17033); Sharkey, F. E.; Frey, R. A.; Stryker, J. A.; Velkley, D. E. Natl Cancer Inst Monogr 61:385-389; 1982 (18 refs).

Seventy-six congenitally homozygous (nu/nu) nude NIH Swiss Webster mice were inoculated sc or id with $3x10^7$ CMV-Mj-HEL-2, T-1 cells along the dorsal midline. The cells were a strain of human embryo lung fibroblasts transformed in vitro by human cytomegalovirus. Of the superficial tumors that developed after a 19-day latent period, 25 were treated with 2,450-MHz microwave hyperthermia (42.5 C for 20 mi followed by fractionated electron beam therapy (641 rad/fraction) (Group HE); 16 tumors received radiation alone (Group E), 15 received only hyperthermia (Group H), and 15 served as controls (Group C). A 50% or greater reduction in tumor vol occured in 77% of Group HE tumors, compared with 12% of Group E, 8% of Group H, and 20% of Group C tumors. Complete regression was observed in 50% of Group HE tumors, as opposed to 6% of Group E, 8% of Group H, and 7% of Group C tumors. These results confirm the efficacy of combined heat and radiation treatment in a moderately radioresistent cell line. The results are significant because the cell line is a virally transformed human strain transformed by a human virus; moderately radioresistant in vivo, and in vitro; and not significantly responsive to heat or radiation alone, and demonstrates metastatic capabilities typical of malignant human tumors.

0471 RESPONSE OF SPONTANEOUS ANIMAL TUMORS TO HEAT AND/OR RADIATION: PRELIMINARY RESULTS OF A PHASE III TRIAL. (Eng.) Dewhirst, M. W. (Div. Radiation Oncology, Dept. Radiology, Univ. Arizona Health Sciences Center, Tucson, AZ 85724); Connor, W. G.; Moon, T. E.; Roth, H. B. Natl Cancer Inst Monogr 61:395-397; 1982 (10 refs).

Relative differences in control rates and response durations of spontaneous tumors in 13 cats and 41 dogs treated in a phase III randomized trial with heat alone, irradiation alone, or heat plus irradiation are reported. Animals were assigned to three treatment groups and were stratified by histological type of tumor. The histological types treated included melanoma (7), mast cell sarcoma (13), mammary adenocarcinoma (6), fibrosarcoma (10), and squamous cell carcinoma (18). Heat treatments were given with a 500-KHz radiofrequency power source by either capacitive or resisitive coupling. Radiation therapy was given by either 4- or 10-MV X-rays, electrons, or orthovoltage. The total tumor dose was 460 rad/fraction given twice weekly for a total of 8 treatments. A comparison of response rates among the three treatment arms showed that the fraction of nonresponders in the heat alone arm (53.3%) was significantly higher than in the other 2 arms combined or the heat plus irradiation arm alone. The relationship between tumor size and response to therapy showed that heat alone and irradiation alone resulted in complete responses only in tumors less than 35 cm^3. In contrast combination of the 2 modalities resulted in com responses in 4 tumors that were larger than 50 The median response duration for heat alone was than 2 mo. This was significantly shorter that for irradiation alone or heat plus irradia The major complication was the development of degree burns from the heat treatments, which occ in 30% of the sujects in both heat arms. No complications such as necrosis were observed. is the first randomized prospective trial to that heat alone is ineffective for long-term co of most tumors.

0472 BIOLOGICAL RATIONALE FOR OPTIMAL SCHED OF HEAT AND IONIZING RADIATION: CLI RESULTS ON NECK NODE METASTASES. (Eng.) Arcan G. (Istituto Medico e di Ricerca Scientifica, V Stefano Rotondo, 6, 00184 Rome, Italy); Clividall Creton, G.; Mauro, F.; Nervi, C. Natl Cancer Monogr 61:407-409; 1982 (8 refs).

A total of 101 neck node metastases from head and cancer were selected from 47 patients and treated different multimodality schedules. Similar le in each patient were treated with at least two m ities. Patients were irradiated according to a s ple daily fractionated (MDF) protocol with 4 hr i vals between fractions; 30/101 nodes were treated MDF alone. Multimodality treatment combined MDF the radiosensitizer Misonidazole (MIS: 22 nodes); hyperthermia (HT) induced by 500 MHz microwave t tion (27 nodes); or with MIS and HT (20 nodes) the nodes treated by HT, a tumor core temperatu 42-43 C was delivered for 45 min to only one le patient on days 1, 3 and 5 of each wk, immedi after the second daily MDF treatment. Tumor res at the end of 6 and 12 mo was compared. The bes sults were obtained in cases where HT was com with MDF or MDF + MIS. In these instances, actu local control rates at 12 mo were 73% and and 8 the lesions, respectively. Little toxicity wa perienced by patients treated by HT + MDF. N hanced skin reactions were seen during treatme follow-up in patients treated with HT, though and care are required to avoid burning the pati skin.

0473 CLINICAL EXPERIENCE WITH MICROWAVE RADIOFREQUENCY THERMOTHERAPY IN THE T MENT OF ADVANCED CANCER. (Eng.) Abe, M. (Dept. ology, Faculty Medicine, Kyoto Univ., 54 Shogoin haracho, Sakyo-ku, 606 Kyoto, Japan); Hirasoka Takahashi, M.; Ono, K.; Nohara, H. Natl Cancer Monogr 61:411-414; 1982.

Clinical experience using microwave (MW) and r frequency (RF) thermotherapy in the treatment o

vanced cancer is presented. Hyperthermia by 2450-MHz MW radiation in combination with radiotherapy was delivered to 13 patients with superficial neoplasms and metastatic tumors in the neck. Tumors were no more than 2 cm deep and 6 cm in diameter. In 10 patients, hyperthermia to 41-43.5 C was administered for 20-40 min within 10 min after irradiation, 1-5/wk; complete regression (CR) was seen in 3/10 patients, partial regression (PR) in 4, and no response in 3. In 3 patients, MW heat (42.3-43 C for 15 min) was applied before and after irradiation 5/wk; CR was seen in 2/3 patients and no response in 1. To raise the temperatures in middle and deep-seated tumors, an RF device with an output >500 W at an inductor-capacitor oscillator-generated frequency of 13.56 MHz was used to conduct initial clinical trials on 9 patients who had advanced superficial tumors considered not amenable to conventional treatment. Six patients who had developed recurrence after radiotherapy were treated by RF hyperthermia alone (41-46 C for 30-60 min, 4 to 10 treatments) and 3 were given radiation plus RF hyperthermia (41-44 C for 3-40 min, 2 to 10 treatments). Only 1 patient receiving RF hyperthermia alone experienced PR; no response was seen in 5/6. PR was seen in 2/3 patients treated with radiation and hyperthermia, and CR was seen in 1/3.

0474 A PATHOLOGICAL STUDY ON INTRALUMINAL MICROWAVE HYPERTHERMIA IN ESOPHAGEAL CANCER. (Eng.) Qiu, S. L. (Dept. Pathology, Inst. Medical Sciences of Henan, Zhengchow, Henan, People's Republic of China); Li, D. J.; Shao, L. F.; Wang, C. Q. Natl Cancer Inst Monogr 61:415-417; 1982 (3 refs).

Tissue specimens from 21 esophagectomy patients who had been treated with intraluminal microwave hyperthermia alone or in combination with radiation were compared with 20 surgical specimens treated with radiation alone or that had received no treatment before resection. The main manifestations after hyperthermia were necrosis of paracancerous epithelium, small round cell infiltration around the cancerous tissue, and damage of the interstitial vessels. No specific histophathological changes were regarded as hyperthermia-related, but the degree of tumor damage was more severe in the hyperthermia plus radiotherapy group than that of the group receiving irradiation only. While the histopathological changes in the hyperthermia and the control groups were different, no specific reaction has been identified as being a hyperthermia-induced one.

0475 INTRALUMINAL MICROWAVE HYPERTHERMIA IN THE COMBINED TREATMENT OF ESOPHAGEAL CANCER: A PRELIMINARY REPORT OF 103 PATIENTS. (Eng.) Li, D. J. (c/o G. M. Hahn, Div. Radiobiology Research, Dept. Radiology, Stanford ford Univ. Sch. Medicine, Stanford, CA 94305); Wang, C. Q.; Qiu, S. L.; Shao, L. F. Natl Cancer Inst Monogr 61:419-421; 1982 (5 refs).

Preliminary results of treatment of 103 patients esophageal cancer using intraluminal microwave hy thermia and surgery (10 patients) or hyperthermia radiation (93) are reported. Tumor size was 5 c less (36 patients), 5-8.9 cm (74), 9-15 cm (11). mors were localized by endoscopy or fluoroscopy. perthermia was induced with a 6-mm diameter micro antenna with an active length of 105 and 157 mm. antenna was 3-4 cm longer than the tumor. Treat temperature was above 43 C. Most patients under treatment without discomfort when the esophageal perature was 43 C; they felt warm but had no pai 45 C. At surgery, a hyperemic zone on the outer of the esophagus and pleura was seen; extensive, s round cell infiltration with stenosis and obliter of blood vessels in the muscular layer of the rese specimens were indicative of the effectiveness of hyperthermic treatment.

0476 COMBINATION OF HYPERTHERMIA WITH RADIA IN THE TREATMENT OF CANCER. I. PRELIMI REPORT ON TWENTY-FOUR PATIENTS. (Eng.) Shen, R (Dept. Radiotherapy, Montefiore Hosp. and Medical ter, 111 E. 210 St., Bronx, NY 10467); Wu, H.; W J.; Ku, H. Natl Cancer Inst Monogr 61:423-425; (3 refs).

Preliminary clinical results in 24 patients with vanced cancer treated with 2450 MHz hyperthermi radiation therapy (2000-5000 rad) following hy thermia are reported. In most hyperthermia tr ments, tumor temperatures reached 43 C or more. serious acute complications of hyperthermia were served. An objective response was seen in 20/24 tients and 23/24 had subjective pain relief. Se al complete tumor regressions were seen. The res suggest that hyperthermia enhanced the radiation sponse.

0477 MODERATE WHOLE-BODY HYPERTHERMIA IN CO NATION WITH CHEMOTHERAPY IN THE TREAT OF SMALL CELL CARCINOMA OF THE LUNG: A PILOT ST (Eng.) Neumann, H. (Medizinisches Universitatsk ik, Hugstetterstrasse 55, D-7800 Freiburg, W. many); Fabricius, H-A.; Engelhardt, R. Natl Ca Inst Monogr 61:427-429; 1982 (19 refs).

Chemotherapy was combined with moderate whole body perthermia (WBH) to treat 18 patients with small carcinoma of the lung. A Siemens unit, which cons of a Plexiglas cabin preheated with warm air up to 60 C, was used to induce WBH. The patient rested mattress in which a coil field electrode is conne to a 27-MHz generator. The target temperature (± 0.5 C) was reached in 40-60 min; iv injection adriamycin and vincristine were given at the sele treatment temperature which was maintained for 1 WBH was administered 1 to 5 times per patient in

1 of each 3-wk chemotherapy cycle. Complete remission was seen in 9/18 patients, partial remission in 7, and no response in 1; 1 patient with progressive disease was exposed to WBH only once and was resistant to chemotherapy and radiotherapy. No cardiopulmonary complications, metabolic disturbances, skin burns, neurological lesions, or excessive bone marrow suppression were seen after treatment. There was no evidence of further distribution or stimulation of growth of established metastases during combined treatment. The procedure was well tolerated and appeared to be safe. Preliminary data concerning duration of remission appeared to be encouraging: 8/13 stage C patients treated were in remission at 5 to 28 mo after treatment (most between 7-9 mo) vs. an average of 6-8 mo for patients treated with chemotherapy alone.

0478 TEMPERATURE-CONTROLLED CAVITY SYSTEM FOR MICROWAVE IRRADIATION OF CULTURE CELLS IN VITRO. (Eng.) Vaguine, V. A. (c/o McEuen, Radiation Div., Varian Associates, Palo Alto, CA 94303); Giebeler, R. H.; Tanabe, E.; McEuen, A.H.; Hahn, G. M.; Sapareto, S. A.; Li, G. C. Natl Cancer Inst Monogr 61:457-460; 1982 (6 refs).

The effects of 400-1000 MHz electromagnetic fields on cell cultures were investigated under controlled temperature using a cylindrical reentrant radiofrequency (RF) applicator. The RF applicator is in the form of a cylindrical reentrant cavity, which is similar in structure to a shorted section of coaxial cable line, with a narrow gap introduced in the center conductor near one end. The cavity can be tuned to resonance by varying its length; for the frequency range of 400-1000 MHz, the length is nearly a half wavelength (15-35 cm). Microwave power is coupled into the cavity either by the coupling loop in the floor or by a capacitive probe inserted through the sidewall near the top of the cavity. With 60-80 W of input power, the power density in the sample is 135 to 185 W/cm^3; peak electric field intensity in the sample is about 150 V/cm. The temperature of the sample holders is regulated by circulating water. The experimental setup for the temperature controlled RF irradiation system includes an RF power signal source with a frequency range of 0.2-3.0 GHz, and a maximum output power of 90 W. The system provides differential cooling for the culture medium, which is contained in the RF applicator cavity. This technique offers several advantages over previously published methods with respect to absorbed power density, accuracy of temperature control and measurement, and efficiency.

0479 MICROWAVE DIRECT-CONTACT APPLICATOR SYSTEM FOR HYPERTHERMIA THERAPY RESEARCH. (Eng.) Vaguine, V. A. (c/o McEuen, Radiation Div., Varian Associates, Palo Alto, CA 94303); Tanabe, E.; Giebeler, R. H.; McEuen, A. H.; Hahn, G. M. Natl Cancer Inst Monogr 61:461-464; 1982 (3 refs).

A direct-contact applicator system, designed as a venient instrument for microwave hyperthermia th research at 430 MHz on large laboratory animals described. Three dielectric-loaded cylindrical plicator heads provide a range of field sizes f to 48 cm in diameter with the use of removable fr The polarization of the emitted radiofrequency field can be varied continuously from linear to cular. Coolant is circulated through a thin ch on the front surface of the applicator; the su In contact with the body is a thin flexible mem that conforms closely to the skin contour. T power is generated by an electronically tuned osc tor driving a 200-W solid state amplifer and del energy at 430 MHz. Analysis of the heating pa produced in a static muscle phantom indicated the maximum temperature occurred about 1.5 cm the surface, with the 50% maximum temperature po cm below the surface. Maximum measured leakage power level of 100 W under the worst possible c tions (with the applicator unterminated) was <0. cm^2 at a distance of 1 m.

0480 HYPERTHERMIA INDUCTION BY 27-MHz RADI QUENCY IN CANCER THERAPY. (Eng.) Mend J. (Dept. Radiotherapy, Montefiore Hosp. and Me Center, Bronx, NY 10467); Friedenthal, E.; Bots C.; Sterzer, F.; Paglione, R. Natl Cancer Inst M 61:465-468; 1982 (4 refs).

Experimental and clinical trials to induce hyper mia in deep-seated tumors with 27-MHz ridged wave applicators are described. The open end of the is covered with a rubber membrane, and the gui filled with deionized water which serves to reduc overall size of the applicator. The inside of th plicator is divided into Plexiglas compartments permit placing the applicator in a horizontal tion without danger of rupturing the membrane. gy is introduced from a 27-MHz generator with a able power output (0-500 W). Reflections of 2 power back into the coaxial input port are mini by the use of two capacitive tuners. The appli is inserted into a specially constructed trea table. A saline-filled bag with an adjustable tral aperture is placed on the surface of the a cator to circumscribe the area to be heated. ing patterns were determined in pig muscle with mal blood circulation and in an artificial recta mor in a dog. Patients with advanced tumors tha included primary carcinoma of the uterus, metas carcinoma of the scapula from a primary lung c noma, and carcinoma of the prostate underwent R hyperthermia in conconjunction with or followi course of radiotherapy. Varying degrees of pai lief were reported and no serious side effects noted.

0481 MICROWAVE APPLICATOR FOR HYPERTH

TREATMENT OF RETINOBLASTOMA. (Eng.) Lagendijk, J. J. W. (Dept. Radiotherapy, Univ. Hosp. Utrecht, Catharijnesingel 101, 3500 CG Utrecht, Netherlands). Natl Cancer Inst Monogr 61:469-471; 1982 (5 refs).

A special microwave (MW) applicator made of flexible silicone rubber was designed for hyperthermic treatment of retinoblastoma at 2450 MHz. Power is delivered by a low impedance microstripline that encircles the eye at a level just posterior to the lens. Only 20% of the power entering the stripline is absorbed in the eye; 80% leaves the stripline and is absorbed in the load, which generates a nearly uniform power absorption in the eye along the stripline. MW absorption distribution was measured in eye phantoms. A thermal, finite difference computer model of human and rabbit eyes was verified experimentally in rabbit eyes. Satisfactory temperature distributions were obtained (entire retina, 42 C; lens <39 C). The apparatus allows the entire retina and the vitreous body to be heated to therapeutic temperatures without heating the lens above 39 C, which is considerably lower than the cataractogenic temperature. Precise noninvasive measurement of temperatures in the eye is still a problem.

0482 HIGH-FREQUENCY TRANSMITTER FOR THE LOCALIZED HEAT TREATMENT OF THE PROSTATE GLAND. (Eng.) Petrowicz, O. (Inst. Experimental Surgery, Technical Univ. Munich, Ismaningerstrasse 22, D-8000 Munich 80, W. Germany); Scheiblich, J.; Crucius, A.; Erhardt, W.; Wriedt-Lubbe, I.; Ultsch, B.; Blumel, G. Natl Cancer Inst Monogr 61:473-476; 1982 (5 refs).

An apparatus consisting of a 433.9 MHz, 200 W generator and a water-cooled 12 mm x 40 mm cylindrical slot antenna for localized heat treatment of the prostate gland was investigated and the morphological changes induced by the irradiation were characterized. The cylindrical cover of the antenna was 20 mm in diameter and the temperature was lowered to 2-10 C by a cooling system so that the maximum heat generated on the applicator surface could be reduced. The prostate glands of 35 mature dogs were irradiated transrectally for 15-20 min by application of 35 to 75 W, resulting in temperatures of 41.5-48 C in the glands. Heat-induced damage of varying degrees to the rectum and surrounding tissues depended on the amount of power applied. Most of these effects could be eliminated by slight modifications of the transmitting and cooling system. It was concluded that power rates of 30-40 W and cooling temperatures of 2-3 C would result in effective local hyperthermia.

0483 MICROWAVE-INDUCED HYPERTHERMIA: AN EXPERIMENTAL ADJUNCT FOR BRAIN TUMOR THERAPY. (Eng.) Samaras, G. M. (Neuro-oncology Res. Labs., MSTF6-34, Dept. Radiation Therapy and Div. Neur cal Surgery, Univ. Maryland Sch. Medicine, 10 S St., Baltimore, MD 21201); Salcman, M.; Cheung, Abdo, H. S.; Schepp, R. S. Natl Cancer Inst 61:477-482; 1982 (7 refs).

A miniature, implantable microwave (MW) anten thermotherapy system was used for interstitial ing in cat and human brain. Adult cats were e to 2450 MHz radiation delivered by a surgical planted, flexible cable antenna. Heating and c in normal feline brain was rapid. Except in of altered blood flow or tissue necrosis, the h pattern was nearly radially symmetric. No rema physiologic alterations were observed during brain heating. While controlling rectal tempe and increasing temperature at the antenna up to no significant alterations in blood pressure, cranial pressure, or EKG were seen. Pupillar remained unchanged. Histological examination c and MW-heated brain showed no significant diffe in both, surgical edema was present probably antenna insertion. For the most part, the resu human implantation were similar to those obtai animals. Monitored arterial blood pressure, cranial pressure, and EKG were virtually unc during the 30 min of heating in the operating and subsequent 60-min heating sessions 6 and later. Studies of the physical performance and iological impact of focal MW heating in the for suggest that the implantation method is techn feasible and a relatively simple method for gli toma treatment.

0484 SYSTEM FOR PRODUCING LOCALIZED HYPERT IN TUMORS THROUGH MAGNETIC INDUCTIO ING OF FERROMAGNETIC IMPLANTS. (Eng.) Stauff R. (Div. Radiation Oncology, Dept. Radiology, Arizona Health Sciences Center, Tucson, AZ Cetas T. C.; Jones, R. C. Natl Cancer Inst 61:483-487; 1982 (6 refs).

A magnetic induction heating system was devel heat small ferromagnetic seeds surgically or tactically imbedded in deep seated tumors. In field frequencies of 1.9 MHz (power, 65 and 4.0 MHz (175 W), and 2.0 MHz (200 W) were used static and dynamic tissue equivalent phantoms, muscle, and canine muscle in vivo, respectivel uniform temperature distributions seen in cat muscle agreed with results obtained in the ph The data indicated that implant temperature entials can be maintained within 1.5 x that throughout the implanted region, regardless sue inhomogeneities. Implant arrays consistin 2 mm stainless steel rods combined excellent characteristics in a 1.5-4.0 MHz magnetic in field with long-term biocompatibility. Power 300 W was sufficient to raise an implantable re any size to therapeutic temperatures safely than 10 min.

0485 EVALUATION OF AN INVASIVE MICROWAVE ANTENNA SYSTEM FOR HEATING DEEP-SEATED TUMORS. (Eng.) Strohbehn, J. W. (Thayer Sch. Engineering, Dartmouth Coll., Hanover, NH 03755); Trembly, B. S.; Douple, E. B.; de Sieves, D. C. Natl Cancer Inst Monogr 61:489-491; 1982 (6 refs).

