effect was obtained at about 35-60 mT and saturation occurred for magnetic fields higher than about 0.15 T. In the absence of dithionite, no field-induced increase was observed. Cooling to 77 K decreased $\Delta F$ at 685 nm, but not at 735 nm, to zero. Measuring the emission spectra of $F$ and $\Delta F$ , using continuous excitation   |

|    |   |  |  |
|----|---|--|--|
|    |   |  | <p>light, at 82, 167 and 278 K indicated that the spectra of F and delta F have about the same maximum at about 730, 725 and 700 nm, respectively. However, the spectra of delta F show more long-wavelength emission than the corresponding spectra of F. (2) Only in the presence of dithionite and with (or after) background illumination, was a luminescence (delayed fluorescence) component observed at 735 nm, after a 15 ns laser flash (530 nm), that decayed in about 0.1 microseconds at room temperature and in approx. 0.2 microseconds at 77 K. A magnetic field of 0.22 T caused an appreciable increase in luminescence intensity after 250 ns, probably mainly caused by an increase in decay time. The emission spectra of the magnetic field-induced increase of luminescence, delta L, at 82, 167 and 278 K coincided within experimental error with those of delta F mentioned above. The temperature dependence of delta F and delta L was found to be nearly the same, both at 685 and at 735 nm. (3) Analogously to the proposal concerning the 0.15 microseconds luminescence in photosystem II (Sonneveld, A., Duysens, L.N.M. and Moerdijk, A. (1980) Proc. Natl. Acad. Sci. U.S.A. 77, 5889-5893), we propose that recombination of the oxidized primary donor P-700+ and the reduced acceptor A-, probably A-1, of PS I causes the observed fast luminescence. The effect of an external magnetic field on this emission may be explained by the radical pair mechanism. The field-induced increase of the 0.1-0.2 microseconds luminescence seems to be at least in large part responsible for the observed increase of the total (prompt + delayed) emission measured during continuous illumination in the presence of a magnetic field</p> |
| 58 | <p><b>J</b> - <a href="#">Robertson D</a> et al<br/>Department of Radiation Biology and Biophysics, School of Medicine and Dentistry, The University of Rochester, Rochester, New York m fl<br/>Publ: <a href="#">Bioelectromagnetics</a>. 1981;2(4):329-40</p> | <p>'Inhibition and recovery of growth processes in roots of <i>Pisum sativum</i> L. exposed to 60-Hz electric fields.'</p> | <p>Roots of <i>Pisum sativum</i> L. were chronically exposed in aqueous inorganic nutrient medium to 60-Hz electric fields between 140 and 490 V/m (growth medium conductivity approximately 0.08 S/m). The growth rate, meristematic mitotic index, and growth rate recovery of the roots were determined. At 140 V/m there was no perturbation in growth rate or mitotic index. At 430 V/m the growth rate and the mitotic index were reduced. The mitotic index had a maximum depression (approximately 55% of control), which occurred at 4 h. The depression in growth rate was immediate and constant over time. When roots were exposed to an electric field at 430 V/m for 2 days, the growth rate was depressed by about 40%. When the field was terminated, the growth rate steadily increased and was almost normal after 5 days. At 490 V/m root growth rate was almost completely arrested. According to these results, there is a narrow range of induced membrane potentials that span the range from slightly altered to almost completely arrested growth rates.</p>  |
| 59 | <p><b>J</b> - <a href="#">Davis FS</a> et al<br/>Texas A &amp; M University, College Station 77843<br/>Publ: <a href="#">Science</a>. 1971 Aug 6;173(3996):535-537</p>  | <p>'Ultra-high-Frequency Electromagnetic Fields for Weed Control: Phytotoxicity and Selectivity.'</p>                      | <p>An ultra-high-frequency electromagnetic field (2450+/-20 megahertz) is lethal to plants and seeds of several species after relatively short exposure times. Some species are highly susceptible; others are relatively resistant to a given field intensity. Phytotoxicity is increased in imbibed seeds and young plants. It is</p>  |