A mathematical model was developed to predict temperature distributions for a multiple antenna system in which numerous small microwave (MW) antennas are inserted into tissue or tissue phantom through hypodermic needles. A single MW source attached to a power splitter usually feeds all the antennas simultaneously. A heat equation based on a two-dimensional model that ignores heat flow along the axial direction of the antennas was solved by the Alternating Direction Method. Blood flow and metabolic effects were not included in the model. Isotemperature contours were calculated and plotted for a frequency of 1.0 GHz, and antenna circles with a radius of 1.414, 2.12, and 2.828 cm, and 3-5, 4-6, and 4-8 antennas, respectively. For an antenna circle with a radius of 1.414 cm and 4 antennas, temperature reached therapeutic levels (42-45 C) within 15 min; the diameter of the heating volume was 3 cm. Five and eight antennas, respectively, were required to produce 4 and 7 cm heating volumes within 15 min.

0486 DEEP HEATING OF CYLINDRICAL OR ELLIPTICAL TISSUE MASSES. (Eng.) Turner, P. F. (BSD Medical Corp., 420 Chipeta Way, Salt Lake City, UT 84108). Natl Cancer Inst Monogr 61:493-495; 1982 (3 refs).

A new technique for producing uniform heating to the center of large tissue masses, i.e., thorax and abdomen, is described. The prototype BSD applicator is an annular phased array composed of radiating apertures operated in the transverse electromagnetic (EM) mode. The patient lies inside a central opening; a water-filled bolus or bladder placed between aperture walls and patient improves energy coupling, stray-field level, and surface-temperature control. The radiation field of the array is a cylindrically convergent transverse EM wave with the electrical field polarized along the cylindrical axis. Measured cylindrical cross-section heating patterns in a homogeneous muscle-equivalent phantom are shown. Temperature rise during rapid heating was monitored at 31 positions within the phantom. Some nonsymmetry was observed attributed in part to the phantom's elliptical shape. Heating experiments with the annular phased array were conducted on a 240-pound pig with chest and pelvic dimensions similar to those of an adult man. A therapeutic temperature of 42.5 C was maintained for 30 min 3-4 cm deep in chest and abdominal regions. No resulting ill effects were observed in the animal for 6 days following the treatment. The animal was then killed to study heating patterns in the absence of blood circulation. The thoracic heating pattern (794 W for 9.8 min) showed heating in the esophageal region to be twice that of ti outside the rib cage. In the central lung area heating rate was 1.2 times that of the outer tis Rapid heating (2,000 W for 10.7 min) of the pelvi sulted in a uniform pattern. The lowest central perature rise was 70% of the maximum at 3 cm depth is concluded that therapeutic heating can be ach even in deep tumor sites.

0487 HYPERTHERMIA INDUCTION BY AN ARRAY OF SIVE MICROWAVE ANTENNAS. (Eng.) Tre B. S. (Thayer Sch. Engineering, Dartmouth Hanover, NH 03755); Strohbenn, J. W.; de Sieve C.; Douple, E. B. Natl Cancer Inst Monogr 61:497 1982 (3 refs).

Temperature distributions produced by an array of insulated antennas radiating at 2 GHz were mea in brain phantom, human brain at autopsy, and tissue of a living dog. A 3-cm (side length) was used for the cadaver and dog tissue, and 2- and 4-cm arrays were used in the phantom. The required for the temperature to reach therap range increased rapidly with increase in array thus square arrays (i.e., 4 antenna arrays) of gr than 3 cm/side may not be clinically useful. Alt heating a cadaver brain was similar to heating phantom, blood flow in living tissue greatly incr the power required to produce therapeutic tem tures. Steady-state power levels needed to mai a 6.5 C antenna temperature were 7.5 W for pha 10 W for cadaver, and 20 W for living dog mu

0488 DOSIMETRY OF INTERSTITIAL THERMORADIOT PY. (Eng.) Cetas, T. C. (Div. Radi Oncology, Dept. Radiology, Univ. Arizona Health ences Center, Tucson, AZ 85724); Hevezi, J. M.; ning, M. R.; Ozimek, E. J. Natl Cancer Inst Mo 61:505-507; 1982 (5 refs).

The dosimetry involved in one method of prod combined insterstitial heat and radiation treat for accessible tumors is described. The tech employs a modified electrosurgery unit (500 kHz) an appropriate matching network as a power sour conventional catheter-mounted thermistors with a ital multimeter for thermometry. An array o gauge hollow needles is inserted through a Plex template into the tissues (up to 15 cm deep) so the tumor volume is encompassed. The array, d mined by the template, can be either of circul rectangular symmetry. Thermistors also are ins through the template. Radiofrequency power i plied to heat resistively the tissue between the dle electrodes. A typical treatment is 44 C f min. Following the heat treatment, the needle after-loaded with ^{192}Ir seeds. The thermal do determined from temperature measurements and com

with analytical and phantom models which use measured thermal and electrical parameters. Computed radiation isodose curves are based on actual seed locations determined from the needle arrangement and from orthogonal projection radiographs. It is concluded that interstitital thermoradiotherapy is safe and effective for treating patients with advanced local disease.

0489 THERMAL DOSIMETRY DURING HYPERTHERMIA. (Eng.) Ozimek, E. J. (General Products Div., IBM Corp., 748/061-2, Tucson, AZ 85744); Cetas, T. C. Natl Cancer Inst Monogr 61:509-512; 1982 (6 refs).

Maximum therapeutic benefit from hyperthermia in cancer treatment requires knowledge of temperature profiles throughout the heated tissue volume. The bioheat equation relates internal energy change rates to heat generation and dissipation processes. Energy deposition and subsequent temperature distribution can be predicted if electrical conductivity and permittivity and effective thermal conductivity are known. The in vivo thermal properties of various normal tissues in laboratory minipigs as well as in humans were measured. Temperatures were measured with calibrated thermistor probes at several points in tissues heated with microwave and with water bath techniques, and the results were incorporated in a numerical solution of the bioheat equation. Temperature profiles determined for minipig thighs heated at 2,450 and 915 MHz showed good agreement between measured and predicited temperatures; blood flow was the only adjustable parameter. At 2,450 MHz, the tissue blood perfusion rate yielding the best tmeperature depth profile agreement was 0.0010 g of blood/cm^3 of tissue/sec.

0490 THERMAL DOSIMETRY SYSTEM WITH BLOOD FLOW SIMULATION. (Eng.) Sandhu, T. S. (Div. Radiation Oncology, Univ. Utah Coll. Medicine, Salt Lake City, UT 84132). Natl Cancer Inst Monogr 61: 513-515; 1982 (7 refs).

A dynamic phantom system was developed for studying temperature distributions produced by external heat sources in tissue-equivalent materials under different blood flow conditions. The system is designed for use with noninvasive heat transducers, such as direct-contact, microwave waveguide applicators or ultrasound transducers. The dynamic phantom consists of a Plexiglas chamber divided into three compartments: the top compartment is filled with liquid maintained at 37 C to simulate in vivo conditions; the second contains foam through which the liquid flows; and the third is a thermal insulator. Thermocouples measure temperature at different points in the foam. Flow is simulated in one direction (along the positive x-axis), but temperature distributio the presence of counter flow can be obtained by manipulation. Measurements at three flow rates 200, and 300 ml/min) were made for a 915-MHz appl tor (35 W for 5 min). The zero flow curve show slight assymmetry due to heat conduction to the c ber's lower portion, whereas the liquid tempera was kept at 37 C. At significant flow rates, temperature position was depressed (positive x di tion), and temperatures beyond the applicator di sions were significantly greater than 37 C. U counter flow conditions, temperature distribut were significantly altered near edges of the appl tor field. At depths of 1 cm or greater from applicator face, there was a decrease in tempera but no change in the pattern. Limitations of system are summarized.

0491 PULSED MICROWAVE THERMOMETRY: AN ALGOR FOR THERMAL PERTURBATION. (Eng.) Los D. D. (Section Medical Physics, Marshfield Cli Marshfield, WI 54449). Natl Cancer Inst Monogr 517-520; 1982 (no refs).

A pulsed microwave (MW) diathermy system that ordinary thermistor temperature sensors is presen Temperature signals from the thermistor sensors sampled under computer control during the "off" s of the pulsed MW generator. These temperature nals are compared with the desired temperature, the duty cycle of the microwave generator is adju to yield regulation about the preset temperat Because blood perfusion produces rapid coolin locally heated tissue, the computer has been grammed to produce a MW pulse lasting from 0 to msec once each second. A residual perturbatio the temperature signal often interferes with measurement during this short period. The natur this residual perturbation was investigated by an sis of the temperature signal from a thermistor p placed in a piece of plastic tubing through which ter at a constant temperature was flowing. Alt tions of the temperature signal could in this ma be attributed solely to the microwave perturbatio the sensor and not to MW heating of the environ Perturbation magnitude increased with length energy of the pulses. The perturbation decayed ponentially with a time constant that was indepen of pulse length but that increased with water rate through the tubing. The computer algorithm sented herein in conjunction with sufficiently thermistor probes may enable pulsed temperature surements with a wider variety of microwave equip and clinical situations.

0492 COMPUTER SOLUTION FOR APPLICATOR HEA PATTERNS. (Eng.) Turner, P. F. (BSD ical Corp., 420 Chipeta Way, Salt Lake City 84108); Kumar, L. Natl Cancer Inst Monogr 61:

523; 1982 (4 refs).

A mathematical solution is presented to the problem of predicting heating patterns in tissue located in a microwave applicator's near-field region. The solution was used to obtain information regarding the effects of frequency, applicator size, aperture field distribution, and low-loss bolus materials on penetration depth and heating patterns. The model solution was extended to both flat surface and cylindrical apertures and to a new array aplicator. Heating patterns were predicted for each at many different frequencies. A significant finding was the limited penetration depth of radiative applicators. By correcting for non-homogeneous losses, reflection, and refraction, accurate power absorption rate predictions can be obtained for living systems. When coupled with the blood heat-flow dynamics of the body, temperature rise can be predicted.

0493 RAPPORTEUR SESSION: HEATING TECHNIQUES. (Eng.) Durney, C. H. (Depts. Electrical Engineering and Bioengineering, Univ. Utah, Salt Lake City, UT 84112). Natl Cancer Inst Monogr 61:525-528; 1982 (no refs).

Basic problems and the state of the art in hyperthermia production and measurement techniques and the contributions presented at the Third International Symposium: Cancer Therapy by Hyperthermia, Drugs, and Radiation held at Colorado State University, Ft. Collins, Co, June 22-26, 1980 (National Cancer Institute Monograph 61) are summarized. The material presented is based on a summary presented by the author in a session devoted to discussion of the poster papers on heating techniques and on the resulting discussion by the audience.

0494 THE FUTURE OF HYPERTHERMIA. (Eng.) Tubiana, M. (Dept. Radiation, Institut Gustave-Roussy, 16 bis avenue Paul-Vaillant Couturier, 94800 Villejuif, France). Natl Cancer Inst Monogr 61:539-543; 1982 (19 refs).

Differences in response to heat of human tumors are a major obstacle to thermotherapy progress. Xenografts of human tumor in nude mice or preferably in nude rats may provide an effective tool for the study of those biological factors which may influence the effect of heat on a tumor or a normal tissue. Probably, physical factors are the most important sources of difference. The development of a unit dose embodying the amount of heat transferred to the tissues as well as quality factors is a goal for the future. However, the relationships between heating time and temperature required to produce various biological effects are open to discussion, and presently there is no substitute to the recording of both temperature time. The search for optimal scheduling req knowledge of dose-effect relationships for both mal tissue tolerance and tumor regression. The velopment of small size probes and of noninv thermodosimetry is a prerequisite for wides clinical use of hyperthermia. Heat alone consti an important modality of hyperthermia but its u routine palliative therapy is still unwarra Treatments should be aimed at the identificatic those tumor types which are responsive to hypert fa, and they must be considered as clinical inv gations conducted within controlled clinical tr Attention should be given to the reporting of he techniques. The rate of heating must be prec stated. For each patient, the spatial and tem temperature distributions must be given as wel the method used for temperature monitoring. tumor should be described precisely and the trea effects assessed quantitatively both on tumor normal tissues. Immediate as well as late sid fects should be recorded. Treatment by heat also provides a good opportunity for assessmer the effects of manipulation of pH or of blood Enhancement by heat of radiation effects is crit ly dependent on the time and sequencing. For a terval between heat and radiation of 1 hr or hours, potentiation is obtained. At 24 hr, the logical effects of the two modalities are indepe and purely additive. The combination of heat an radiation has been used mainly for palliative t ment of large inoperable tumors or for metast As soon as an adequate temperature monitoring s is available, controlled trials on potentially able tumors can begin. Hyperthermia shows syne with many drugs for both normal and neoplastic c Because heat has no harmful effects on bone ma it could be delivered between chemotherapy c when leukopenia and thrombopenia prevent ext radiotherapy. Even when chemotherapy is com with local radiotherapy, hyperthermia might reduction of the radiation field and/or dose.

0495 CHANGES IN BLOOD COAGULATION AFTER SURGERY AND EXPOSURE TO A CONSTANT MAG FIELD. (Rus.) Novikov, Iu. A. (Dept. Hosp. Sur Medical Inst., Ivanovo, USSR). Anesteziol Reani (3):21-23; 1982 (4 refs).

Potentially favorable effects of postoperative sure to a constant magnetic field (CMF) were st in 184 patients (146 men, 38 women; 30-60 yr old) jected to lobectomy or pneumonectomy. The pat were divided into two groups: Group 1 (130 pati received conventional postoperative analgesia narcotic substances, while Group 2 (54) receive plications of 2-3 magnetic plates at the site o surgical incision and on the thoracic region o spinal column. CMF produced pain relief in 4 the patients. Tests of blood coagulation showed ed inhibition of fibrinolysis with simultaneous vation of blood coagulation in Group 1. The

ents in Group 2 showed normalization of the heparin level, fibrinolytic activity, and time of thromboplastin formation. Improvement of blood coagulation indices was not correlated with the analgesic effect of CMF. It was concluded that the negative charge acquired by the blood-formed elements after exposure to CMF maintains them in a suspended state and prevents sequestration and sludging.

0496 MORPHOLOGICAL CHARACTERISTICS AND THE MECHANISM OF BIOLOGICAL EFFECTS OF MAGNETIC FIELDS. (Rus.) Toroptsev, I. V. (Dept. Pathology, Medical Inst., Tomsk, USSR); Taranov, S. V. Arkhiv Patologii 44(12):3-12; 1982 (96 refs).

Literature data on the mechanism of biological effects of magnetic fields are reveiwed. Numerous studies confirmed the greater biological activity of alternating and pulsed magnetic fields compared with constant magnetic fields. Biological parameters of magnetic fields include the intensity, gradient, direction of the vector, duration of exposure, and frequency. Even short-term exposure to magnetic fields was shown to produce marked morphological changes in the nervous and endocrine systems. Morphological changes in the cardiovascular system after exposure to magnetic fields were characterized by circulation disorders, increase in capillary permeability, development of interstitial edema, dystrophy, and necrosis of vascular walls. Exposure to weak and moderate magnetic fields (intensity of 20 to 7,000 Oe) produced swelling of Kupffer cells, increase in the proliferative pool and mitotic activity of enterocytes in the small intestine, and increase in the metabolic activity of liver and small intestine cells. The mechanism of biological action of magnetic fields is associated with primary interactions between the magnetic field and the biological substance, reception by the biological object of the magnetic field, and response of the biological object to the magnetic field.

0497 MAGNETIC SUSCEPTIBILITY OF SINGLE HUMAN ERYTHROCYTES. (Rus.) Kondorskii, E. I. (Physics Dept., M. V. Lomonosov State Univ., Moscow, USSR); Norina, S. B.; Litvinchuk, N. V.; Shalygin, A. N. Biofizika 26(6):1104-1106; 1981 (8 refs).

A method of measuring the magnetic susceptibility of isolated human erythrocytes is described. The movement of erythrocytes in a hetergeneous magnetic field of thin ferromagnetic wire (8×10^9 A^2/m^3) was monitored by a specially designed movie camera. Analysis of the distribution of erythrocytes and the relationship between the magnetic susceptibility and the velocity of erythrocytes showed that the magnetic susceptibilities of erythrocytes containing methemoglobin, deoxyhemoglobin, and oxyhemoglobin were $(0.54 \pm 0.05)/10^6$, $0.46 \pm 0.050/10^6$, and $(-).75 \pm 0.05)/10^6$, respectively.

0498 MAGNETIC SUSCEPTIBILITY OF RHODOSP (Rus.) Vilenchik, M. M. (Inst. Biologi Physics of USSR Acad. Sciences, Pushchino, Moscow gion, USSR). Biofizika 27(1):31-36; 1982 (31 ref

To test the hypothesis that the physical mechanism biological effects of a constant magnetic field is sociated with the anisotropy of magnetic susceptib ity of protein molecules, the anisotropy of rhodop molecules in photoreceptor membranes was calculat Assuming that the anisotropy of rhodopsin is det mined by orientation of aromatic amino acids and p tide bonds, it was calculated that the majority the external segments of the retina were orien along the force lines of the magnetic field with intensity of approx. 80 Oes (6.4×10^3 A/m). Du tion of the orientation of the external segment the frog cone was approximately 10 sec for a field intensity of 8×10^5 A/m and approximately 24 hr fields of threshold intensity (6.4×10^3 A/m). tential applications of the observed orientation protein molecules in constant magnetic fields incl cancer chemotherapy (administration of liposomes c taining an antineoplastic agent and feromagnetic fi er) as well as inhibition of tumor growth in the m netic anisotropy of membrane proteins from normal tumor cells.

0499 EFFECT OF HIGH-FREQUENCY ELECTROMAGNE FIELDS ON TETRAPHENYLBORATE TRANSP THROUGH BILAYER LIPID MEMBRANES. (Rus.) Alekse S. I. (Inst. Biological Physics, USSR Acad. Scienc Pushchino, Moscow Region, USSR); Tiazhelov, V. Faizova, L. Kh.; Chertishchev, V. V. Biofizika (1):162-163; 1982 (8 refs).

The effects of high-frequency electromagnetic fie (0.9 GHz) on the transport of tetraphenylborate (T ions through the bilayer lecithin membrane were st ied in sodium chloride solution. TPB transport established by changes in the saturatin current. increase in the membrane saturation current was p portional to the electrolyte concentration and to specific absorbed power (up to 200 W/kg), and did depend upon TPB concentration (within a 10^{-4}-10^{- range). The increase in the electrolyte temperat by 10 C resulted in a 1.8-fold increase in the satu tion current. These findings indicated that the fects of high-frequency electromagnetic fields w associated with local heating of the electrolyte la adjacent to the membrane.

0500 THE ABSENCE OF EFFECT OF MAGNETIC FIE ON SODIUM, POTASSIUM ION-DEPENDENT ATPA

(Rus.) Savich, M. L. (Res. Inst. Biological Testing of Chemical Compounds, Kupavna, Moscow Region, USSR); Shcheglova, M. V.; Raikhman, L. M.; Kuznetsov, A. N. Biofizika 27(3):532-533; 1982 (8 refs).

To evaluate the direct effects of magnetic fields on sodium, potassium ion-dependent ATPase, the membrane preparation of enzyme isolated from bovine brain was exposed to an electromagnetic field (EMF) with inductance of up to 1,500 mT. The experiments were conducted at 15 C, 20 C, and 37 C. Sodium, potassium ion-dependent ATPase activity was estimated by the amount of released inorganic phosphate. Duration of exposure was 15 min. Exposure to EMF did not affect enzyme activity, Michaelis constant for ATP, activation constants for sodium and potassium ions, or Hill coefficients for ATP and ions. It was concluded that EMF with inductance of up to 1,500 mT had no direct effect on isolated enzyme preparations, and that the changes in active transport after exposure to EMF were associated with the effect on regulators of sodium, potassium ion-dependent ATPase.

0501 MECHANISM OF MICROWAVE EFFECT ON CONDUCTANCE OF BILAYER LIPID MEMBRANES. (Rus.) Alekseev, S. I. (Inst. Biological Physics, USSR Acad. Sciences, Pushchino, Moscow Region, USSR); Chertishchev, V. V.; Kim, Iu. A. Biofizeka 27(3):545-546; 1982 (7 refs).

The effects of microwave radiation (MW) on the conductance of modified bilayer lipid membranes (BLM) were studied. Changes in the conductance of BLM modified with amphotericin B, gramicidin C and tetraphenylborate showed a linear relationship with the specific absorption rate (SAR) and was proportional to the changes in the temperature. Temperatures of the BLM equivalent to the changes in the conductance after exposure to a SAR of 200 W/kg were 7.2 C for BLM membranes modofied with amphotericin B, 6.3 C for gramicidin C-modified BLM, and 6.2 C for tetraphenylborate-modified BLM. It was concluded that the mechanism of MW effects was associated with local heating of BLM.

0502 NONTHERMAL EFFECT OF EXTREMELY HIGH FREQUENCY PULSES OF NANOSECOND DURATION ON TRANSEPITHELIAL TRANSPORT OF SODIUM IONS. (Rus.) Deviatkov, N. D. (Inst. Radio Engineering and Electronics of USSR Acad. Sciences, Moscow, USSR); Chernov, Z. S.; Betskii, O. V.; Novskova, T. A.; Putvinskii, A. V. Biofizika 27(3):552-554; 1982 (5 refs).

Nonthermal effects of pulsed microwave (MW) radiation on the transepithelial transport of sodium ions were studied in isolated frog skin. The MW source was a NS generator(10 nanosec pulses, peak power 30 mW, and 3 cm wavelength). Exposure of skin specimens t pulses resulted in reversible activation of s transport. The increase in the transepithelial um transport could be associated with the increa sodium, potassium-dependent ATPase as well as the crease in membrane permeability.

0503 HYDROLYSIS OF GLOBULAR PROTEINS WITH T SIN IN A STRONG MAGNETIC FIELD. (R Nazarova, N. M. (Res. Inst. Biological Testin Chemica l Compounds, Kupavna, Moscow Region, US Livsnits, V. A.; Anzin, V. B.; Veselago, V. G.; netsov, A. N. Biofizika 27(4):720-721; 1982 (8 re

To evaluate possible physico-chemical mechanism biological effects of magnetic fields, hydrolysi various globular proteins with trypsin was studie a strong (up to 10 T) magnetic field. Incubatic trypsin with serum albumin or with methemoglobin sulted in an approximately 48% yield of the hydrol products. Kinetics of hydrolysis after exposure magnetic field with inductance of 1.4 or 10 T dic differ from that in control. The magnetic field did not affect the rate of proteolysis with the of immobilized trypsin. These findings indicated strong magnetic fields had no effect on the kine of hydrolysis of globular proteins.

0504 THE ABSENCE OF EFFECT OF A MAGNETIC F ON OXYGEN SOLUBILITY IN AQUEOUS SOLUTI (Rus.) Ushakova, T. V. (Res. Inst. Biological T ing of Chemical Compounds, Kupavna, Moscow R USSR); Livshits, V. A.; Kuznetsov, A. N. Biof 27(5):757-761; 1982 (10 refs).

To evaluate whether the potential mechanism of bi gical activity of magnetic fields (MF) is associ with changes in solubility or molecular mobilit paramagnetic oxygen the rate of oxygen solubilit distilled water or in an aqueous solution of s chloride was studied. Exposure of solutions to manent MF with inductance of 0.35 T did not ch oxygen solubility in distilled water or in the e trolyte solution. The absence of an effect on o solubility was observed for both homogeneous and terogeneous MF with gradient of 10 T^2/m. These f ings indicated that the MF of an order of 1 T not alter the rate of solubility and the coeffici of oxygen diffusion.

0505 SCAR BASALOMA FOLLOWING MIRCOWAVE THER (Ger.) Ipoen, H. (Universitats-Hautkli 3400 Gottingen, W. Germany). Derum Beruf Umwel (2):60; 1982 (2 refs).

A 57-yr-old woman presented with a basal cell carcinoma which had developed in a burn scar on her back. The burn resulted from exposure of the metal hooks on her brassiere to microwave radiation during treatment 6 yr earlier. The patient was not aware that the burn had occurred until the following morning when she experienced slight discomfort. This case serves as a reminder that skin burns can be caused by therapeutic use of 10-300 MHz and 2450 MHz radiation if the skin comes into contact with metal during treatment.

0506 MAJOR RESEARCH ON THE BIOLOGICAL EFFECTS OF MICROWAVE RADIATION IN THE USSR (Rus.) Shandala, M. G. (Kiev, USSR); Rudnev, M. I.; Stolan, E. F.; Vinogradov, G. I. Gig Sanit (10): 4-7; 1981 (20 refs).

Studies of the biological effects of low intensity (1-1,000 uW/cm^2) microwave (MW) radiation conducted in the USSR are reviewed. Characteristic features of the Soviet investigations include prolonged (up to several mo), daily exposure (from several hr/day to 24 hr/day) of different animals with follow-up examinations for 1-3 mo after completion of the irradiation. Analysis of adaption reactions after exposure to MW indicate that power flux densities of 500 and 50 uW/cm^2 caused certain changes in the central nervous system and in the immune system, while MW at 10 uW/cm^2 stimulated adaptation reactions (subthreshold levels) and MW at 1 and 5 uW/cm^2 failed to induce any functional changes. Examinations of humans with occupational exposure to MW revealed functional and neurological changes. The incidence and severity of the observed changes depended upon the duration of exposure, the wavelength, and the type of electromagnetic field (pulsed or continuous).

0507 FUNCTION OF THE HYPOPHYSEAL-ADRENAL SYSTEM AFTER EXPOSURE TO DIFFERENT REGIMENS OF ALTERNATING MAGNETIC FIELDS OF INDUSTRIAL FREQUENCY. (Rus.) Udintsev, N. A. (Medical Inst., Tomsk, USSR); Moroz, V. V. Gig Tr Prof Zabol (12):54-56; 1982 (16 refs).

To determine the maximum permissible levels of exposure to alternating magnetic fields (AMF: 20 mT) of industrial frequency (50 Hz), albino male rats were subjected to either continuous AMF exposure (for a period of several sec to 7 days) or to interrupted AMF exposure (15 min/day or 6.5 hr/day for 7 days, or 15 min with 2-hr intervals between exposures). The effects of AMF were estimated by the functional activity of the hypophysealadrenal system. Continuous exposure to AMF resulted in increased blood levels of 11-hydroxyketosteroids, an increase in the levels of adrenocorticotropic hormone (ACTH) in the pituitary gland and in the blood, and in an increase of steroid levels in the myocardium. The effects of AMF during interrupted exposure depended upon the period and duration of exposure. Prolonged repeated sures (6.5 hr/day for 7 days) produced marked in tion of the corticotropic function of the pitu gland and of steroid hormone synthesis in the nal glands.

0508 ELECTRIC POWER TRANSMISSION LINES SOURCE OF ELECTROMAGNETIC FIELDS AN PROBLEM OF ENVIRONMENTAL HYGIENE. (Rus.) Duman Iu, D. (Res. Inst. General & Community Hygiene, USSR); Andrienko, L. G.; Gordynia, N. P.; Liubch S. A. Hygiene of Residential Areas (20):18-22; (no refs).

To evaluate the health hazards associated with tric power transmission lines, the biological ef of an industrial frequency (50 Hz) electric field studied in albino rats and human volunteers. Ch exposure of animals to electric fields with int ties of 5000, 2000, 500, and 100 V/m produced m changes in animal behavior, hyperemia of eye an sal mucosa, decrease in blood cholinesterase act and SH-group content, increase in urinary excr of 17-ketosteroids, inhibition of oxidative pho rylation, and changes in brain, myocardium, l kidney, and thyroid tissues. The minimum effe intensity after exposure for 24 hr/day for 4 m 1000 V/m. The minimum effective intensity aft hr/day exposure for 4 mo was 7000 V/m. Examin of human volunteers exposed to an electric fi hr/day for 1 mo demonstrated the safety of an i sity of 5000 V/m. It was recommended that the mum permissible exposure levels should be establ at the level of 0.5 kV/m for 24 hr/day exposu kV/m for short-term exposure (< 2 hr/day), and 1 m for sporadic exposure.

0509 EFFECT OF 50-Hz ELECTROMAGNETIC ON FORMATION OF COMPLEX CONDITIONED FLEXES IN ALBINO RATS. (Rus.) Bezdol'naia, (Res. Inst. General & Community Hygiene, Kiev, U Hygiene of Residential Areas (20):22-25; 198 refs).

Potential biological effects of electromag fields (EMF) of industrial frequency (50 Hz) wer vestigated in albino rats. The animals were subj to daily, 6-hr exposure to EMF of 20, 15, and 10 intensity for 4 mo. The effects of the EMF wer timated by the latent period of food-motor refle escape reaction. Exposure to 50-Hz EMF affecte interaction of stimulation and inhibition proc in the cerebral cortex. The changes in the laten riod of conditioned reflexes depended upon the i sity of EMF and the duration of exposure. Durin first mo of exposure, all animals showed elong of the latent periods, while during the third

exposure, only the rats exposed to 20 and 15 kV/m EMF showed significant decrease in the latent period.

0510 EFFECTS OF AN EXTREMELY HIGH FREQUENCY ELECTROMAGNETIC FIELD (2,375 MHz) ON VARIOUS FUNCTIONAL AND MORPHOLOGICAL PARAMETERS IN ONTOGENESIS. (Rus.) Shandala, M. G. (Res. Inst. General and Community Hygiene, Kiev, USSR); Rudnev, M. I.; Obukhan, E. I.; Akimenko, V. Ia.; Chernen'kii, N. N. Hygiene of Residential Areas (20):26-29; 1981 (5 refs).

Age-related characteristics of sensitivity to extremely-high frequency (EHF) electromagentic fields (EMF) were studied in young, mature, and old albino rats. The EHF EMF was generated by a Luch-58-1 apparatus (2,375 MHz, 50mW/cm^2). The animals were irradiated with the E-component of the EHF EMF. Exposure to EHF EMF produced marked physiological changes indictative of the stimulation or inhibition of the central nervous system. Old rats showed a marked increase in the threshold of galvanic skin response. Old rats also showed the greatest increase of rectal temperature (by 4.1 C, compared with 2.1 C and 3.9 C in young and mature rats, respectively). The effects of EHF EMF on the bone marrow included increase in lymphocyte count, release of neutrophils, and subsequent hyoplasia of immature precursors of granulocytopiesis. The hematopoietic changes in mature and old rats were more pronounced than those in young animals.

0511 IMMUNOLOGICAL AND HEMATOLOGICAL EFFECTS OF LOW-INTENSITY EXTREMELY-HIGH FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Vinogradov, G. I. (Res. Inst. General and Community Hygiene, Kiev, USSR); Gonchar, N. M.; Belonozhko, N. G.; Zhelezniak, A. A.; Vinarskaia, E. I. Hygiene of Residential Areas (20):29-33; 1981 (3 refs).

The effects of low-intensity microwave (MW) radiation on various immunological and hematological indices were studied in guinea pigs and in random-bred albino rats. The animals were subjected to daily MW irradiation (2,375 MHz, wavelength of 12.6 cm, power flux density of 500, 50, 10, 5, and 1 uW/cm^2; 7 hr/day, for 30 days). MW at 500 uW/cm^2 and 50 uW/cm^2 caused inhibition of the phagocytic function of the neutrophils, while MW at a lower power flux density produced stimulation of phagocytosis. MW at 500 and 50 uW/cm^2 caused marked inhibition of cellular immunity estimated by phytohemagglutinin-induced reaction of T-lymphocytes blast-transformation. MW at 50 uW/cm^2 induced formation of autoantibodies against the brain and liver. Cytochemical studies showed significant increase in glycogen content and alkaline phosphatase activity in the peripheral blood neutrophils of the animals exposed to MW at 10 and 50 uW/cm^2. MW at 500 uW/cm^2 resulted in a transient inhibition of neut phil cytochemical activity.

0512 HYGIENIC EVALUATION OF A 20-22 kHz ELECT MAGNETIC FIELD (ELECTRICAL COMPONEN (Rus.) Kochergin, S. M. (Res. Inst. General and munity Hygiene, Kiev, USSR). Hygiene of Resident Areas (20):33-36; 1981 (no refs).

To evaluate potential health hazards of 20-22 electromagnetic radiation emitted by an Elektror induction furnace (maximal intensity of 60 V/m recorded at a distance of 0.1-0.15 m from the of the furnace), random-bred albino rats were exp to an electric field of 5, 1, and 0.5 kV/m. The el tric field was generated by a parallel-plate capa tor. The animals were subjected to three exposure 180 and 45 min each. Exposure to the electric fi at intensities of 5 and 1 kV/m caused progressive hibition of cerebral cortex activity (increased tent period of conditioned reflexes, decreased sponse to a positive stimuli), decrease in respor to electric stimulation, decrease in muscular er rance, decrease in blood urea and nitrogen concent tions, decrease in cytochrome oxidase activity, crease in blood glucose level, decrease in liver cogen levels, and increase in ascorbic acid leve An electric field with an intensity of 0.5 kV/m fai to induce changes in the physiological and biochemi parameters tested. These findings indicated that intensity of 0.5 kV/m can be accepted as a maxi permissible exposure level.

0513 CONDITIONED REFLEXES IN ANIMALS EXPOSE LOW INTENSITY PULSED EXTREMELY HIGH QUENCY ELECTROMAGNETIC FIELDS. (Rus.) Zotov, S. (Res. Inst. General and Community Hygiene, K USSR). Hygiene of Residential Areas (20):36-39; (3 refs).

To evaluate the health hazards of modern radiolocat systems, albino rats were subjected to continuous posure to pulsed electromagnetic fields (EMF) wit 3-cm wavelength and intensities of 40, 25, and 10 cm^2. The biological effects of EMF were estimate the changes in formation of the conditioned food flex. Exposure to EMF at 40 uW/cm^2 resulted in gressive increase in the latent period of conditi reflex. EMF with intensities of 25 and 10 uW failed to induce significant changes in the format of food reflexes. These findings indicated that intensity EMF can have an unfavorable effect on central nervous system.

0514 COMPARATIVE CHARACTERISTICS OF THE BIOL

CAL EFFECTS OF 3-cm AND 8-mm ELECTROMAGNETIC FIELDS. (Rus.) Los', I. P. (Res. Inst. General and Community Hygiene, Kiev, USSR); Tomashevskaia, L. A.; Nikitina, N. G. Hygiene of Residential Areas (20):39-44; 1981 (3 refs).

The results of factor analysis of biological effects of 3-cm and 8-m electromagnetic fields (EMF: pulse duration of 1.2 usec, sample frequency of 800 Hz, bell-shaped pulses) are reported. Random-bred rats were irradiated 12 hr/day for 4 mo; the power flux densities were 5, 60 and 115 uW/cm^2 for 3-cm EMF and 60, 100 and 140 uW/cm^2 for 8-mm EMF. The biological activity of EMF was estimated by an integral D-parameter, which characterized the probability of normal functioning of an organism. The battery of tests conducted 1 mo after completion of EMF exposure included determinations of skin galvanic response, physical endurance, emotional stimulation, blood complement activity, plaque-formation, residual blood nitrogen concentration, cholinesterase activity, saturation of Fe-transferrin, cytochrome oxidase activities in liver and brain mitochrondria, succinate dehydrogenase activity in brain mitochondria, and ceruloplamin activity. Regression analysis indicated that 3-cm EMF produced more significant biological effects than 8-mm EMF. At an equal density and an equal duration of exposure, the 3-mm EMF were approximately sixfold more effective than the 8-mm EMF. These findings confirmed the biophysical data on the greater penetration of 3-cm EMF compared with that of 8-mm microwave radiation.

0515 EFFECT OF EXTREMELY-HIGH FREQUENCY ELECTROMAGNETIC FIELDS ON BACTERIA. (Rus.) Pedenko, A. I. (Dept. Nutrition, Hygiene and Microbiology, Inst. Public Nutrition, Kharkov, USSR); Belitskii, B. I.; Lerina, I. V.; Makeev, Iu. V.; Kutashev, V. N. Izv Vyssh Ucheb Zaved Pishchev Tekhnol (5):54-56; 1982 (no refs).

The sterilizing effect of extremely-high frequency (EHF) electromagetic fields (EMF) was studied in suspensions of various bacteria. The EHF EMF were created by a continuous wave GZ-10A 2375 MHz generator with output power of 3 W. The viability of the irradiated cultures was compared to those of heated and intact suspensions. The viability of an Escherichia coli suspension after 30 sec to 20 min exposure to EHF EMF was 2-3 x lower than that after conventional heating to 29-56 C. A complete sterilizing effect was achieved after 8-min exposure and a temperature of 46 C. A similar decrease in viability after exposure to EHF EMF was observed in cultured Staphylococcus, Pseudomonas aeruginosa and sporogenous Bacillus subtilis.

0516 ROLE OF POLARIZATION AND RESONANCE IN EVAL-

UATION OF BIOLOGICAL EFFECTS OF ELECTROMA NETIC RADIATION. (Rus.) Galkin, A. A. (no affil tion given). Kosm Biol Aviakosm Med 16(2):84-1982 (16 refs).

To provide a more correct approach to the evaluat of biological effects of electromagnetic radiati (EMR), the relationships between the absorbed d and polarization and resonance of the biological terials were analyzed. It was shown that a human b can be considered as a homogeneous ellipsoid of ro tion and that this model provides a sufficiently curate estimate of effective absorption surface. parameter of relative absorption coefficient was sh to reflect the resonant properties of absorbed EMR biological materials.

0517 EFFECT OF LOW-INTENSITY ELECTROMAGNE FIELDS ON HUMAN AND ANIMAL ERYTHROCYT (Rus.) Shabaev, V. P. (no affliation given). K Biol Aviakosm Med 16(3):91-92; 1982 (7 refs).

Biological effects of low-intensity electromagen fields (EMF) were studied in suspensions of human rat erythrocytes. The erythrocyte suspensions w stored in a lead housing that provided a 100-200-f reduction of the Earth's EMF. The effects of Ea EMF were estimated by oxygen concentration in Rin solution and by osmotic hemolysis. Erythrocyte s pensions stored in the shielding housing showed increase in oxygen content (by 8% compared with t in erythrocytes exposed to the Earth's EMF). Elect phoresis of erythrocyte extracts showed the pres of three protein fractions, compared with one fract in erthrocytes exposed to Earth EMF. It was sugges that the mechanism of the shielding effect is asso ated with changes in the structural characteris of intracellular and extracellular water.

0518 CONSTANT LOW-FREQUENCY ELECTRIC AND EL TROMAGNETIC FIELDS (BIOLOGICAL EFFECT, GIENE EVALUATION). (Rus.) Davydov, B. I. (no aff iation given); Karpov, V. N. Kosm Biol Aviakosm 16(5):18-25; 1982 (27 refs).

In an effort to establish the maximum permissible posure levels for atmospheric electric and elect magnetic fields, literature data on the biologi effects of low-frequency (LF) electromagnetic fie (EMF) are reviewed with special attention to the ex sures of airplane pilots. The degree of biologi activity of EMF is directly related to its frequen the integral power of all sources of radiation, re men of irradiation, duration of exposure, and the d tance from the source of radiation. The dosimet approach should be based upon relative biological fectiveness of absorbed energy for the entire sp

trum. Marked increase of the specific conductivity of biological tissues after irradiation with frequencies of 10^4-10^5 Hz can be explained by chain-like involvment of intracellular water into ion formation. The energy of electromagnetic radiation absorbed by biological tissues is transformed into thermal energy. For frequencies up to 10 MHz, the size of a human body is small compared with the wavelength, so that the human body can be considered as a homogeneous ellipsoid conductor. Calculation of the levels of irradiation with EMF at frequencies of up to 3 x 10^8 Hz indicated that exposure to natural sources of EMF is relatively safe.

0519 PHYSICAL FACTORS OF THE ENVIRONMENT AS A HYGIENIC PROBLEM. (Rus.) Shandala, M. G. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR). Vestn Akad Med Nauk SSSR (1):9-16; 1981 (23 refs).

Potential public health hazards of mechanical, thermal, optical, electric, magnetic, electromagnetic and ionizing environmental factors are briefly discussed, with special emphasis on establishment of maximum permissible exposure levels (MPEL). The biological effects of a static electric field included reduced sensitivity to various stimuli, reduced skin blood supply, and inhibition of the reduction-oxidative processes in the skin. The MPEL of static electrical fields after chronic exposure was recommended at 20 kV/m. Biological activity of microwaves at thermal (> 1 mW/cm2) and nonthermal levels included changes in the nervous, cardiovascular, and immunological systems. Prolonged exposure to an industrial frequency electromagnetic field (50 Hz) induced changes in the functional state of the central nervous system, endocrine system, cardiovascular system, and reproductive system. The MPEL for industrial frequency electromagnetic fields was recommended at < 1,000 V/m.

0520 BIOLOGICAL AND THERAPEUTIC EFFECTS OF MICROWAVES. (Rus.) Obrosov, A. N. (Central Res. Inst. Balneology and Physical Therapy, Moscow, USSR); Krylov, O. A. Vopr Kurortol Fizioter Lech Fiz Kult (2):1-8; 1982 (no refs).

Therapeutic applications and the mechanism of action of microwave (MW) radiation are reviewed. In Soviet literature, both decimeter-band waves (100-10 cm) and centimeter-band waves (10-1 cm) are classified as extremely-high frequency waves, while ultra-high frequency waves include only electromagnetic fields with a wavelength of 1-10 m. The effect of MW on biological materials includes a thermal component, which depends upon the power flux density, and a nonthermal or specific component. Most of the therapeutic applications of MW are based upon their thermal effects. MW are characterized by significant penetration and absorption in the tissues and the thermal effect: MW are measured by total or local specific absorp rates. Absorption of MW energy also depends upon orientation of the electric field, grounding, and flecting surfaces. Irradiation of animals that a system of active thermoregulation (dogs) was si to produce less marked increase in brain temperat than the irradiation of animals that do not hav cooling system (rabbits). Decimeter-band waves moderate power flux density (80 mW/cm2) were foun reduce blood pressure, while MW with a higher p flux density (400 mW/cm2) were found to induce troduodenal ulcers. Decimeter-band waves and s modulated currents were found to stimulate dopa content in the cerebral cortex and in the caudate cleus. Local irradiation of the adrenal glands whole body irradiation at extremely low power density (1 mW/cm2) stimulated release of glucoc coids and thus inhibited the immune response. nonthermal effects of MW radiation observed at latively low power flux densities (< 10 mW/cm2) associated with changes in the structure of int cellular water, and, in turn, with changes in pro conformation.

0521 EFFECT OF DECIMETER-BAND WAVES ON THE FU TIONAL STATE OF THE CARDIOVASCULAR SY AND VARIOUS IMMUNOLOGICAL AND BIOCHEMICAL INDICES PATIENTS WITH MYOCARDIAL INFARCTION DURING THE RE PERATION PHASE. (Rus.) Sorokina, E. I. (Cent Res. Inst. Balneology and Physical Therapy, Mosc USSR); Poshkus, N .B.; Tupitsina, Iu. Iu.; Volkova, P.; Shubina, A. V.; Krasnikov, V. E. Vopr Kurol Fizioter Lech Fiz Kult (2):9-13; 1982 (9 ref

Therapeutic efficacy of decimeter-band waves was st ied in 142 men with myocardial infarction. The de meter-band waves were produced by a Volna-2 generat (output power of 20 and 40 W). Of 142 patients, received irradiation of the D_{I-V} region, 25 of D_{XI}-L_{IV} region, and 16 of the posterior surface of shins. The patients received daily, 10-min radiat treatment (10-15 applications per treatment cours The recuperation period was complicated by angina p torfs attacks (79.6% of the patients) or by sporad extrasystoles (75%). Favorable effects of decimet band waves included increase in the aerobic capac of the heart, decrease in hypoxia zone (normalizat of ST segment), improvement of energy metabolism, crease in the titer of anticardial antibodies and level, and decrease in enzyme activities. The b results were achieved after irradiation of the I region at 40 W.