|                                  |   |  |   |
|----------------------------------|---|--|---|
|                                  |   |  | decreased in dry seeds and sometimes decreased in mature plants. Soil partially attenuates the field but is not opaque to it.   |
| <b>Andra publicerade studier</b> |   |  |   |
| <b>60</b><br>J-                  | D. Lerchl et al, University of Wuppertal, University of Karlsruhe, Tyskland (2000)<br>Publ: <a href="#">Trans Bioelectromagnetics Soc</a> 22:160.   | 'Studies on the effects of radio-frequency fields on conifers'<br>Pinus pumila (Dvärgtall), Abies alba (Silvergran) och Abies grandis (Kustgran).  | Exponering för 383 MHz pulsad signal i 222 dygn.<br>Tillväxten hos de exponerade träden skilde sig något från kontrollgrupperna.<br>Klorofyllet minskade och dödligheten i de exponerade grupperna var ca 200-300% högre än i kontrollgrupperna.<br>Dödligheten var högst hos Pinus pumila (20,4% mot 6,0% för kontrollerna), vilket skulle kunna förklaras av att denna arts barr har ett mer vertikalt växtsätt hos unga individer, än de andra arterna.  |
| <b>61</b><br>J-                  | Brauer, (1950)<br>Publ: <a href="#">Chromosoma</a> , Vol. 3 pp. 483-509   | 'Experimental studies on the effect of meter waves of various field intensities on the growth of plants by division'   | Tillväxten hos växten <i>Vicius fabus</i> stimulerades vid exponeringsnivån 0.000000027 $\mu\text{W}/\text{cm}^2$ .<br>Tillväxten hämmades i stället vid 0.0027 $\mu\text{W}/\text{cm}^2$   |
| <b>62</b><br>J-                  | Selga T, Selga M (1996)<br>Department of Plant Phssiology, Institute of Biology, Latvia<br>Publ: <a href="#">The Science of the Total Environment</a> Vol. 180, 2 February 1996, pp. 65-73, Elsevier Science BV | 'Response of Pinus sylvestris L. needles to electromagnetic fields. Cytological and ultrastructural aspects'   | Tallbarr åldrades i förtid vid exponeringsnivån 0.000027 $\mu\text{W}/\text{cm}^2$<br>The effects of pulsed radio frequency electromagnetic field (RF EMF) on plant growth and development are still unclear and contradictory. The aim of this work is to study the impact of RF EMF generated from the Skruna Radio Location Station, Latvia, on growth and development of pine trees. Pine needles and cones were collected in 1993 from the tops of 50–60-year-old pine trees in four locations near the Skruna RLS: A — no EMF exposure, B — low EMF exposure, C and D — high EMF exposure. The chloroplasts of mesophyll of second-year needles are ultrastructurally characterised by dense stroma, a compact granal membrane system and variable amounts of starch granules and plastoglobules. Low and especially high EMF exposure from the Skruna RLS increased the amount of plastoglobules. the structure and export products of Golgi apparatus were changed and in different types of cells, large osmiophilic globules appeared. Evidently, EMF induces modification of Golgi apparatus and switches its functions from synthesis of predecessors of cell walls (lignins) to formation and export of resin predecessors. The stress due to RF EMF generated from Skruna RLS causes an unspecific response — accelerated resin production and promoted senescence of pine trees. |
| <b>63</b><br>J-                  | Balodis V, et al (1996)<br>Publ: <a href="#">The Science of the Total Environment</a> , Vol. 180, No. 1, 2 February 1996, pp. 57-64(8)  | 'Does the Skruna Radio Location Station diminish the radial growth of pine trees'<br>Skruna Radio Location Station (RLS) i Lettland har varit i bruk mer än 30 år, och erbjuder ett unikt område för studier av pulsade radiofrekventa (RF) EMF. | - Permanenta lokaler med tallskog i närheten av Skruna RLS samt kontrollområden har etablerats.<br>- Statistiskt signifikanta ( $P < 0.01$ ) negativa samband kan konstateras mellan trädens tillväxt (årsringar) och nivåerna av elektromagnetiska fält. Tillväxten har minskat på samtliga lokaler som exponerats för elektromagnetisk strålning.<br>- Tillväxtminskningen började efter 1970, vilket sammanfaller med när Skruna RLS startades, och observerades under hela mätperioden.<br>- Effekten av en rad andra miljöfaktorer värderades, men inga signifikanta effekter på tillväxten kunde  |

|                  |   |                                  |   |
|------------------|---|----------------------------------|---|
|                  |   |                                  | observeras av dessa.  |
| <b>64</b><br>j - | Derek Clements Croome, Publ:<br><a href="#">Electromagnetic Environments and Health in Buildings</a> (2004)<br>p. 263 | Damage to trees – ‘Oak Die Back’ | I Storbritannien observerades att ekar började dö från toppen i stället för normalt från rötterna och uppåt. Över 100 lokaler inspekterades av Skogsstyrelsen (the Forestry Commission) och samband konstaterades mellan sjuka träd och avstånd till höga master. Slutsats: Sambandet antyder att denna typ av (modulerade) fält interfererar med växtens interna hydrauliska och elektroosmotiska processer. Detta genom att de naturliga elektriska fälten ‘maskeras’, speciellt vid ‘vackert’ väder. |