0522 IMMUNOSUPPRESSIVE AND IMMUNOSTIMUATING FECTS OF DECIMETER-BAND WAVES DURING PRIMARY IMMUNE RESPONSE. (Rus.) Bogoliubov, V. (Central Res. Inst. Balneology and Physical Thera I. M. Mechnikov Res. Inst. Vaccines and Sera, Mosc

USSR); Frenkel', I. D.; Pershin, S. B.; Ponomarev, Iu. T.; Sokolova, Z. A.; Zubkova, S. M.; Kuz'min, S. N.; Galenchik, A. I.; Kozlova, N. N. Vopr Kurortol Fizioter Lech Fiz Kult (2):13-17; 1982 (10 refs).

Immunological effects of decimeter-band waves (DBW) were studied in male rabbits immunized with thymus-dependent antigen of sheep erthrocytes. The 460 MHz DBW were generated by a Volna-1 apparatus with a contact ceramic irradiator (4 cm in diameter) at power flux density of 120 mW/cm^2. The animals were irradiated for 6 min/day for 10 days. Group 1 was irradiated in the thyroid gland region and Group 2 in the adrenal gland regions. The animals were immunized after two or six exposures, or on day 10 after completion of irradiations. The immune response was estimated by the number of antibody-forming cells in the spleen and by a titer of serum hemagglutinins. The effect of DBW on the primary immune response depended upon the site of irradiation and the time period between irradiation and immunization. Irradiation of the thyroid gland region during the induction of immune response had an immunosuppressive effect, while irradiation 10 days prior to antigen administration had an immunostimulating effect. In contrast, irradiation of the adrenal gland regions produced inhibition of the immune response, regardless of the timing of antigen administration.

0523 EFFECT OF DECIMETER-BAND WAVES ON TEMPERATURE OF THE BRAIN AND THE ADJACENT TISSUES (EXPERIMENTAL STUDY). (Rus.) Malikova, S. N. (Experimental Dept., Central Res. Inst. Balneology and Physical Therapy, Moscow, USSR); Malyshev, V. L.; Balakireva, V. N.; Gorban', L. G. Vopr Kurortol Fizioter Lech Fiz Kult (2):18-25; 1982 (4 refs).

The effects of decimeter-band waves (DBW) on body temperature regulation were studied in phantoms, rabbits, and dogs. The DBW were generated by Romashka and Ranet apparatuses with contact irradiators (40 mm in diameter), output power of 5, 15, and 25 W, and power flux density of 400, 1200, and 2000 mW/cm^2, respectively. The site of irradiation was the parieto-temporal region. The temperature of the brain and the adjacent tissues was measured by a thermocouple. In the phantom, temperature was measured at depths of 5, 15, 20, 25, and up to 50 mm; temperature was found to decrease with depth. Increased duration of exposure was associated with increased heat emission and thus with a decrease in the rate of temperature gain. Measurements of brain and skin temperature in rabbits and dogs indicated that increases in temperature depended upon distance from the DBW source, duration of exposure, and the power flux density. The increase in brain temperature in rabbits was significantly more pronounced than in dogs.

0524 EFFECTS OF DECIMETER-BAND WAVES AND MODULATED CURRENTS ON NUCLEAR DNA C IN BRAIN NEURONS (EXPERIMENTAL STUDY). (Rus.) hailik, L. V. (Lab. Physiology, Experimental Central Res. Inst. Balneology and Physical The Moscow, USSR). Vopr Kurortol Fizioter Lech Fiz (2):22-25; 1982 (7 refs).

The effects of decimeter-band waves (DBW) alone combination with sine-modulated currents (SMC) content in sensorymotor cortex and caudate nu neurons were studied in male Wistar rats. DBW generated by a Volna-1 apparatus with a 4-cm ir tor at a power flux density of 110 mW/cm^2 (3 mi for 10 days). SMC were generated by an Ampli apparatus (30 Hz, carrier frequency of 5 kHz, modulation, 2-3 mA current; 20 min/day, for 20 The DBW were applied to the head and SMC were a to the femur region. Combined exposure consis irradiations with SMC for the first 10 days, fo by DBW for 3 min and SMC for 20 min during th 10 days. DNA content was measured cytospectro metrically. Single and repeated applications did not affect DNA distribution in the sensor cortex and caudate nucleus neurons. Single ap tions of SMC also did not affect DNA content neurons. Repeated applications of SMC resulte significant increase in DNA content in the neur the sensorymotor cortex, while DNA content in th rons of the caudate nucleus did not differ fro in controls. Combined exposure to DBW and S hanced polyploidization of neurons of the sensor cortex (DNA content of 3.96 units, compared wit units in controls) and to a lesser degree of th rons of the caudate nucleus (3.44 units, compare 3.16 units in controls).

0525 THE EFFECT OF BRAIN IRRADIATION WITH METER-BAND WAVES ON AUTONOMIC FUNCTI HYPERTENSION (EXPERIMENTAL STUDY). (Rus.) G kaia, M. S. (no affiliation given). Vopr Ku Fizioter Lech Fiz Kult (2):25-28; 1982 (8

The effects of decimeter-band waves (DBW: wave of 65 cm) on the autonomic nervous system were ied in Wistar rats with immobilization-induced tension. DBW were generated by Romashka and G apparatuses (power flux density of 80 and 400 mW The functional activity of the autonomic nervou tem was evaluated by motor activity, maximum pressure, heart rate, and energy metabolism. diations of the brain region with DBW resulted creased blood pressure (130 and 108 mm Hg after sure to 80 and 400 mW/cm^2, respectively, compare 158 mm Hg in controls). The decrease in blood sure after irradiation at 80 mW/cm^2 was assc with mild inhibition of motor activity, decre energy metabolism, and decrease in heart and re tion rates. Irradiations at higher power flux d (400 mW/cm^2) produced hemorrhages in the myoca brain, and small intestine mucosa, disorders

atrioventricular conduction, and marked inhibition of energy metabolism (7/20 rats died after the seventh irradiation). These findings indicate that the use of DBW in the treatment of hypertension should be limited to irradiations at low power flux density.

0526 DECIMETER-BAND WAVES IN COMBINED TREATMENT OF PATIENTS WITH INSUFFICIENCY OF CEREBRAL CIRCULATION. (Rus.) Strelkova, N. I. (Central Res. Inst. Balneology and Physical Therapy, Moscow, USSR). Vopr Kurortol Fizioter Lech Fiz Kult (2):28-31; 1982 (11 refs).

Therapeutic efficacy of decimeter-band waves (DBW) was evaluated in patients with Parkinson's disease (Group 1), in patients with complications of brain injuries (Group 2), in patients with spastic hemiparesis due to cerebral ischemia (Group 3), and in patients with transient cerebral ischemia (Group 4). The DBW were generated by a Volna-2 apparatus. The output power was 20-40 W in Group 1, 20-30 W in Groups 2 and 3, and 20 W in Group 4. The patients received daily, 10-15-min irradiations (10-15 applications per treatment course). Exposures to DBW resulted in marked improvement of cerebral circulation, formation of collateral circulation, and improvement of dopamine metabolism. Irradiations of the cervical region were more effective than irradiations of the occipital region.

0527 EXPOSURE TO CENTIMETER-BAND WAVES WITH SUBSEQUENT ELECTROPHORESIS OF NICOTINIC ACID IN COMBINED TREATMENT OF PATIENTS WITH COMPLICATIONS OF VIRAL ENCEPHALITIS. (Rus.) Ezhova, V. A. (Res. Inst. Physical Therapy and Medical Climatology, Yalta, USSR); Kunitsina, L. A.; Kornienko, E. G.; Leshchinskaia, N. P.; Cherfus, I. S.; Guz, S. Ia. Vopr Kurortol Fizioter Lech Fiz Kult (2):32-35; 1982 (8 refs).

Therapeutic efficacy of centimeter-band electromagnetic fields alone and in combination with electrophoresis of nicotinic acid was studied in 200 patients (80 men, 120 women; 20-40 yr old) with complications of viral encephalitis. All patients had manifestations of cerebral circulation disorders. The centimeter-band waves were generated by an apparatus Luch-58 (output power of 20-40 W). Electrophoresis of nicotinic acid was carried out by sine-modulated current (5000 Hz, 10-15 mA current, 0 modulation): the active electrode was placed in the region of the C_{VI-VII} and D_{I-III} vertebrae and the second electrode was placed on the extensor surface of the right forearm. One hundred patients were exposed to the centimeter-band waves in combination with nicotinic acid electrophoresis and 50 patients received irradiations with centimeter-band waves alone (controls). Combined treatment resulted in marked improvement of clinical and neurological symptoms: headache disappeared in 57% of the patients (compared with 46% of contro 65% stopped complaining of dizziness (versus 52 controls), 71% showed normalization of sleep (ve 58% of controls). Normalization of rheoencephalo phic indices was observed in 80% of the patients received combined treatment and in 68% of cont Combined treatment resulted in normalization of t heparin level and in normalization of the urinary cretion of catecholamines.

0528 EFFECT OF DECIMETER-BAND WAVES ON IMMUN GIC REACTIVITY OF PATIENTS WITH OSTE THROSIS DEFORMANS. (Rus.) Dalimov, Z. A. (Dept. ical Therapy and Balneology, Inst. Advanced Trai for Physicians, Tashkent, USSR); Alimova, M. Iu. Kurortol Fizioter Lech Fiz Kult (2):51-52; 1982 refs).

The effects of decimeter-band electromagnetic (DB EMF) on indices of non-specific immunity were vestigated in 60 patients (22 men, 38 women; 35-6 old) with osteoarthrosis deformans. The DB EMF generated by a Volna-2 apparatus (output power of 50 W). The patients received daily 8-10-min irr ations of the involved joints (a total of 16-20 diations). The DB EMF treatment produced local a gesic effect in 80% of the patients, reduced in sity of inflammation in 72%, and improved the pheral circulation in 74%. Two-thirds of the pati showed normalization of blood protein fractions, crease of C-reactive protein concentration (from to 1.02 units), and decrease in erythrocyte sedime tion rate (from 28 to 16). Treatment with DB EMF duced significant decrease in the titers of autob bodies to the synovial membranes, to the heart, sils, kidneys, liver, and spleen. These findings indicative of a high efficacy of DB EMF in com treatment of patients with osteoarthrosis defor

0529 DECIMETER-BAND THERAPY WITH THE USE TRANSPORTABLE APPARATUSES. (Rus.) Shu hina, L. A. (Central Res. Inst. Balneology and P ical Therapy, All-Union Res. Center for Mother and Childhood Protection, N. N. Burdenko Chief M tary Clinical Hosp., Moscow, USSR); Strugatskii M.; Ushakov, A. A. Vopr Kurortol Fizioter Lech Kult (2):68-69; 1982 (no refs).

Therapeutic applications of Romashka and Ranet (20) transportable apparatuses generating decim band waves (460 MHz, wavelength 65 cm) are descri Characteristic features of these apparatuses inc relatively low output power (17-20 W) and relati small size of the contact irradiators (20, 40, 100 mm); the 20-mm irradiator is used for intrav nal applications, while the 40-mm and 100-mm irra tors are applied to the skin. The transportable meter-band wave generators are effective in the t

ment of bronchial asthma, nonspecific bronchopulmonary diseases in children, stomach and duodenal ulcer, neuralgia of the trigeminal nerve, acute neuritis of the facial nerve, lumbosacral radiculitis, subacute and chronic pyelonephritis, subacute and chronic uterine inflammations, hematoma, tonsillitis, otitis, inflammation of the maxillary and frontal sinuses, furunculosis, and prostatitis.

0530 SPECIFIC EFFECTS OF MILLIMETER-BAND RADIO WAVES ON BIOLOGICAL SYSTEMS. (Rus.) Sevast'ianova, L. A. (no affiliation given). In: Nonthermal Effects of Millimeter-band Radiation. Deviatkov, N. D., ed. (Moscow: USSR Acad. Sciences): pp. 86-113; 1981 (23 refs.)

Literature data on the specific biological effects of millimeter-band radio waves (RW) are reveiwed. Biological changes induced after exposure to millimeter-band RW were found to depend upon the wavelength, the threshold power flux density, and duration of exposure. Numerous experiments showed the resonant-type relationship between the wavelength and the biological effect. Approximately 70% of the energy of millimeter-band RW was absorbed in the tissues at a depth of 300 microns. Millimeter-band RW had a selective effect on bone marrow cells: exposure to RW prior to x-irradiation was found to have a radioprotective effect on medullary hematopoiesis, while exposure to RW after x-irradiation was found to have a radiosensitizing effect. Millimeter-band RW in combination with x-rays and antineoplastic agents enhanced the inhibition of tumor growth and reduced radiation injuries to the bone marrow.

0531 EFFECT OF MILLIMETER-BAND ELECTROMAGNETIC WAVES ON BACTERIAL CELLS. (Rus.) Smolianskaia, A. Z. (no affiliation given). In: Nonthermal Effects of Millimeter-band Radiation. Deviatkov, N. D., ed. (Moscow: USSR Acad. Sciences): pp. 132-146; 1981 (24 refs).

The results of experiments on the biological effects of millimeter-band electromagnetic fields (EMF) on bacterial cells are reported. Analysis of induction of lethal colicin synthesis in Escherichia coli K12 C 600 after exposure to 5.8-7.1-mm EMF showed the resonant relationship between the wavelength and the number of colicin-synthetizing bacteria. The effect was directly relaced to the duration of exposure and was independent of the power flux density. The millimeter-band had a similar effect on the inducible synthesis of beta-galactosidase in lysogenic Staphylococcus aureus. These findings indicate that the lethal effects of millimeter-band EMF were associated not with direct thermal action but rather with indirect action mediated through resonant stimulation of bacterial systems.

0532 EFFECT OF MILLIMETER-BAND RADIO WAV TUMOR GROWTH IN EXPERIMENTAL AN (Rus). Sevast'ianova, L. A. (no affiliation g Borodkina, A. G.; Golant, M. B.; Rebrova, T. B Nonthermal Effects of Millimeter-band Radiation Iatkov, N. D., ed. (Moscow: USSR Acad. Sciences 147-166; 1981 (19 refs).

Therapeutic efficacy of millimeter-band radio (MB RW) in combination with x-rays or antineop agents was studied in male rats with sarcoma-45 random-bred mice with sarcoma-180, and female CB with transplanted cervix carcinoma CC-2. The a with sarcoma-45 and CC-2 were exposed to MB RW length of 7.11 mm, power flux density of 12.5 m for 1 hr) and to x-rays (total dose 2,100 rads) posure to MB RW following x-irradiation resul a 2.5-fold increase in the inhibition of sarc growth over that after x-irradiation alone. Ex to MB RW before x-rays did not enhance the inhi effect of irradiation. Inhibition of CC-2 grow ter exposure to x-rays followed by MB RW was t greater than after exposure to x-rays alone. sure to MB RW before x-irradiation prevented tion injuries to the bone marrow and the peri blood in the animals with sarcoma-45 and CC- RW after x-irradiation failed to provide a rad tective effect. MB RW enhanced the antitumor vity and reduced the toxicity of cyclophosphami ftorafur in mice with sarcoma-180.

0533 ENHANCED LIPID PEROXIDATION IN LIP AFTER EXPOSURE TO MILLIMETER-BAND TION. (Rus.) Andreev, V. E. (no affiliatio en); Betskii, O. V.; Il'ina, S. A.; Kazarinov, Putvinskii, A. V.; Sharov, V. S. In: Nontherm fects of Millimeter-band Radiation. Deviatkov, ed. (Moscow: USSR Acad. Sciences): pp. 167-176 (23 refs).

Nonthermal effects of millimeter-band electroma fields (MB EMF) on biological membranes were in gated. The rate of lipid peroxidation after ex to 7.1-4.7-mm (42-64 GHz) waves was studied in pholipid liposomes. Lipid peroxidation was ini by addition of iron sulfate + ascorbic acid mi by ultraviolet irradiation, and by irradiatio visible light. MB EMF resulted in a 20-30% in in the rate of lipid peroxidation. The enhance of peroxidation was observed for all three typ initiation and for all wavelengths tested. The anism of MB EMF-induced increase in the rate of peroxidation could be associated with free r processes in the membranes, with structural c in the liposome membranes, or with changes in sion of peroxidation substrates and products.

0534 NATURAL RADIOFREQUENCY ELECTRICAL OSCILLATIONS IN THE LIVING STATE (MEETING ABSTRACT). (Eng.) Pohl, H. A. (Oklahoma State Univ., Stillwater, OK 74078). Abstracts of Papers of the American Chemical Society 183(March):A14; 1982.

The research of this laboratory has recently shown that cells emit radiofrequency (RF) electric fields, especially at or during mitosis. This is observed in bacteria, in yeasts, in algae, in avian cells, and in mammalian fetal, normal, and oncogenic fibroblasts; and hence is probably "universal". For some years we have been using non-uniform electric fields to manipulate and examine cells by the phenomenon of dielecdielectrophoretic. (The pull of neutral particles exerted by a non-uniform electric field.) From these gentle dielectrophoresis effects one can obtain unique dielectric relaxation spectra and also sort cells. In a recent turnabout, we used the phenomenon of dielectrophoresis to study the oscillating fields of cells themselves, as evidenced in two fundamental ways. We observe that the natural RF fields of cells produce an attraction for tiny and highly polarizable particles ("magic" particles), and ignore "non-magic" particles of low polarizability. These simple and direct experiments demonstrating natural RF fields from cells require little more than a microscope and a knowledge of what to do. In a second technique, these observations were supplemented by showing that living cells spin in a resonant manner in response to narrow frequency ranges (Cellular Spin Resonance). The CSR spectra and the micro-dielectrophoresis studies were a direct outcome of the theories of H. Frohlich. Our model for these natural RF oscillations of nucleate cells is that of charge-density waves arising from the ionic phases of periodic intracellular reactions, operating in collective coherance, and collimated by intra-cellular structures to form the externally observable oscillating fields.

0535 EFFECTS OF INDUCED ELECTROMAGNETIC FIELDS ON HORMONAL RESPONSIVENESS OF OSTEOBLASTS IN VITRO (MEETING ABSTRACT). Luben, R. A. (Div. Biomedical Sciences and Dept. of Biochemistry, Univ. California, Riverside, CA 92521); Cain C. D. Abstracts of Papers of the American Chemical Society 183(March): A15; 1982.

Pulsing electromagnetic fields are known to significantly improve the healing of bone fractures in vivo. The current study was designed to investigate the molecular basis of the actions of these fields on bone, by using bone and bone cells cultured in vitro. Mouse osteoblasts (cell line MMB-1) were exposed in culture to fields produced by devices currently approved for clinical use (Bi-Osteogen™). These fields produced little or no change in basal activities in the cells, but significantly inhibited the cAMP responses of the cells to added parathyroid hormone (PTH) or osteoclast activating factor (OAF). The effects of PTH on synthesis of collagen were also blocked by the fi However, the fields had no effects on activiti vitamin D derivatives in the cells, suggesting only hormones acting at the cell membrane were fected. The inhibition of cAMP responses was med by reductions in the activity of PTH-activated a cyclase in cell membrane preparations; however fields had no effect on the total fluoride-acti adenyl cyclase activity in the same fractions, cating that the effects were localized either t hormone receptor or the receptor-cyclase cou moieties of the cell membrane. Similar effects o fields were observed using intact mouse cranial in organ culture. The results suggest that th fects of electromagnetic fields on bone are at partially mediated by modification of the resp of the cells to endogeneous hormones, and that stimulation of bone formation in vivo by these f is the result of localized blocking of the osteo effects of PTH.

0536 EFFECTS OF ELECTRIC FIELDS ON NE GROWTH IN VITRO (MEETING ABSTRACT). Poo, M.-M. (Dept. Physiology & Biophysics, Univ lifornia, Irvine, CA 92717); Patel, N. Abstrac Papers of the American Chemical Society 183(Ma A16; 1982 (4 refs).

The effect of DC fields on neurite growth in cu has been a controversial subject over many dec Recent investigations on cultured ganglionic exp and on dissociated single embryonic neurons have vided convincing evidence that DC fields on the of 0.1 to 10 V/cm could produce at least three typ effects on neuronal growth: (1) accelerated grow the neurites facing the cathode, (2) bending and entation of the neurite tip toward the cathode general enhancement of neurite outgrowth from soma and the survival of the neuron in cul Furthermore, the effects are not due to seco mechanical or chemical factors in the growth env ment of the neuron. Rather, the electric fiel erts its action directly on the neuron. Since lar fields produced electrophoretic accumulatio cell surface glycoproteins on the cathodal si the neuron, the field-induced reorganization of ma membrane components could be a cellular mech underlying the electric field effects on neu growth.

0537 SYNERGY OF POLYMER IMMUNOMODULATION PULSATILE ELECTROMAGNETICALLY INDUCED RENTS IN INHIBITION OF GROWTH OF MURINE MALI MELANOMA (MEETING ABSTRACT). (Eng.) Norto (Mount Sinai Sch. Medicine, New York, NY); Tansma S.; Regelson, W.; Geller, S.; Pilla, A. A. Abst of Papers of the American Chemical Society 183(Ma A17; 1982.

We have reported that pulsating electromagnetically induced current (PEMIC), designed to modulate membrane enzyme kinetics, has anti-cancer activity in B16 melanoma in mice, acting synergistically with cytotoxic combination chemotherapy. In this work it is shown that PEMIC and Pyran co-polymer, an immunomodulating drug, are effective tumor growth inhibitors with combined use. (C57 female BDF$_1$ or BCF$_1$ mice were given no drug or Pyran, 75 mg/kg, 1 or 7 days after implantation of 1 mm^3 B16 melanoma. PEMIC treated mice were placed in spatially constructed cages between Helmholtz air-gap coils for 12 hr/day. The pulsating magnetic field (dB/dt = 0.. G used) included 1 Hz currents configured of 50 msec bursts of 15% msec main polarity and .. msec opposite polarity asymmetrical pulses. The average induced current per pulse varied from ... - 1 uA/cm^2. The results show that the median survival time for control animals of seven wk was not affected by PEMIC or Pyran alone. However, treatment with PEMIC and Pyran increased survival time to 1.. wk in 100% of the mice. Histologic studies showed enhanced necrosis for PEMIC treated tumors, suggesting a mechanism of synergy with the macrophage and NK-cell stimulating Pyran. These results provide evidence for an effective and non-toxic anti-cancer treatment modality.

1528 EFFECTS OF WEAK PULSATING CURRENT ON VITALITY IN PARAMECIUM (MEETING ABSTRACT). Eng. Smith-Sonneborn, J. (Zoology & Physiology Dept., Univ. Wyoming, Laramie, WY 8207.). Abstracts of Papers of the American Chemical Society 183(March 1 A55, 1982.

Since the surface membrane of the ciliated protozoan Paramecium exhibits properties of excitability which mimic metazoan nerve and muscle cells, this eukaryote has been used extensively for studies of membrane excitation and motor behavior. The biological effects of specific pulsating current on these cells was investigated using electromagnetic current induction in the expectation that these cells would respond to proper electrochemical stimulation. The induced voltage was obtained using air-gap coils driven by a programmable power supply (Electro-Biology Inc., Fairfield, NJ). The basic pulse wave form is bipolar and asymmetrical in width and amplitude usually in a ratio of 1:10. Periodicity of the wave form, single pulse versus burst and repetition rate was examined. The response of the cells to specific pulsating current with respect to 1) their daily cell division rate and 2) duration of lifespan was monitored. Paramecium have been used as a model system of cellular senescence since the number of cell divisions after origin at fertilization until death is limited, predictable and species-specific and therefore can be used to study effects on longevity. Specific pulsating currents and ionic environments were found to increase the rate of cell division and duration of lifespan.

1534 NON-EQUILIBRIUM MODELS OF CELL MEMBRANE I TERACTIONS WITH weak ELECTROMAGNETIC FIE MEETING ABSTRACT). Eng. ademy of Sc. Loma Li VA Hosp., CA 9[illegible]. Abstracts of Papers of the Am ican Chemical Society 183(March Suppl, 19[illegible].

Studies in various tissues, including cerebral cort and synaptosomal fractions, cultured astrocytes, cytotoxic T-lymphocytes and pancreatic islets, ... good evidence that tounling of weak, oscillating ele trochemical fields to cell membranes occurs on the brane surface polyanions, characterized by transie coherent states of nearest neighbor Ca^{++}-bindi sites. First steps in transductive coupling may cur in the length of the membrane surface where herent states may exist for considerable distance Binding and release of calcium ions at these membra sites correlates closely with exposure to certa weak electromagnetic fields. Sensitivity to the fields in narrow frequency and amplitude "window supports models based on highly cooperative dissi tive interactions at cell membrane surface glycop teins. Reaction-diffusion (dispersive) soliton p cesses may also be involved. Soliton waves may ar from interactions with phonons and excitons al linear molecules producing nonlinear molecular vib tions. Solitons exist in a minimal energy st and are extremely long-lived in comparison to lin oscillations. They may also couple reaction-dif sion processes in the extracellular and intracellu domains. Calcium fluxes in the extracellular sp of the central nervous system are considered as non-linear reaction-diffusion system. Solitons membrane long-chain molecules (Davydov type) may significant in charge transfer or conver ene as nonlinear waves along helitic domains from protein site to another (sine-Gordon soliton).

1535 THE EFFECT OF MICROWAVE IRRADIATION O tRNA-SYNTHETASE SYSTEM OF THE [illegible] BRAIN AND LIVER (MEETING ABSTRACT). Eng. [illegible] E. S. "Frederic Joliot-Curie" Natl. Res. Inst Radiobiology and Radiohygiene, H-1[illegible] Budapest, Box 101, Hungary; Ballay, L.; Szabo, L. V. Acta chim Biophys Acad Sci Hung 17(3-4):305, 1982.

The biological effect of microwave irradiation embryonic organisms of higher radiosensitivity studies. White Leghorn chick embryos were incu at 37.5±[illegible] C at a relative moisture [illegible] tinuous irradiation (CW) was brought about with power density range between 100-300 mW/cm^2 and a fre quency of 2450±50 MHz. We have found that embr irradiated at different days of the embryonic deve tween the 2nd and 19th day of incubation with vari power density ranges showed differences both in the survival and characteristics of the development as well as in their radiosensitivity. We have fou that the radiosensitivity increases reciprocally wi the age of the embryos. Effect of the microwave r radiation on the embryonic protein synthesis was s

vestigated with a specific absorption of 220 mW/g at the 15th day of embryonic life. In order to compare some macromolecules taking part in protein synthesis, tRNAs and aminoacyl tRNA synthetases were isolated from the brain and the liver of chicken embryos irradiated at the 15th day. tRNAs' acceptor activity and enzyme activity of synthetases showed a small decrease in liver, and about 50% increase in brain. The activity of tRNA seems to be more sensitive than that of the synthetases.

0541 RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS A RISK FACTOR IN DIFFERENT PROFESSIONAL GROUPS IN BULGARIA (MEETING ABSTRACT). (Eng.) Dobrev, B. (Inst. Hygiene, Bul. D. Nestorov N 15, Sofia 1431, Bulgaria); Israel, M. S.; Todorova, L. C. J Occup Accidents 4(2-4):187; 1982.

The intensity of electromagnetic fields (EMF) have been measured in industrial enterprises, radio and TV stations, medical establishments, high frequency telecommunication stations, electronic industry, radar installations, scientific institutes etc., in connection with the application of new technologies. EMF intensities (or power density) in the machine and metal processing industry, in physiotherapy, in some of the radio transmitting stations, in the plastics industry, in some scientific institutes, are higher than the occupational health norms in Bulgaria. Clinical, functional, paraclinical, biochemical and immunological investigations have been preformed on 390 workers in order to define the effect of electromagnetic fields in working conditions. Electromagnetic fields have been found to cause a health hazard in the machine building industry - 28.6% of the examined workers, in the plastics industry - 31% (machine workers), at high frequency telcommunications stations - 71%, in the metal processing and metallurgical industries - 15.1% of the workers.

0542 MEASUREMENTS OF THE INTENSITY OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS A RISK FACTOR IN BULGARIA (MEETING ABSTRACT). (Eng.) Israel, M. S. (Inst. Hygiene and Occupational Health, Bul. D. Nestorov N 15, Sofia 1431, Bulgaria). J Occup Accidents 4(2-4):189; 1982.

The measurement of the intensity of the electromagnetic fields (EMF) in working rooms is connected with many difficulties: EMFs are very intensive, the workplaces are near to grounding metal masses, in the room there are reflected surfaces, etc. There are no apparatuses (serial production) with the necessary characteristics about the purposes for such measurements. The attempt to create and construct devices for measuring the EMFs in the frequency range below 30 MHz is described in the report and also the questions and problems which should be resolved in the future. We construct antennas for measuring the tensities of the EMFs below 30 MHz with an accur of 10.5-12%.

0543 EFFECT OF MICROWAVE-INDUCED WHOLE-BODY PERTHERMIA ON THE MUCOSA OF MOUSE SMALL TESTINE (MEETING ABSTRACT). (Eng.) Tsubouchi, (Fukui Medical Univ., Matsuoka, Nagoya, Japan); Nis moto, Y.; Kano, E.; Nakamura, W. J Radiat Res (Tok 23(1):14; 1982.

Effect of microwave-induced whole-body hyperther was examined using ddy/SLC mice for the basic und standings of the critical organs. The treatment 43.5 C for 20 min resulted in the mortality rate 30-40% within day one. The surviving mice showed specific disease. Preliminary autopsy examinat showed that a considerable amount of the body fl had leaked into intestinal lumen due to the tran tory denudation of the epithelial cells of the sm intestine villi within 3 hr, whereas epithelial ce of the crypts appeared intact until these cells villi were completely denuded. After 4-9 hr, cr tal epithelial cells regenerated in some of animals which probably could have survived for least more than one day if they had not been sac ficed. The histology of the mice that died wit one day suggested that the complete denudation the villus epithelial cells might be the init cause of death. These preliminary results sugg the following: 1) one of the critical target org of the whole-body hyperthermia is mucosa of small intestine; 2) whole-body hyperthermia affe the epithelial cells of intestinal villi wher those of the crypts were not injured; in contra radiation effect is mainly given on the proliferat epithelial cells, i.e., of the crypts.

0544 CHANGES OF HEMATOCRIT, SODIUM AND POTASS ION CONCENTRATION IN PLASMA INDUCED WHOLE-BODY HYPERTHERMIA (MEETING ABSTRAC (Eng.) Ohtsuka, K. (Aichi Cancer Center Res. Ins Nagoya, Japan); Nakamura, W. J Radiat Res (Tokyo) (1):16; 1982.

The physiological effects of whole-body hyperther on animals and normal tissues are not well-known. this report, we investigated the changes of hema crit, sodium and potassium concentration in pla and water content in small intestine of mouse duced by whole-body hyperthermia (43.5 C; 15, 20, 30 min) with 2450 MHz microwave. Water content in small intestine increased gradually after the hyp thermic treatment. It might result from leakage blood components into the intestinal tract and in bition of reabsorption of water due to intesti lesion by the treatment. Hematocrit also increa after the treatment; there was a very high corre

tion between these two values. The longer the time of the treatment, the more the mice died. While the change of potassium concentration in plasma was small, sodium ion concentration of agonal or dead mice were more than twice of normal value. Moreover, erythrocytes of hyperthermia-treated mice were more fragile than those of non-treated control. From these results, it was suggested that abnormally high concentration of plasma sodium, which leaked out mainly from erythrocytes, was one of the lethal factors.

0545 COMBINED EFFECT OF SYSTEMIC HYPERTHERMIA AND MITOMYCIN C ON INTRAMUSCULARLY TRANSPLANTED TUMOR (MEETING ABSTRACT). (Eng.) Nakamura, W. (Aichi Cancer Center, Nagoya, Japan); Nishimoto, Y.; Nakayama, T. J Radiat Res (Tokyo) 23(1):16; 1982.

Tumor cells were of a cloned cell line FMA3 which were derived from Furth's mastocytoma and kept as ascites type by serial transplantation into the abdominal cavity LAF_1 mice. The cells in logarithmic growth were transplanted into right hind leg muscles of 9-12 wk-old mice. Treatments with 2450 MHz-wave alone, with Mitomycin C alone or with both in combination were started two days after the transplantation. Among several protocols examined, the most promising one was the daily systemic hyperthermia (rectal temperature of 42 C for 5 min for 5 days) which was used in combination with a single injection of 20 ug Mitomycin C 10 min prior to the first heat treatment. Two sessions of the combination carried out with an interval of one wk significantly suppressed not only tumor growth at the site of the transplantation but also the metastases in the lungs, liver, spleen and other tissues.

0546 EFFECT OF TRENTAL ON HYPERTHERMIA-INDUCED THROMBOCYTOSIS IN MICE (MEETING ABSTRACT). (Eng.) Nakayama, T. (Aichi Cancer Center, Nagoya, Japan); Nakamura, W. J Radiat Res (Tokyo) 23(1):16; 1982.

Effect of pre- or post-treatment of mice with 1-5 (oxohexyl) theobromine (Trental) on the hyperthermia-induced thrombocytosis was studied. Systemic hyperthermia was induced in mice by exposing them to 2450 MHz-wave and by controlling the electric power automatically with the use of a thermocouple inserted into the rectum as a sensor. The rectal temperature was kept at 43.5 C for 10 min. In these mice, the thrombocyte count decreased gradually reaching its minimal level in about 3.5 hr. Thereafter, it increased and returned to the initial level in 2.5 hr and reached the maximum level 2 or 3 days after the heating which was 2.3 times higher than normal. Injection of Trental was carried out immediately before or after the heating and was effective in preventing the occurrence of thrombocytopenia as well as that of thrombocytosis.

0547 FOCUSSING OF THE 915 MHz ELECTROMAGN POWER IN DEEP HUMAN TISSUES: A MATHEMAT MODEL STUDY (MEETING ABSTRACT). (Eng.) Arcang G. (Istituto Medico e di Ricerca Scientifica, O Rome, Italy); Lombardini, P. P.; Lovisolo, G.; Ma glia, G.; Piattelli, M. Strahlentherapie 158(6): 1982.

Most of the external microwave or radiofrequency plicators for local hyperthermia induce maximum h ing on the tissue surface with a progressive temp ture decrease with depth. The resulting tempera gradient does not allow a homogeneous heating to sions deeper than 3-4 cm with a single applica even if skin cooling is used. However, deep hea could be achieved by an array of applicators. difficulty of understanding microwave propoga within the human body is due to the numerous dis tinuities favoring microwave scattering. The res ing electromagnetic field exhibits an intensity phase and a polarization varying dramatically point to point. In this work, we have studied behavior of the electromagnetic field in an adult thorax section. This section, obtained by a CAT at the level of fifth thoracic vertebra, was ide subdivided in 235 sub-volumes with dimensions inferior to the diffraction limit. Values of die tric constant and conductivity, as measured in laboratory, were attributed to each sub-volume. our model, a peripheral array of 50 equidistant e ed, water-loaded, contacting antennae at 915 having an equal intensity and an externally contr able phase, have been assumed as microwave sour The integral equation matricial method has been for the calculation. As a result, a system of 1 scalar linear complex equations, which have been ved numerically, was obtained. In this study, possibility of focussing ohmic power in a given p deep in the body has been tested, ignoring the the dynamic problem, and the following results have obtained: 1) Focussing of 915 MHz power in deep po is always possible, but it is generally associate concentration of ohmic power also in other, unwa points. The unwanted power may exceed that delir in the focus; 2) however, it is possible to antenna phase configurations, capable of lowe the unwanted powers below that at the focussed le These configurations can be determined by appl minimization methods.

0548 NON-LINEAR EFFECTS IN THE ELECTROMAGN HEATING OF LIVING TISSUES (MEETING STRACT). (Eng.) Bardati, F. (Istituto di Ele nica dell'Universita di Roma, Italy); Gerosa, Strahlentherapie 158(6):378; 1982.

The problem of electromagnetic heating of living tissues has been considered, with reference to local microwave-induced hyperthermia for cancer therapy. In order to investigate theoretically the temperature distribution, a mathematical model of the living tissue has been specified before solving the thermal boundary value problem. The model takes into account the complicated thermal phenomena of the living tissue, namely metabolic heat generation and heat exchange with blood flow. We have assumed a time-independent metabolic heat generation to be present. The cooling effect due to blood flow has been assumed to be a function of the difference between the local temperature and the arterial blood temperature. In previous works a linear function has been considered. This linear model, however, disregards the local thermoregulating influence of the blood flow. In this work the thermoregulation has been taken into account by assuming the blood flow cooling effect to be a non-linear function of the difference between local and arterial blood temperature. The effect of a cooling fluid forced past the surface of the living tissue has also been taken into account. The theoretical temperature distribution induced by exposure to electromagnetic fields has been determined according to the following steps: at first the non-linear operator has been linearized by using the iterative Newton-Raphson's method; then a matrix formulation has been obtained through the moment method. In particular, the case of a slab simulating living tissues, which is irradiated by a plane electromagnetic wave, has been considered. The temperature distribution has been carried out for various types of non-linear blood cooling functions, in order to evaluate the matching between the assumed mathematical model and the true biological phenomena.

0549 RADIOTHERAPY-HYPERTHERMIA ASSOCIATION: TWO PATIENTS (MEETING ABSTRACT). (Eng.) Bellossi, A. (Centre Eugene Marquis 35000 Rennes, France); Fleury, F.; de la Perelle, A.; Kernec, H. Strahlentherapie 158(6):379; 1982.

Many authors have reported that radiotherapy-hyperthermia association potentializes the effect of each method. We present two patients who confirm the favorable effect of this association. Hyperthermia was delivered by a 13.56 MHz generator (STAE prototype) used in capacitive diathermy. Two 1-hr sessions took place a week, every 2 or 3 days, 3 hr after radiotherapy. The first patient was treated for cutaneous recurrence of a cancer of the right pyriform sinus. In December 1980, electrontherapy was administered, associated twice a wk with hyperthermia. The result was positive but, in May 1981, two permeation nodules appeared out of the treated lesion. For 7 wk these nodules were treated each week by three electrontherapy sessions (3 Gy) and two hyperthermia sessions (1 W.cm^{-2}). In July, the lesions had disappeared; in December, the results were excellent. The second patient was bed-ridden by the recurrence of a prostatic cancer, which had been operated on, then treated by cobaltotherapy (60 Gy) 7 yr ago. Cobaltotherap Gy a session) and hyperthermia (1.5 W.cm^{-2}) t wk had been given for 5 wk. The results were lent. The patient died of a myocardial infarc yr later.

0550 CLINICAL PRACTICE OF 434 MHz MICROWA PERTHERMIA (MEETING ABSTRACT). (Eng. P. (Centre Alexis Vautrin, Avenue de Bourgogne, Vandoeuvre les Nancy, France); Marchal, C.; Hof ter, S.; Metz, R.; Escanye, J. M.; Robert, J. lentherapie 158(6):379; 1982.

To determine the efficacy of hyperthermia al combined with radiotherapy, we compared the r sions of heated tumors with unheated others i patient. Thirty-eight patients with advanced c mainly local evolutions of ear-nose-throat ca mas, melanomas or skin metastasis, have been t using a 434 MHz microwave hyperthermia appa Microthermo-couples are placed inside or unde the tumors and temperature is controlled by a ter which automatically shuts off the power for ometry and regulates tumor thermal level betw and 45 C. Fortyfive tumors were submitted to waveinduced hyperthermia (5 sessions of 45 min, or 3 D/7). Radiotherapy followed hyperthermia time interval ranging from 3 to 30 min. Dif total radiation doses from 12 to 30 Gy were del every day or thrice a wk. For 6 patients, hype mia was associated with conventional chemoth Tumor response was assessed by measuring the volume. Hyperthermia combined with radiot sessions seems the most effective for inducing regressions (>50% cases). This 434 MHz mic hyperthermia apparatus is well adapted for rec lymph nodes of head and neck, even those pret with a high radiation dose.

0551 2450 MHz HYPERTHERMIA MONITORING S CLINICAL APPLICATIONS FOR THE TREATM SUPERFICIAL TUMORS (MEETING ABSTRACT). (Eng.) dure, G. (Centre d'Etudes d'Electronique des So Univ. Sciences et Techniques du Languedoc, 34060 pellier Cedex, France); Delauzun, J. P.; Richa P.; Dubois, J. B.; Hay, M. H. Strahlentherap (6):379; 1982.

Our study deals with a hyperthermia system whi ploys open space applicators and computer moni for the treatment of superficial or nearly su cial tumors. The applicator consists of a rec lar wave guide coupled with a cooling system f perficial tissue which introduces air along the axis. Following an established protocol, this cator rapidly creates a homogeneous temperatur tribution (between 42 and 43 C) up to to a dept cm and covering a surface of 16 cm^2 comparable

results obtained with microwaves at 434 MHz using a direct contact waveguide and tissue cooling system). Hyperthermia was monitored by a single temperature sensor implanted in the superficial tissue. A microprogram regulates microwave power and reduction of superficial temperature. The program was designed to reach a predetermined temperature with minimal delay and without overheating of superficial tissue. The technique is well tolerated by the patient and is without risk to either operator or patient. Our results were based on our experience with 10 patients with recurrent thoracic wall tumor from breast carcinomas. Consideration is given to the potential use of open space applicators to treat surfaces on the order of 100 cm2 by a system which can be perfectly adapted to numerous clinical situations.

0552 A STUDY OF RF 27 MHz ELECTROMAGNETIC FIELD TECHNIQUES FOR THE LOCALIZED HEATING OF HEAD AND NECK TUMORS (MEETING ABSTRACT). (Eng.) Carnochan, P. (Royal Marsden Hosp., Fulham Road, London SW 3, England); Jones, C. H. Strahlentherapie 158(6): 379; 1982.

The effective use of localized hyperthermia in cancer treatment requires careful optimization of the heating techniques employed. To this end useful information may be obtained about the design of applicators by investigating the distribution of power deposited within phantoms in vitro, and by the assessment of applicator performance in vivo using invasive thermometry and/or thermography. Infrared thermagraphy has been utilized to investigate the heating patterns produced by both capacitive and inductive short-wave diathermy applicators in phantoms having the electrical characteristics of typical tissues. The boundaries within the layered, cylindrical phantoms were chosen to approximate to some of the major dielectric discontinuities of the cervical region. The results of these studies indicate the potential of the capacitive diathermy technique for heating small volumes of subcutaneous tissue. Further studies of excised animal tissue using this technique, have suggested that anomalous heating of tissues in the region of the cervical vertebrae is unlikely. In vitro studies allow investigation of only those parameters which have an influence upon the distribution of power absorbed by tissues from the electromagnetic field, and knowledge of the thermal properties of tissues in vivo is necessary before localized hyperthermia treatment can be optimized. A method is described whereby the careful positioning of implanted thermocouple probes used in conjunction with external heat sources allows: a) the optimization of parameters influencing thermal distributions in vivo, b) an estimation of the thermal dose delivered to a tumor during heating, and c) a quantitative index of the blood cooling efficiency of peripheral tumor regions.

0553 FOCUSSED MICROWAVE HYPERTHERMIA AT MHz (MEETING ABSTRACT). (Eng.) Conway (Sheffield Univ. and Area Health Authority, Dept. ical Physics and Clinical Engineering, Royal Hal shire Hosp., Glossop Road, Sheffield S gland); Melek, M.; Anderson, A. P.; Brown, B. Strahlentherapy 158(6):380; 1982.

A technique to introduce hyperthermia at depth wi the human body using focussed microwave arrays been studied. A computer simulation of the power sipation within a cylindrical body, assuming uni permittivity and attenuation, indicates that, by u a semi-circular or semi-elliptic geometry of radia and applying appropriate phase and amplitude illum tion, a significant thermal enhancement may be ind at a site within the body compared with its surro ings. A configuration of 11 array elements (6 ments curved around the cylinder and 5 elements the cylinder axis) yields a sufficient energy con tration to produce a focussed region heated twic much as any other region inside the cross-sect Computer simulations indicate that the size, sh and position of the high temperature region sh be approximately controllable and that the stab of the system is tolerant to typically 20% errors the phases and amplitudes of the radiators. Meas ments have been performed on a simple thorax pha using the same arrangement of dipole elements cribed above. The elliptical body was filled water-saturated sand yielding a permittivity of and an attenuation constant of 140 dB/m. An ant probe was utilized to measure the intensity distr tion at 49 points within the body. Results indi a high intensity peak at a region 5 cm deep into thorax phantom, the second high intensity region ing 40% below and occurring at 1 cm deep. These sults agree well with theoretical computer pre tions. In practice, the focussing effect may be ified by thermal dissipation due to blood flow heterogeneity of the body. However, the relative nitude of the focussed region could be enhanced air cooling of the skin surface. Results obtaine far indicate that heating of deep seated tumors i in the body is possible using a non-contacting cussed microwave array system.

0554 EXPERIENCE WITH 13-56 MHz RF IN CLIN HYPERTHERMIA (MEETING ABSTRACT). (E Griffiths, H. (Physics Dept., Velindre Hosp., W church, Cardiff, England). Strahlentherapie 158 382; 1982.

A series of selected patients with advanced ca have been treated by hyperthermia using a LeVeen Thermotherapy machine. This machine uses capaci coupling to apply the radiofrequency (RF) p to the tissue. Saline-filled pillows were pl between the RF electrodes and the skin to enh cooling. Cooled saline was circulated through pillows during treatment to avoid excessive hea

of the superficial tissue. Tumor temperatures between 43 C and 45 C were taken as the objective of each treatment, temperature profiles in the tissue being measured with copper-constant thermocouples. Patient response was assessed using a number of different criteria.

0555 THE INFLUENCE OF WHOLE-BODY HYPERTHERMIA ON SIDE-EFFECTS OF DOXORUBICINE AND RADIOTHERAPY I... ATS (MEETING ABSTRACT). (Eng.) Hinkelbein, W. (Zentrum Radiologie, Abteilung Strahlentherapie, Univ. Freiburg i. Br., W. Germany); Engelhardt, R.; Mehlert, W.; Neumann, H.; Wannenmacher, M. Strahlentherapie 158(6):382; 1982.

The effects of two combined treatment modalities (simultaneous combination of whole-body hyperthermia and doxorubicine treatment, simultaneous combination of whole-body hyperthermia and total-body irradiation) were studied in rats. Whole-body hyperthermia was induced by IRF (41 C±0.35 C core temperature for 10 and 20 min). Doxorubicine was administered in two injections (6 mg/kg on day 0 and 8 mg/kg on day 14). Total-body irradiation was 3.5 Gy γ-rays (Co^{60}). Haematotoxic (myelotoxic) and cardiotoxic side-effects were investigated. Hyperthermia alone produced leucocytosis and isolated sarcolysis. In combined treated rats intensified and reduced side-effects of doxorubicine and irradiation were seen depending on heating time.

0556 ASSESSMENT OF THERMOCOUPLE PROBES FOR USE IN RF FIELDS (MEETING ABSTRACT). (Eng.) Joiner, M. C. (Gray Laboratory of the Cancer Res. Campaign, Mount Vernon Hosp., Northwood, Middlesex HA6 2RN, England); Bremner, J.; Vojnovic, B. Strahlentherapie 158(6):384; 1982.

In order to compare different heating methods and quantify temperature patterns during hyperthermia, measuring probes should be able to accurately resolve temperature gradients in heated tissues. Such gradients can be large (>1 C/mm) in small experimental animal tumors heated by RF, microwaves or ultrasound where heated volumes are typically less than 0.5 cm^3. Data will be presented showing the extent to which bare (exposed junction) or metal and plastic sheathed thermocouple probes of varying sizes "smooth out" a sharp temperature change across a thin membrane. For probes sheathed in hypodermic needles, this effect is due to heat conduction along the metal shaft from hot to cooler regions and increases as needle diameter increases. Probes sheathed in plastic may read incorrectly if the connecting wires are large and the surrounding plastic tube has low thermal conductivity. The use of RF for heating generally leads to non-thermal interference with electronic temperature measuring equipment which necessitates the heating field being turned off before a measurement is made. However, the use of metallic probes in direct electri contact with surrounding tissue also results in apparent temperature rise in the immediate vicin of the probe which must be allowed to decay after RF has been switched off before an accurate measu ment of the true temperature in the tissue bulk be made. This effect is not seen with electrica insulated probes which are therefore preferable use in RF fields.

0557 EXPERIMENTAL AND CLINICAL STUDIES OF VA OUS SYSTEMS OF ELECTROMAGNETIC HYPERTH MIA (0.5 MHz, 13 MHz, 434 MHz, 2450 MHz) (MEETING STRACT). (Eng.) Lauche, H.-M. (Lab. Thermolo Biomedicale, Faculte de Medicine, Univ. Louis Paste 11, rue Humann, 67085 Strasbourg Cedex, France); Gu quin-Kern, J. L.; Pillement, P.; Moyses, B.; Gauth le, M.; Methlin, G. Strahlentherapie 158(6):3 1982.

The proper use of electromagnetic hyperthermia cancer treatment requires comprehensive knowledge numerous parameters concerning the target volume the irradiation system (generators and applicator Before starting investigations on patients, expe mental studies of several pieces of equipment effected using two different physical models: 1) cised animal tissues and post operative specime e.g. after mastectomy (analysis of deep temperat with an infrared thermograph, immediately after irradiation); 2) on original phantoms made of tra parent gels with known electric, dielectric and th mal properties corresponding to those of biologi tissues (analysis of deep temperature by means thermosensitive liquid crystal film) during the irr iation. Additional studies were carried out in a mals, in particular dogs, in vivo after anesthe and then post mortem, in order to investigate the fluence of blood flow and regualtory processes. these experiments, deep temperature was control using implanted needle probes, either metallic or interfering. Two categories of methods were used; capacitive hyperthermia using generators operating the radiofrequency range (0.5 MHz, 13 Mhz) with ext nal flexible applicators, or implantable needle pr allowing accurate heating in situ; b) radiative hyp thermia using generators operating in the microw range (434 MHz, 2450 Mhz) with new systems of exter applicators (surface cooling, cross-fire arrangeme ...). From these studies it follows that (1) mod may only be used to design, improve and compare he ing systems, and (2) the tumor temperature pattern largely dependent upon blood flow, histology and m phology of host and tumor. Protocols of therapeu trials may therefore be established on phase I stud on patients in order to take the individual changes vascular and thermal conditions into account. To t purpose, preliminary investigations have been effe ed on patients with advanced cancer, mainly skin m astases and breast carcinomas for which temperat control and clinical follow-up is relatively ea

Emphasis was laid on combination of hyperthermia with radiotherapy.

0558 LOCAL MICROWAVE HYPERTHERMIA COMBINED WITH RADIOTHERAPY: ONE YEAR'S EXPERIENCE (MEETING ABSTRACT). (Eng.) Valdagni, R. (Oncologic Center, Istituti Ospedalieri S. Chiara, 38100 Trento, Italy); Amichetti, M. Strahlentherapie 158(6):390; 1982.

From February 1981 to February 1982, 26 patients (32 fields) with histologically proven malignancy were treated with hyperthermia combined with radiotherapy. Most of the patients had failed conventional treatments. The patients were 19 male and 7 female, and the median age was 62 years, ranging from 45 to 94. Of the 26 patients, 25 had Karnofsky indices greater than 50%. Histologically the lesions include: 17 squamous carcinoma, 8 malignant melanoma, 3 adenocarcinoma, and 4 chordoma. RT (2-3-5 fractions/wk - dose per fraction: 1.80-6.00 Gy T. D.: 8.00-65.00 Gy) was applied using 2 linear accelerators (Mevatron Siemens) at 6-12 MV (electron of photon beam). Simultaneous microwave H (209 heat treatment sessions), external or interstitial. (42.5-44.0 C x 20 to 55 min 2-3 fractions/wk) was delivered by BSD - 1000 unit. Thermometry was performed by means of non-perturbing probes placed on the skin and in catheters inserted in the tumors. The frequency (300-900 MHz) and power (up to 130 W) used depended on the depth and size of treated lesions (maximum diameter: 8 cm, up to 5 cm depth). An analysis of technical data and clinical results will be presented.

0559 PRELIMINARY CLINICAL RESULTS OF LOCAL HYPERTHERMIA IN COMBINATION WITH LOW DOSE RADIOTHERAPY (MEETING ABSTRACT). (Eng.) van der Zee, J. (Dept. Exp. Radiotherapy, Erasmus Univ. Rotterdam, Rotterdamsch Radiotherapeutisch Instituut, The Netherlands); van Rhoon, G. C.; Wike-Hooley, J. L.; Reinhold, H. S. Strahlentherapie 158(6):390-391; 1982.

In the Rotterdam Radiotherapeutic Institute, 80 patients have been treated with l cal hyperthermia. This communication reports on the results from 28 of these patients, treated on 34 fields with local hyperthermia combined with a low dose of radiotherapy, and having evaluable tumor responses. Lesions treated were predominantly recurrences in previously irradiated fields. Histologies included mammary, lung, gynecological, kidney, and skin carcinoma. Tumors were heated using electromagnetic radiation with frequencies of 2450, 433 or 27 MHz. Temperatures were always measured with thermocouple needles and more recently also with an optical fiber temperature measuring system. Local hyperthermia was administered twice weekly, 30-60 min following radiotherapy, for a mean treatment duration of 60 min (3-10 treatme The average radiotherapy dose was 20±3.4 Gy. A "hyperthermia dose" we selected the mean of ma temperatures of all points measured in all trea sessions, the average for all patients being 1.4 C (range 40.5-45.3 C). Tumor response was de following WHO criteria (complete response = disap ance of tumor; partial response = 50% or more dec in tumor size). In this heterogeneous, non-rando group of patients we found a response rate of complete response in 6/35 fields and partial res in 22/35 fields. The separate contributions of treatment modalities to response were investi retrospectively. We found no significant correl between either the total X-ray dose or the X-ray tion size and response rate, bu the response rat + PR) was found to be correlated with the mean o maximum tumor temperatures. This indicates tha increasing temperature results in an increasing ponse rate. The combined therapy, in this heter eous group of patients, resulted in a 50% res rate at a mean maximum tumor temperature of 41 and an 80% response rate at a mean maximum tem ture of 42.3 C.

0560 INTERFERENCE OF 433 MHz MICROWAVES W MEGAVOLTAGE LINEAR ACCELERATOR (MEETIN STRACT). (Eng.) van Rhoon, G. C. (Dept. Exper tal Radiotherapy, Erasmus Univ., Rotterdam, The erlands); van der Poel, J. A. Strahlentherapie (6):391; 1982 (1 ref).

A series of experiments was conducted to invest the effect of 433 MHz microwaves on the perfor of a megavoltage linear accelerator, the Sagitt The microwave equipment consisted of a Sirether Siemens generator, power 250 W and a standard dir field dipole antenna. In all experiments the m wave unit stood in a room adjacent to that of th celerator. Microwave power levels were measured a Narda broadband radiation monitor, model 8300 at levels greater than 200 m W/cm^2 at 5 cm fro antenna no more than 2 mW/cm^2 were ever detect the control room of the Sagittaire. The element the Sagittaire itself were contained in 4 sep rooms, i.e., for the accelerator tube, the co units and the treatment of the patients. Measure of the accelerator performance were achieved wit use of conductor and thermoluminescense (TLD; lit fluoride) dosimetry systems. For the TLD measure the rods were situated in a 18x28x25 cm3 water f perspex box. In accordance with earlier findin W. J. Kopecky et al., we also found that the m operation of the Sagittaire was disturbed. How our observations do not indicate that there change in the dose delivered. But only showed the microwave interference was directed towards beam energy. For example, a consol set beam e of 25 MeV increased to 29 MeV when the microwave erator operated freely at maximum power. When of the microwave energy was absorbed by a 10 cm muscle phantom in front of the antenna there

still an increase of the beam energy to 26.9 MeV. With the measurements performed, no interaction of microwaves with beam homogeneity could be demonstrated. If the dose measured at the dose maximum in the water phantom was corrected for the change in energy, there was no evidence that the delivered dose was different from the one set on the control consol. Interference between these two systems is very difficult to discern. We would therefore like to advise, in agreement with the earlier investigators, that each accelerator/hyperthermia installation be carefully checked for possible interference effects, even when the accelerator appears to be operating normally.

0561 BLOOD FLOW AND OXYGEN SUPPLY TO MALIGNANT TUMORS DURING HYPERTHERMIA-EFFECT OF VARIOUS DOSES (MEETING ABSTRACT). (Eng.) Vaupel, P. (Dept. Physiology, Univ. Mainz, D-6500 Mainz, W. Germany); Otte, J.; Muller-Klieser, W.; Manz, R. Strahlentherapie 158(6):391; 1982 (1 ref).

Since tumor tissue oxygenation seems to play a decisive role during heat treatment in vivo, systematic investigations concerning the respiration rate of isolated ascites tumor cells, the O_2 consumption of solid tumors in situ, and both the oxygen partial pressure distribution and the oxyhaemoglobin saturation (HbO_2) of single red blood cells in tumor microvessels have been performed during and immediately after elevated tissue temperatures. The results clearly show that changes in tumor oxygen supply during hyperthermia are predominantly mediated through changes in tumor blood flow which showed the same directional changes. The present series of experiments was performed in order to get some data on the susceptibility of tumor oxygenation to various thermal doses as determined by the duration of heating and the tissue temperature increment during treatment. As a measure of tissue oxygenation, the oxyhaemoglobin saturation of single erythrocytes within tumor microvessels was determined immediately after localized microwave hyperthermia (2.45 GHz). For the present work, tumors of DS-carcinosarcoma implanted in the hind foot dorsum of SD-rats were used. The experiments were performed on 70 tumors with a mean wet wt of 3 g. Mean tissue temperatures were held at four levels: control (34 C), 40 C, 43 C and 45 C for 30 and 60 min. The results obtained indicate that thermal doses below 260 C/min can evoke an improvement of the tissue oxygenation. At higher doses a deterioration of the oxygenation status occurred. A 50% reduction of the tissue oxygenation was found at a thermal dose of approximately 400 C/min. The present study provides evidence that tissue oxygenation during heat treatment is probably dependent on the thermal dose. This is in contrast to previous findings of Reinhold and Van den Berg-Blok who found comparable effects of hyperthermia on microcirculation at different thermal doses. Further investigations will be necessary to clarify these controversies.

0562 DEVICE FOR TEMPERATURE MEASUREMENT [illegible] LIQUID-CRYSTAL PROBES DURING HIGH-F[illegible] SHORTWAVE HYPERTHERMIA (MEETING ABSTRACT). ([illegible] von Ardenne, M. (Res. Inst. Manfred von Ard[illegible] DDR-8051 Dresden, W. Germany); Bohme, G.; Kell[illegible] Schlechte, P. Strahlentherapie 158(6):391; 1982

Certain liquid-crystal mixtures are known to ex[illegible] color changes over a limited and adjustable oper[illegible] temperature range. These color changes correspo[illegible] shifts of intensity, shape of the maximum, and [illegible] length of the reflected light. Known devices me[illegible] ing mainly intensity of reflected light are af[illegible] ed by severa artefacts, e.g., variable sensitivi[illegible] the optoelectronic detector, instability of the [illegible] source and its variation with the ambient tempera[illegible] We present a measuring device, which exclusivel[illegible] tects and evaluates the temperature-dependent [illegible] length of the maximum of the light reflected by[illegible] liquid crystals and which is insensitive to ext[illegible] influences exemplified above. A minute amount o[illegible] quid-crystal mixture is entrapped into a sufficie[illegible] small probe which is introduced into the tumor [illegible] heated or into healthy reference tissue, respecti[illegible] The probe is connected with the detector unit by [illegible] of a two-component fibre optic. At the site of [illegible] energy electromagnetic fields there is hence onl[illegible] probe, which is indifferent to these fields and [illegible] versa, whereas the electronic setup is placed [illegible] shielded room apart from the patient. The reco[illegible] unit contains an automatically and periodically [illegible] monochromator with chopped light-source and an [illegible] tronic part consisting of the optoelectronic de[illegible] tor, the noise-limiting amplifier and the data-[illegible] cessing unit. The apparatus delivers values r[illegible] senting temperature. Each value persists on the [illegible] play during measuring cycle of the next value. [illegible] temperatures measured are also available as ana[illegible] signals at the output for recording. The prot[illegible] described has been successfully tested during cl[illegible] cal trials using the CMT Selectotherm technique [illegible] heating human tumors at 27.12 MHz.

0563 UPTAKE OF ^{99m}Tc-MDP AT A FRACTURE [illegible] TREATED WITH ELECTROMAGNETIC INDUCTIO[illegible] CURRENT (MEETING ABSTRACT). (Eng.) McCarthy, [illegible] (Univ. Dept. Orthopaedic Surgery, Princess Mar[illegible] Rose Orthopaedic Hosp., Fairmilehead, Edinb[illegible] Scotland); Annan, I. M.; Loudon, I.; Law, H.[illegible] Hughes, S. P. F. In: Transactions of the Secon[illegible] nual Meeting of the Bioelectrical Repair and [illegible] Society, held on 20-22 September 1982 in Ox[illegible] England; 211; 1982.

The uptake of the bone seeking tracer, ^{99m}Techne[illegible] labelled methylene diphosphonate (^{99m}Tc-MDP), [illegible] quantitatively measured to objectively assess [illegible] effectiveness of induced electrical current in [illegible] hancing fracture healing. A fracture model was [illegible] duced by open osteotomy of the sheep tibia. [illegible] Helmholtz coils which were driven by a trapez[illegible]

wave form in which the rising and falling slopes were approximately equal were placed on either side of the treatment site. At weekly intervals, for 5 wk after the osteotomy, ^{99m}Tc-MDP was injected into the sheep. The count rate at the fracture site was measured at 1, 5, 15 and 60 min after the injection by placing a collimated scintillation detector on the plates over the fracture site. In eight sheep studied (4 experimental and 4 controls), the count rate at 60 min increased during the 5 wk studied (360 ± 90 to 760 ± 280 for the experimental group, and 230 ± 40 to 670 ± 200 for the controls). At each of the measurement times, the values in the experimental animals were relatively higher than in the control sheep, e.g., 0.40 ± 0.09 compared with 0.26 ± 0.04 at 1 min after injection (where the data had been normalized to unity at 60 min after injection). This difference was statistically significant ($p<0.05$). The results demonstrate that in vivo measurements can detect changes in fresh fractures stimulated with induced electrical currents.

0564 EFFECTS OF ELECTRICAL STIMULATION ON CALCIUM-45 UPTAKE IN FRACTURED FIBULAE FROM NORMAL AND THYROPARATHYROIDECTOMIZED RABBITS (MEETING ABSTRACT). (Eng.) Guy, D. K. (Dept. Anatomy, Health Sciences Center, Univ. Louisville, Sch. Medicine, Louisville, KY, 40292); Wald, H. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:2; 1982.

An investigation was undertaken to determine whether electrical stimulation of fracture healing enhances the uptake of calcium into bone and whether the enhanced mineralization, if present, is independent of hormonal influence. A transverse, mid-shaft fracture of the fibula was produced bilaterally in 20 New Zealand White rabbits. The right fibula of each animal was electrically stimulated with 18-20 uA of direct current while the left side served as control. Ten of the rabbits also underwent thyroparathyroidectomy at the beginning of the experimental period. These ten animals received thyroid hormone as replacement therapy but were considered to have an absolute deficiency of calcitonin and parathyroid hormone. All animals received ^{45}Ca iv at intervals during the healing period. At the end of the 21-day study, bone samples from both fibulae and the proximal half of the radius were taken from each animal. The amount of ^{45}Ca per unit wt of bone was determined by analyzing the samples on a liquid scintillation counter. The results demonstrated no difference in ^{45}Ca uptake between stimulated and non-stimulated fibulae. Fractured bones did exhibit a significant increase in uptake over non-fractured bones. In the absence of calcitonin and parathyroid hormone, all bone categories studied demonstrated a statistically significant increase in ^{45}Ca uptake. Since all bone categories were equally affected, these data are believed to reflect an increase in the turnover rate rather than an actual increase in the total amount of calcium present.

0565 ELECTRICAL ACCELERATION OF THE RATE FRACTURE HEALING IN THE PRIMATE METATAR (MEETING ABSTRACT). (Eng.) Walter, J. (Pennsylv Coll. Podiatric Medicine, 8th at Race St., Philad phia, PA 19107); Harrington, D.; Walker, E.; Gl T., Black, D.; Bodamer, W. In: Transactions of Second Annual Meeting of the Bioelectrical Rep and Growth Society, held on 20-22 September 1982 Oxford, England; 2:3; 1982.

The primate Cebus Albafrons (organ grinder monk was used to explore the effects of small amounts electric current on acceleration of fracture heal in the primate metatarsal. Young (late adolescen monkeys were chosen because of the biological biomechanical similarities between the primate the human. Each animal was anesthesized and dorsal region of the third metatarsal was exposed each foot. Two Kirshner wires were inserted pr imally and distally, perpendicular to the long a of the bone, in the dorsal aspect of the metatars Then a third Kirshner wire was placed and fixed ho zontally across both vertical wires, thereby creat an external fixation device. Next, a 2.0-mm ost tomy was made between the proximal and distal fi tion pins, and a stainless steel electrode (tef coated except for the tip) was placed in the ost tomy site and fixed in place by being attached to horizontal portions of the external fixation devi The incisions were closed and casted, then one f was chosen at random to be the experimental (active electrode) while the other metatarsal ser as control (dummy electrode). Anodes were placed different sites. Three groups of animals with animals per group were used for this study. Grou represented 8 days post-operative, Group B was days post-operative and Group C ran for 22 days af surgery. The data indicated that the electrica stimulated osteotomies healed faster than the cont groups, that the electrically stimulated bone appe ed as normal, woven bone with little or no endoch dral formation, and its ossification was more vanced than control samples. Osteoblastic activ and vascularization was also greater in experimen samples.

0566 BIOELECTRIC AND HISTOMORPHOMETRIC CHAN DURING FRACTURE HEALING (MEETING ABSTRAC (Eng.) Chakkalakal, D. A. (Orthopaedic Res. Lab., Medical Center and Dept. Orthopaedic Surgery, U Nebraska Medical Center, Omaha, NE 68105); Lippiel L.; Connolly, J. F. In: Transactions of the Se Annual Meeting of the Bioelectrical Repair and Gr Society, held on 20-22 September 1982 in Oxford, gland; 2:4; 1982.

The correlation between local electric fields calculated from voltage measurements in bone and new bone formation obtained in the osteotomized canine radius was investigated. Four Ag.AgCl bead electrodes were implanted in the bone; two in the cortical region and two in the medullary region. Voltage measurements were done 1x wk. At 9, 8, 10 and 12 wk post osteotomy the dogs were sacrificed; the radius was sectioned transversely into 2-mm sections and a point counting method was used to quantitate new bone formation. From the voltage measurements the average electric field strengths in the regions between electrodes were calculated. A correlation was found between the combination of magnitude and duration of electric field of negative polarity ("field dose") and the amount of new bone formation. In one dog the amounts of new bone in the regions proximal and distal to the osteotomy were comparable corresponding to similarity of the "doses" in the two regions. In contrast, in a second dog, considerably more bone formation occurred in the distal region corresponding to the much larger "dose" there compared to the proximal region. Work is in progress to seek further correlations between osteogenesis in specific stages and the details of changes in the local electric field.

3567 PRIMARY INDUCED CELLULAR CHANGES AND CELL SPECIFICITY IN PULSED CAPACITIVE STIMULATION OF BONE CELLS IN VITRO (MEETING ABSTRACT). (Eng.) Korenstein, R. (Weizmann Inst., Dept. Membrane Res., Rehovot, Israel); Somjen, D.; Fischler, H.; Binderman, I. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:5; 1982.

Results of a study on pulsed capacitive stimulation of mixed population of bone cells in culture are reported. Stimulation of bone cells was performed by a series of rectangular voltage pulses (25 usec width, 3 Hz repetition rate) of varying amplitudes, lasting 5 min. Low field strength stimulation (13 V/cm prevailing in the culture medium) caused immediate decrease of 30% in intracellular level of cyclic AMP (cAMP) which was followed by a 1.3- to 1.4-fold increase in DNA synthesis 24 hr later. Middle field strength (22 V/cm) caused no change both in cAMP and DNA. High field strength (54 V/cm) caused a 1.8-fold increase in cAMP level and a 2.5-fold increase in DNA synthesis. These bone cell cultures, prepared from rat embryocalvaria were shown to respond both to parathyroid hormone (PTH) and to prostaglandin-E_2 (PGE_2). When bone cells were subcultured they lost their responsiveness to either PTH or electric field but responded to PGE_2 by an increase in cAMP production. Furthermore the subcultures lost their responsiveness to either PTH or PGE_2 in terms of DNA synthesis and maintained their responsiveness to low electric fields only (1.3-fold increase in DNA synthesis). It is suggested that the cells that respond to low field stimulation are the PGE_2 sensitive cells and those that respond to high f are the osteoclast-like, PTH-responding cells. different cell types are stimulated at diff regions of the applied electric fields. The ele cal stimulation was shown to induce cascade of chemical events, where the immediate bioche changes included cyclic nucleotide changes (and ion fluxes (Ca^{+2} fluxes). This transmi of the electric stimulus at the membrane through a second messenger mechanism is compar the stimulus-signal transmission mechanisms by mones and growth factors.

3568 ALTERNATING MAGNETIC FIELDS ENHANCE SYNTHESIS IN FIBROBLASTIC CELLS ME ABSTRACT). (Eng.) Liboff, A. R. (Dental Res. Br Stop #18, Naval Medical Res. Inst., Bethesda 20814); Strong, D. M.; Wistar, R. In: Transac of the Second Annual Meeting of the Bioelect Repair and Growth Society, held on 20-22 Sept 1982 in Oxford, England; 2:9; 1982.

The effect of sinusoidally varying magnetic fiel DNA synthesis in cells was investigated in vitr pair of matched incubators equally fitted wi specially designed set of coils, 0.5-m inside dia and 0.25-m in length. Three-coil configurations employed with spacing equal to half the radi turns on the center coil and 2N on the end coil order to optimize the field uniformity over a l volume than could be obtained with a classical holtz arrangement. Two independent series of e iments were performed using this set-up. Human skin fibroblasts (HEM-HFS-15) were seeded int and 96-well tissue culture plates using DMEM an FCS and the plates distributed equally betwee experimental and control incubators. An amplitu 0.2 G was used as well as frequencies ranging be 40 and 80 Hz. The relative amounts of thymidin take in the experimental and control plates wer termined using: (1) a 1-hr ^{3}H-thymidine pulse an 18-hr pulse, and (3) an integrated ^{3}H-thym label introduced with the initial inoculation. was found that in 45/48 paired plates, the leve incorporated thymidine was significantly highe the experimental plates; it was further observed the amount of incorporated thymidine in exposed peaked at a two-fold ratio over the control cel the vicinity of 20 hr after the beginning of sure. It is concluded that there is a consi stimulatory effect of sinusoidal magnetic fiel the DNA synthesis of human foreskin fibroblast vitro and that the specific pulsed electromag field waveshape is not required to elicit this fect.

3569 THE EFFECT OF PULSATING ELECTROMAG FIELDS ON PROSTAGLANDIN SYNTHESI OSTEOBLAST-LIKE CELLS (MEETING ABSTRACT).

Johnson, D. E. (Dept. Oral Biology, Univ. Connecticut, Sch. Dental Medicine, Farmington, CT 06032); Rodan, G. A. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982, in Oxford, England; 2:7; 1982.

The effect of pulsating electromagnetic fields (PEMF) on prostaglandin synthesis was investigated in the rat osteosarcoma-derived osteoblastic cell line ROS 17/2.8. Cells were grown to confluence in F-12 medium supplemented with 10% fetal bovine serum and were exposed to PEMF for up to 24 hr. Prostaglandin E was measured in cell media by radioimmunoas ; the release of ^{14}C-arachidonate (the prostaglandin precursor) from phospholipids of prelabelled cells and its conversion to ^{14}C-PGE$_2$ were assessed by thin layer chromatography of organic solvent media extracts; the activity of cyclooxygenase, the prostaglandin synthesizing enzyme, was assayed by incubating living cells with arachidonate and measuring PGE by RIA. It was found that PEMF: (i) had no effect on cyclooxygenase activity, which had a K_m of 20 uM and a V_{max} of 160 ng/10^6 cells/min; (ii) stimulated the release of arachidonate from phospholipids by about 50%; and (iii) increased PGE production from 200 pg/hr/culture to 350 pg/hr/culture. The PGE concentration in culture media exceeded 10 nM, a level which enhances cyclic AMP accumulation, growth and osteoclast activation in bone explants. The stimulation of PGE synthesis by PEMF in osteoblastic-lineage cells is consistent with membrane-mediation and cyclic AMP-involvement in the transduction of electrical signals and the subsequent effects on growth and maturation.

0570 IN VITRO CAPACITIVELY COUPLED ELECTRICAL STIMULATION OF BOVINE ARTICULAR CHONDROCYTE PELLETS IN VARYING SERUM CONCENTRATIONS (MEETING ABSTRACT). (Eng.) Brighton, C. T. (Dept. Orthopaedic Surgery, Univ. Pennsylvania, Philadelphia, Pa 19104); Unger, A. S.; Stambough, J. L. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982, in Oxford, England; 2:8; 1982 (2 refs).

A facilitory response of in vitro bovine articular chondrocyte pellets is reported which is dependent on the concentration of newborn calf serum (NBCS) in the presence of a capacitively coupled field. Articular cartilage was obtained in a sterile manner from the stifle joints of male Holstein calves (1-2 wk old). Pellets were formed from 4 x 10^6 isolated articular chondrocytes prepared by selective matrix digestion using sequential enzymes (trypsin, hyaluronidase, collagenase) and grown in tissue culture media (TCM) with 10% NBCS for 72 hr prior to stimulation. Tissue culture media with 1% or 10% NBCS was labelled with ^{35}S-sulphate (10 uCi ml) or ^{3}H-thymidine (5 uCi ml). The freshly labelled system was stimulated for 24 hr in an externally applied 250-V peak-peak, 60 kHz, sine wave capacitively coupled field which g a current density in each 16.1 mm^2 petri dish uA/cm^2 (RMS value). In the presence of a cur density of 37 uA/cm^2/dish (250 V peak-peak) and with 10% NBCS, ^{3}H-thymidine incorporation per ug tein and DNA was significantly increased ($p < .05$), ^{35}S-sulphate incorporation per ug protein was signi cantly decreased ($p<.05$). Repeating the same exp ment in 1% NBCS showed an increase in ^{35}S-sulp incorporation per ug protein and DNA ($p < .05$), but thymidine incorporation was not significantly aff ed. A current density of 37 uA/cm^2/dish (250 V p peak external signal) further enhances these in v effects in a statistically significant manner. T findings emphasize the importance of serum concen tion in in vitro cellular systems. More importan this study shows that a capacitively coupled elec signal can act to modulate a predetermined cell response in mammalian articular chondrocytes.

0571 STIMULATION OF CONNECTIVE TISSUE PRO SYNTHESIS IN FIBROBLAST CULTURES BY PU MAGNETIC FIELDS (MEETING ABSTRACT). (Eng.) Mur C. (Strangeways Res. Lab., Cambridge, England). Transactions of the Second Annual Meeting of the logical Repair and Growth Society, held on 20-22 tember 1982, in Oxford, England; 2:9; 1982.

The effect of the Bi-Osteogen system (E.B.I., U Ltd) on protein synthesis, in particular the synth of matrix components, by embryonic chicken te fibroblasts (CETF) in culture was investigated. mary cultures of CETF were exposed to pulsed elec magnetic fields (PMF) of the repetitive pulse b type on a 6 hr-on/6 hr-off cycle through a 9 growth period. Cell numbers were measured electr cally and protein synthesis studied by incorpora of ^{3}H-proline into non-dialyseable material. To gen was estimated by analysis of conversion of proline to ^{3}H-hydroxyproline. No effect of two ferent PMFs, varying only in negative width, observed on cell proliferation. Protein synth was not affected during exponential growth, but significantly elevated (+40-60%) by one partic waveform. Collagen was also relatively increa approximately 11% of the total protein being re sented by collagen in treated cultures, compared 5% in controls. Collagen types were unaffecte PMF. Both control and treated synthesized type and III in a ratio of 9:1, with trace amounts type V. Concurrent with this increase in pro synthesis, was an 80% increase in the amount of belled material precipitable with antiserum to fi nectin, in treated cultures. These data suggest certain PMFs can alter protein metabolism and particular the accumulation of connective tissue ponents by tendon fibroblasts in culture, but during the confluent phase of growth. In addit not all waveforms have the same biological eff

0572 A GENERALIZED THEORETICAL APPROACH TO THE DETERMINATION OF LOCAL FIELD PARAMETERS DURING CAPACITIVELY COUPLED ELECTRIC STIMULATION IN VIVO (MEETING ABSTRACT). (Eng.) Vresilovic, E. J. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19104); Pollack, S. R.; Brighton, C. T. In: Transactions of the Second Annual Meeting of the Biological Repair and Growth Society, held on 20-22 September 1982, in Oxford, England; 2:10; 1982 (2 refs).

Dielectric, circuit, and control theory were used to develop a generalized theoretical approach to the determination of local field parameters during capacitively coupled electric stimulation in vivo. A generalized capacitively coupled in vivo experiment places the limb of an animal between two stimulation electrodes to which a driving signal is applied. These electrodes may be on the skin or separated from it by air or another material. Generally, an in vivo experiment is found to have a less accurately defined environment when compared to its in vitro counterpart. This holds true for modeling geometries and electrical properties as well. The model must approximate the actual geometry and also adequately define the boundary conditions needed to solve the Laplace equation. However, animal limbs represent complex geometries and approximate models must be used. Additionally, these models are further complicated by animal to animal variation. The electrical properties, the conductivity and the permittivity, must be defined as a function of frequency for each material. Electrode-dermal impedance may be conveniently thought of as the electrode impedance coupled to the skin impedance. The electrode-dermal impedance for humans is primarily dependent on electrode type, area, current density, signal frequency, stimulation location, and sweat gland activity. Electrode-dermal impedance has not been fully described for other species, and the applicability of the human impedance model raises questions based on the species variation in skin morphology. The relationship of the LFPs to the driving signal is established by solution of the Laplace equation with Laplace Transform methods once the system is modeled. This results in a transfer function in the s frequency-domain which is used to define the LFPs as a function of the driving signal in the time domain. The in vivo theoretical approach is illustrated with an experiment where 1.5-cm diameter stimulation electrodes were placed on the medial and lateral surfaces over a fibular fracture in a rabbit. A 10-V 60-kHz signal was applied with 50% amplitude modulation. Using human electrode-dermal impedance values, the calculated maximum values of field and current density were 15 V/cm and 1.5 mA/cm^2, respectively.

0573 FREQUENCY WINDOWS IN STIMULATING A CELL WITH ELECTRIC FIELD: A COMPUTER SIMULATION (MEETING ABSTRACT). (Eng.) Ridella, S. (Consiglio Nazionale delle Ricerche, Istituto Circuiti Elettronici, Via Opera Pia, 11 - 16145, Genova, Italy); Drago, G. P.; Marchesi, M. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Gr Society, held on 20-22 September 1982 in Oxford, land; 2:11; 1982.

The effects of an electric field on the cell mem were investigated using a computer simulation cell, simulated by a multilayer spherical struc on a digital computer, was exposed to an alterna current electric field. The electrical properti possible biological interest, such as, fields, v ages, currents and ion densities were evalu throughout the cell to elucidate which part of cell is stimulated and what kind of charge trans will occur. Every layer was characterized by dat complex dielectric constant or equivalent impeda which was obtained through experimental measureme The cell membrane model was developed to obtain ion densities at the surface and the ion-flux ac the membrane. The nucleus was modelled so a account for the binding of divalent ions to the fixed charged phosphate groups. With an app field of 200 V/m it was found that: (1) the density variation on cell membrane reached a max (about 2%) in the frequency range 0.1-10 Hz, possible consequences on membrane receptors and, sequently, on biological behavior; (2) the vol on the membrane reached a maximum of 2 mV in frequency range 1 kHz-1 MHz: a safety threshold mV had been suggested; (3) the ion passive flux the vicinal ion concentration reached a maximu 7.8 x 10^{-2} A/m^2 and 6.9 x 10^{-6} coulombs/m^2, res tively, in the frequency range 0.1 kHz-1 MHz, frequency range used in bone-healing; (4) the sorbed ion density reached a sharp maximum of coulombs/m^2 in the frequency range 0.1-1 Hz; frequency range in which strong calcium ion eff influx has been observed; (5) current density ir nuclear membrane pores reached a very high and maximum of 44 A/m^2 in the frequency range 1-10 it has been estimated that currents of this order modify chromatin; (6) the charge shift inside nucleus, which could influence chromatin deconde tion, had a maximum at about 7 kHz. It is concl that some electric fields inside the cell are gre than external ones at particular frequencies and each transfer function between one of the electi quantities of biological interest to the exte field shows a maximum in the range 0-10 MHz.

0574 INDUCED ELECTRIC POTENTIALS IN VIVO DUCED BY CAPACITIVELY COUPLED SIG (MEETING ABSTRACT). (Eng.) Brager, M. D. (Dept thopaedic Surgery, Sch. Medicine, Univ. Pennsylva PA 19104); Brighton, C. T.; Pollack, S. R. In: Tr actions of the Second Annual Meeting of the Biol cal Repair and Growth Society, held on 20-22 Sep ber 1982, in Oxford, England; 2:12; 1982 (1

Induced electric potentials in vivo produced by acitively coupled signals were investigated. subjects for this study were six, 3-4 kg adult

New Zealand white rabbits and four adult male humans. The humans were patients who had electrodes inserted for treatment of ununited fractures and consented to participate in these measurements made prior to connection of the direct current power supply. The electrodes were 1.2-mm diameter stainless steel wire insulated except for a 1.3-cm tip that was implanted in bone. Two of the same electrodes were percutaneously inserted through the lateral and medial femoral condyles of the rabbit right hind limb. These were then advanced into the femoral canal in a parallel fashion along the lateral and medial endosteal surfaces. The implanted tips acted as probes for monitoring induced potentials (V_I). Bare, stainless steel capacitor plates were applied to the skin on opposite sides of the limb external to the location of the uninsulated monitoring tips. The plate diameters were 3.0 cm for human studies and 1.7 cm for rabbit studies. A function generator supplied sine wave driving signals (applied voltage, V_A) to the capacitor plates. Induced potentials in RMS voltage were measured directly across the exposed portions of the electrodes (monitoring electrodes) using a digital voltmeter. Increase in V_A always resulted in a linear increase in V_I. Limb size had no significant effect on V_I. Increasing plate diameter resulted in no significant difference in V_I. Increasing plate pressure against the skin in rabbits resulted in an increase in V_I. Through a sequence of V_A 2, 5, 10, 20 and 30 V peak-peak, loosely applied plates (determined by minimum stable current draw in capacitor plate leads) produced a mean V_I of 15.5 mV. Through the same sequence of V_A, tightly applied plates (determined by maximum stable current draw in the capacitor plate leads) produced a mean V_I of 52.5 mV. The total range of V_I was 0.5 to 168.0 mV. A monatonic increase in V_I was observed with increasing frequencies of 0.1, 1.0, 10, 20 and 60 kHz. V_A, plate size, and plate pressure were kept constant during these measurements. Measurements of remote V_I were made with the capacitor plates in locations of the body away from the monitoring electrodes. In humans the largest falloff of V_I occurred within 20 cm from the coupling site. In rabbits, at V_A of 5.6 V peak-peak the mean local V_I was 3.9 ±1.3 mV while the mean remote V_I (plates on the opposite hind limb) was .55 ±.19 mV. Therefore, the ratio of the mean local V_I to mean remote V_I was 7.1 to 1. It is concluded that the relationship between the induced or stimulating signal and the signal applied to the capacitor plates is influenced by a variety of experimental variables which must be controlled for definitive experimentation.

0575 HELMHOLTZ COIL - CELL SYSTEM SPATIAL RELATIONSHIP AND ELECTRICAL DOSAGE IN THE ELECTROMAGNETIC MODULATION OF TISSUE GROWTH AND REPAIR (MEETING ABSTRACT). (Eng.) McLeod, B. R. (Dept. Electrical Engineering and Computer Science, Montana State Univ., Bozeman, MT 59717); Pilla, A. A.; Sampsel, M. J. In: Transactions of the Second Annual Meeting of the Biological Repair and Growth Society, held on 20-22 September 1982, in Oxford, England; 2:13; 1982.

The spatial distribution of pulsating electromagn ically-induced current (PEMIC) in physiologic sal was quantitated for the most commonly employed c culture and suspension system as a function of c ori- nation. Theoretical predictions were based Ma 's field equations for cylindrical (coils h iz) and rectangular (coils vertical) geometri Com data were generated from the theory so fi plots could be done to graphically illustrate current density changes with position. Experimen verification utilized specially constructed electr probes with which both the induced electric fiel E, and current density, J, vectors were measured saline. The results showed that, for cylindri geometry, E and J were concentric rings about center of a Petri dish or culture tube placed a where in the region of spatially constant magne field, B. Both E and J increased linearly w radius, r, having maximum values at the outerm ring, just inside the insulating vessel wall. vertical coils, E and J vary in the vertical dir tion approximately linearly with saline height, for planes not adjacent to the vessel walls. complete induced field pattern for this geometry complex. However, on the bottom of a dish wh most cells reside in a culture experiment) the maj ity of J lines were perpendicular to B. Electri dosage in a cell culture experiment, therefo clearly depends upon coil orientation, the dim sions of the vessel, and the height of the cult medium. For example, compared to J at any r cylindrical geometry, its value on the bottom pl for vertical coils differed by approximately factor h/2r. All of the above considerations summarized using theoretical and experimental curr density-position plots. The essential results in cate that nearly uniform electrical dosage is achie only when the cell system is relatively planar (c culture - vertical coils). All other cases result a spatially variable induced current density, w maximum dosages depending on coil orientation.

0576 A NEW PROCEDURE FOR ELECTRICALLY STIMUL ING CELLS IN CULTURE (MEETING ABSTRAC (Eng.) Liboff, A. R. (Naval Medical Res. Inst., Be esda, MD 20814); Halverson, B. A. In: Transacti of the Second Annual Meeting of the Biological Rep and Growth Society, held on 20-22 September 1982, Oxford, England; 2:14; 1982.

A novel capacitive, noninvasive procedure for el trically stimulating cells in culture is report The procedure has the capability of (1) allow simultaneous study of many cluster plates, (2) m nicking the waveshapes induced by pulsed electrom netic field coils, (3) allowing simple control frequencies, and (4) accurately characterizing charge density applied to the cell substrate. excellent electric permittivity associated with t sue culture cluster plates allows one to use the w capacitance to intrinsically differentiate pulses plied to the outside of the plates; monolayer c

cultures plating the interior of each well are thereby subjected to precisely the same charge signature. In these studies, 24-well COSTAR tissue cluster plates were used which have a well bottom thickness of 1 mm and a dielectric constant of 3.3. These plates were modified by painting silver electrodes on the outside bottoms of all wells, experimental and control. Pulses from a function generator and a pulse-shaping circuit were applied to the plates directly in the incubator. Preliminary results have been obtained for two distinct experiments; one testing the effect of repetitive (15 Hz) electric pulsing on cell adhesion and the other measuring the effect on cellular metabolism. Human foreskin fibroblasts (HEM-HFS-15) were used throughout. Enhanced rates of adhesion and increased uptake of radiolabeled thymidine, uracil and proline were observed for negative pulses generating surface charge densities of 4 pC/cm^2/pulse.

0577 ON THE TREATMENT OF LOOSENING OF ENDOPROSTHESES BY MEANS OF PULSING ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Eng.) Kraus, W. (Inst. Medical Physics, Augustenstrasse 41, D-8000 Munich 2, W. Germany); Lechner, F.; Ascherl, R.; Blumel, G. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:15; 1982.

A clinical multicenter study including 13 orthopaedic surgery clinics and 10 private orthopaedists was performed to evaluate the use of electrical and electromagnetic stimulation in the treatment of patients with loosened endoprostheses. Low frequency (12-22 Hz, 30 Oe), sinus pulsing magnetic fields were used to treat 462 patients with cemented prostheses and 15 with cement-free prostheses. All patients were candidates for reoperation. Adjustable and special shaped coils around the hip joints were applied and the treatment was performed on an average of 2-3 hr/day for 15.4 wk with a maximum observation period of 8 yr. Treatment results were staged according to spontaneous pain, pain in motion, use of crutches, distance of walking, and dose of analgesics. In 122 (26%) of the patients excellent results were recorded, i.e., painless walking without the use of crutches was obtained, and in 188 (41%) good results were yielded; 97 (21%) reported no effects. In 55 (12%) of the cases in which treatment failed totally, patients underwent further surgery with a re-implantation. Thus, in 67% further surgery could be avoided, even in intractable cases. Comparison with previous studies indicated that the efficacy of the treatment seemed to be significantly better in cases of loosened cement-free prostheses. This treatment should be limited to cases in an early stage of loosening. Septic loosening, fractured cement, broad radiolucent lines and dislocation of the implant must be treated surgically.

0578 PULSATILE ELECTROMAGNETICALLY INDUCE RENTS SYNERGIZE WITH POLYMER IMMUN LATING DRUGS IN THE INHIBITION OF GROWTH OF MALIGNANT MELANOMA (MEETING ABSTRACT). (Eng.) A. A. (Bioelectrochemical Lab. Dept. Applied Che and Chemical Engineering, Columbia Univ., New NY 10032); Norton, L.; Tansman, L. In: Transac of the Second Annual Meeting of the Bioelectric pair and Growth Society, held on 20-22 Septembe in Oxford, England; 2:16; 1982.

Inhibition of the growth of murine malignant me with the combined application of pulsatile el magnetically-induced currents (PEMIC) and polym munomodulating drugs was investigated. One hu female BDF_1 or BCF_1 mice were implanted with 1 m melanoma. The animals were then divided into co PEMIC alone and PEMIC + Pyran (75 mg/kg, 1 or after implantation) groups. Mice treated with were placed (free roaming) in specially constr cages between horizontal Helmholtz air-gap activated for 12 hr/day. This coil configu allowed electrical dosage to be relatively in dent of animal movement. The pulsating ma field (dB/dt approx. = 0.1 G/usec) induced currents configured of 50 msec bursts of 250 main polarity and 4 usec opposite polarity asym cal rectangular pulses. The average induced c per pulse could be varied from approximately uA/cm^3 (i.e., average pulse current per unit of treated tissue) while maintaining all other parameters constant. Results were obtained b sessing palpable tumor volumes as a function o and by observation of survival time. The survival time for control animals was 7 wk an not affected by PEMIC or Pyran alone. Ho treatment with PEMIC + Pyran increased surviva to 10 wk in 100% of treated mice. This repres significant reduction in tumor growth rate, po via enhancement of immune response. These r provide strong evidence that an effective and toxic anti-cancer treatment modality may be at

0579 THE SIDE EFFECTS TO THE INTERNAL ORG PULSING ELECTRO-MAGNETIC FIELDS (M ABSTRACT). (Eng.) Ohashi, T. (Dept. Orthopaedic ery, Murakami Memorial Hosp., Gifu Coll. Dent 1-6 Wakamiya-cho, Gifu, Japan 500); Inoue, S.; S H.; Ashihara, T. In: Transactions of the Second al Meeting of the Bioelectrical Repair and Growt iety, held on 20-22 September 1982 in Oxford, En 2:17; 1982.

Complications involving internal organs were in gated following exposure to pulsing electroma fields (PEMF). One group of rats was exposed t while housed in a plastic cage while a second which served as control, was maintained in an i cal cage without exposure. Following sacrifice abdominal organs of the rats were examined hist cally and the results were compared according

age of the animal, i.e., young, young adult and adult. Vacuolar degeneration was observed in the kidney and liver of rats stimulated continuously for 2 days with PEMF; the effect was age-dependent with the severest degeneration found among the younger rats. The same degree of vacuolar degeneration was observed in the liver, but not the kidney, of animals exposed 12 and 16 hr/day, resp., for 1 wk. Liver degeneration in rats exposed for 3 days was not reversed after 11 days of non-stimulation. The spleen, testis, and skin were not affected by PEMF. The results indicate that great care should be observed when applying PEMF to the spine or pelvis.

0580 TREATMENT OF AVASCULAR NECROSIS OF THE FEMORAL HEAD WITH DIRECT CURRENT: A PRELIMINARY REPORT (MEETING ABSTRACT). (Eng.) Steinberg, M. E. (Dept. Orthopaedic Surgery, Univ. Pennsylvania, Sch. Medicine, Philadelphia, PA); Brighton, C. T.; Tooze, S. E.; Hayken, G. D.; Steinberg, D. R. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:18; 1982.

The effectiveness of direct current stimulation as a supplement to surgical decompression and bone grafting in the treatment of avascular necrosis of the femoral head was investigated. Initially, 250 cases of avascular necrosis, including 48 hips treated nonoperatively, 7 treated with drilling/decompression, and 9 treated with decompression and grafting, were reviewed. Seventeen hips were treated by decompression and grafting with either of two techniques of electrical supplementation. In one, 4 wire cathodes were inserted around the central graft and connected to an external power source. In the other, a single cathode was coiled about the graft and connected to a subcutaneous power pack; 20 uA were delivered to each electrode. Hips were evaluated preoperatively at 3, 6, 12 and 18 mo. Of 48 hips treated non-operatively, 44 showed progression. All 7 hips treated with drilling/decompression and 7 of 9 treated with grafting progressed, although these groups did better than the non-operative group. To date, none of the hips treated with electrical stimulation have progressed and 5 have shown healing of cystic areas. Most have noted pain relief and one has achieved a significant increase in motion. Electrical stimulation as a supplement to decompression and grafting, gives a significant improvement in the results obtained by surgery alone. Although this is a preliminary report and longer follow-up will be needed for definitive conclusions, the present results are promising and may have important clinical implications.

0581 SELECTIVE IN-VIVO CELLULAR STIMULATION WITH A DIRECT CURRENT - A PRELIMINARY REPORT (MEETING ABSTRACT). (Eng.) Schmidt, R. G. (McKay Orthopaedic Surgery Res. Lab., Dept. Orthopaedic Surgery, Univ. Pennsylvania, Philadelphia, PA); Freiberg, Z. B.; Brighton, C. T. In: Transactions of Second Annual Meeting of the Bioelectrical Repair Growth Society, held on 20-22 September 1982 in ford, England; 2:19; 1982.

Results obtained using a novel design for electr stimulation in vivo to determine if a selecti applied direct current could induce bone formatic muscle or cause any other cellular effects are ported. Selective in vivo stimulation was applie securing a 26-gauge multistranded cathode wire i a diffusion chamber (Millipore Corp., volume 130 pore size .45 microns) implanted ip in adult New Land rabbits. Each rabbit contained 2 sc imple battery packs, each of which supplied 3 separate c odes with a constant direct current of 5 uA. A genous muscle was instilled into each of the chan at the same cellular concentration of 3.10^6 cells chamber in the form of a cellular suspension. T rabbits for a total of 36 chambers were stud Rabbits were sacrificed at 7, 13, and 18 day in vals. Two chambers from each animal (1 stimula 1 control) were processed histologically while remaining 10 chambers were analyzed biochemica Of the six chambers analyzed histologically (3 trol, 3 stimulated) no difference could be dete in cell morphology or in the amount of muscle generation. None of the chambers demonstrated osteoblastic activity on hematoxylin-eosin, saf min-O, or alkaline phosphatase stains. Of th chambers analyzed biochemically, no difference c be detected in protein or DNA content between st lated and control chambers. Control and stimul chambers demonstrated the same degree of cell gr with time. This new technique for electrical st lation allows for the in vivo determination of effects of a direct current on any isolatable type.

0582 SIMILARITY OF PIEZOELECTRIC PROPERTIE DRY BONE AND POLED POLYMERS (MEETING STRACT). (Eng.) Williams, W. S. (Dept. Ce Engineering, Univ. Illinois, 105 S. Goodwin A Urbana, IL 61801) In: Transactions of the Second nual Meeting of the Bioelectrical Repair and Gr Society, held on 20-22 September 1982 in Oxf England; 2:20; 1982 (6 refs).

The objective of this study was to understand the signals produced by cantilever bending of bone are so large, independent of orientation of specimen, linearly dependent on the bending mo about the electrodes, and not predictable fr piezoelectric d-matrix which adequately descr the response to uniaxial compression; an explana was also sought as to why poled sheets often ha larger than expected converse effect (bending def tion with applied electric field) and also dis the direct response features described above for bone. It has recently been shown that the piezoe

tric response of dry bone to cantilever bending can be understood on the basis of a spatially-varying value of the appropriate d-coefficient, within the framework of the classical third tensor theory of piezoelectricity: $P_i = d_{ijk}(x,y,z)\sigma_{jk}$. This spatial variation is justified by the finding of a radial component of the spontaneous polarization. The rectangular geometry of a beam cut from a radially poled cylinder (whole bone) requires a spatial variation of the polarization between the electrodes placed on either side of the beam in the cantilever bending apparatus. Integration of the electric field, now a function of position, between the electrodes yields a predicted voltage that has the characteristics observed. A spatially-varying value of the converse-effect coefficient has been shown to explain the large deflections observed with polymer "benders." It was found that with electrically-inhomogeneous specimens, bimorph behavior can be duplicated with "monomorphs." (The bimorph analogy was invoked earlier to explain bone behavior, and the validity of the equations produced was confirmed with these ceramic devices.) Thus the puzzling piezoelectric response of synthetic polymers (PVF_2) and natural polymers (collagen) to inhomogeneous stress can be explained on the basis of specimen inhomogeneity.

0583 IN VITRO MEASUREMENTS OF BIOLOGICAL IMPEDANCES (MEETING ABSTRACT). (Eng.) Tuerlinckx, B. (Electricite Generale CP. 165; Univ. Libre Bruxelles, Ave. F-D. Roosevelt, 50, B-1050 Brussels, Belgium); Henrotte, J-L.; Rybowski, L.; Dierickx, M.; Hinsenkamp, M.; Burny, F. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:21; 1982.

The induced currents and fields in the area adjacent to a bone subjected to electromagnetic stimulation were calculated. In order to obtain realistic results, accurate and reliable impedance values for bone and muscle (both transverse and longitudinal) and fatty tissues over the same frequency range as the stimulation signal had to be obtained. A sophisticated measurement technique was therefore developed, which features: fast measurement (less than a msec) for "quasi in vivo" conditions; low amplitude, wide spectrum input current signal (4-20 uA, 100 Hz to 2 MHz); well-defined current flow geometry; a 4-electrode system, cancelling the effects of electrode impedance; a high-performance output voltage differential amplifier; discrete-time domain transfer function analysis; and, microcomputer controlled measurement and data acquisition. The collected data are processed by a CDC-Cyber computer, using a maximum likelihood method, and results are validated by several statistical hypotheses tests, giving a high degree of confidence in the final values. The equipment was first tested with reference R-C networks, showing excellent overall reliability and accuracy ranging from .5 to 5%. Measurements on salt water and physiological saline proved the absence of parasitic electrode effects, and confirmed the expected accuracy. Impedance values for several biological materials were then obtained, including blood, muscle and bone, and compared with previously published values. The results include: optimum order of the transfer function; transfer function parameters (Laplace and Z-transform); equivalent network parameters; standard deviations and confidence intervals for each measurement; standard deviations between different samples; and evolution of parameters in time.

0584 ON THE ORIGIN OF STRESS GENERATED POTENTIALS IN WET BONE (MEETING ABSTR. (Eng.) Salzstein, R. (Dept. Bioengineering, Pennsylvania, Philadelphia, PA 19104); Pollack, In: Transactions of the Second Annual Meeting o Bioelectrical Repair and Growth Society, held on 22 September 1982 in Oxford, England; 2:22; 19 refs).

The origin of stress-generated potentials (SGP) in wet bone was investigated with particular reference to the fluid influence on the form, magnitude and time dependence of the measured SGP. SGP measurements were made as a function of time on 6 cortical bovine femoral samples in step-loaded four-point bending. From classical streaming potential theory the zeta potential of bone was proportional to (SGP)(fluid vicosity)(conductivity)/(dielectric permittivity)(outer fiber strain) for four-point bending of bone. For the 6 samples, the value zero occurred in a range between M=.152 and .337 g-mol the crossover range. Bone is porous, possessing Haversian and Volkmann's canals, canaliculi, and a porous matrix. Therefore, the zeta potential of bone may not be a single-valued parameter, but may be a function of the local composition of the matrix and the fluid at their interface. Accordingly, the zeta potential will vary spatially and with electrolyte concentration. At low concentrations (zeta>0), component A is observered at high concentrations (zeta<0), component D is observed. For concentrations near the crossover range, both components A and D may be expected. A spiked component, peculiar to piezoelectric in nature, is expected at the crossover concentration (zeta=0). The observed SGP will be composed of these 3 components each with a given magnitude, depending upon the bone architecture and the fluid dynamics within the bone.

0585 FACTORS INFLUENCING HEALING IN THE TREATMENT OF NON-UNION WITH ELECTRICITY (MEETING ABSTRACT). (Eng.) Brighton, C. T. (Dept. Orthopaedic Surgery, Univ. Pennsylvania, Sch. of Medicine, Philadelphia, PA 19104). Friedenberg, Z. B.; Black, J.; Heppenstall, R. B.; Esterhai, J. L. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:23; 1982.

The cases of 382 patients with non-union secondary to trauma treated with constant direct current were reviewed to determine those factors that influenced the healing rate. The patient population consisted of 231 males and 151 females of average age 38.7 yr and with an average duration of the non-union of 2.5 yr. There were 392 non-unions in the 382 patients. Forty-three percent of the original fractures were open, 66% of the non-unions had been been operated on previously, and 22% had a history of osteomyelitis at the non-union site. Forty-seven percent of the non-unions were hypertrophic and 13% atrophic, 40% were neither or were mixed; the "classical" mortar and pestle configuration was uncommon (3%); 12% of the non-unions contained a synovial pseudarthrosis (the humerus showed the highest incidence of this, 41%); a non-union "scar" remained in the medullary canal in 12% of the healed patients; and the majority of tibial and femoral non-unions were sclerotic or of normal density, and the majority of humeral non-unions were osteoporotic. Factors that adversely affected healing were: (1) presence of synovial pseudarthrosis (healing rate 0%); (2) interfragmentary gap greater than one-half the diameter of the bone (healing rate 7%); combined thickness of the cortices (either proximal or distal to the non-union site) of less than 20% of the total width of the bone at that level (healing 25%); osteoporosis of the ends of both fragments at the non-union site (healing rate 29%); and (5) osteomyelitis at the fracture site (healing rate 61%). The age of the patient, the duration of the non-union, and the presence of pre-existing metallic fixation devices did not affect the heal rate. The overall heal rate for those patients treated adequately with direct current was 81%. Heal rates for the individual bones were as follows: metatarsal, malleolus, fibula, and and talus - 100%; radius - 93%; tibia - 86%; carponavicular and ulna - 82%; femur and clavicle - 71%; and humerus 54%. Complications were few and consisted mainly of mild i[illegible]ation around the cathodes at the skin level i[illegible]se patients who were too active with the casted extremity. No deep infections occurred in this series. It is concluded that the treatment of non-union with direct current is as effective as bone graft surgery with a much lower risk/benefit ratio.

0586 TREATMENT OF NON-UNION WITH CONSTANT DIRECT CURRENT (MEETING ABSTRACT). (Eng.) Ahl, T. (Dept. Orthopaedic Surgery, Danderyds Hosp., S-182 88 Danderyd, Sweden); Andersson, G.; Herberts, P.; Kalen, R. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:24; 1982.

A series of 20 non-union cases are presented which were treated with constant direct current at Sahlgrenska Hospital and Ostra Hospital in Gothenburg and at Danderyds Hospital in Stockholm, Sweden. Three to four teflon-coated Kirschner wires, which acted as cathodes, were inserted percutaneously into a non-union area. A small portable battery delivered a stant direct current of 20 uA/cathode. During of electrical treatment the non-unions of the extremity were immobilized in a non-weight bea plaster cast. Casts were also used for the upper tremity except in 3 cases with non-unions of the erus where a Hoffman external apparatus was Only fractures that were not clinically healed wi a minimum of 6 mo and that had not shown any fur signs of healing on x-ray during the last 3-mo pe were included. The bones involved included the t in 12 patients, the scaphoideum in two, the femu one and the humerus in four patients. One unsucc ful fusion of the ankle was also included. The d tion of non-unions ranged from 6.5 to 43 mo, wi mean duration of 17 mo. Two of the non-unions originally open fractures. Four non-unions had operated on earlier in unsuccessful attempts achieve union, and three patients had a previous tory of deep infection. Of 20 patients treate achieved solid bone union. However, most of non-unions of the long bones did not heal until mo after the beginning of electrical stimulat The tibia was the easiest bone to treat, while humerus seemed to be the most difficult, an exp ence which agreed with other reports. Minor com cations such as broken and dislocated Kirschner-w and superficial skin irritation were observed cases. One patient with a previous deep infec experienced a recurrence of osteomyelitis and patient with a non-union of the scaphoideum wit previous infection developed a deep infection a 9 wk of treatment. Electrical stimulation of unions is considered to be a promising complemen accepted surgical therapy, especially in cases suitable for surgery. This study also indic that all types of non-unions do not respond wel electrical treatment.

0587 ROENTGENOGRAPHIC OBSERVATION OF ELECTR CALLUS FORMATION IN CLINICAL CASES (MEE ABSTRACT). (Eng.) Inoue, S. (Dept. Orthopaedic gery, Murakami Memorial Hosp., Gifu Coll. Dentis 1-6 Wakamiya-cho, Gifu, Japan 500); Ohashi, T.; K kawa, K.; Tada, M.; Saito, Y. In: Transaction the Second Annual Meeting of the Bioelectrical Re and Growth Society, held on 20-22 September 198 Oxford, England; 2:25; 1982.

Approximately 40 cases of non-union or delayed were treated with electrical stimulation using st less steel cathodes and stainless steel or ca fiber anodes. Roentgenographic analysis of the e trical callus formation in these cases indicated the shape and site of the callus were not unif Some cases showed callus formation all around ins ing and projecting areas of the cathode. Other c showed callus formation in either part of inser and projecting areas of the cathode. Some showe significant callus formation at the cathode site, gradual filling appeared at the fracture site callus formation was found at the pin site of the

ternal skeletal fixation apparatus. It is not known why the different types of electrical callus are formed. The electric potential distribution and current between cathode and anode are too complicated in vivo to clarify even with a computed simulator. Results of experiments using rats indicate that the callus is formed by proliferation and differentiation of periosteum and endosteum promoted with electric stimulation. It is postulated that electrical callus is formed at the most proper area of electric current and potential distribution.

0588 ELECTROMAGNETIC FIELDS USED IN THE TREATMENT OF FRESH FRACTURES OF THE RADIUS (MEETING ABSTRACT). (Eng.) Wahlstrom, O. (Dept. Orthopaedic Surgery, Univ. Hosp., Linkoping, Sweden) In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:26; 1982.

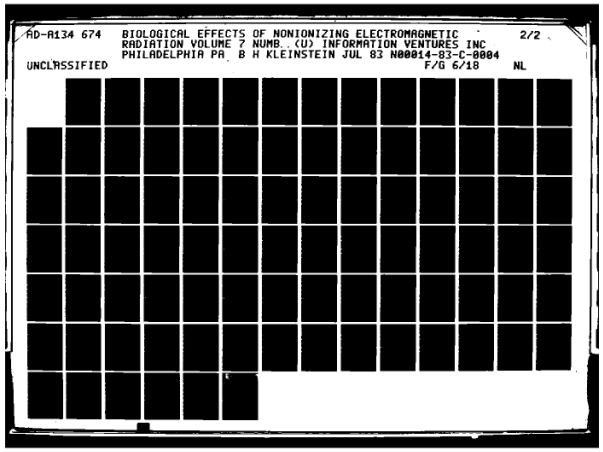
The effect of extremely low frequency (ELF) electromagnetic fields (EMF) on the healing activity of fresh fractures was investigated. Thirty women (50-70 yr old) with extra-articular, dislocated fractures of the distal radius underwent routine treatment with closed reduction and immobilization in a cast for 4 wk, and were then randomized into a therapy and a control group. The therapy group was treated during immobilization with EMF in the ELF range (1-1000 Hz) by means of a copper wire coil and a battery-powered current-generator. Scintimetrical examinations were performed 1, 2, 4 and 8 wk after the initial trauma, with ^{99m}Tc-diphosphonate used as a tracer. The results obtained after 2 wk showed a significantly ($p<0.01$) higher increase in scintimetric activity over the fracture area in the EMF-treated group compared to the control group ($p<0.01$). The serial scintimetric examinations indicated that EMF-treatment gave a significantly higher increase at the beginning of the healing process ($p<0.01$) and there was probably also a retrogression toward normal values faster in the therapy group than in the control group. The results indicate that treatment of fresh fractures with EMF of this type is efficacious.

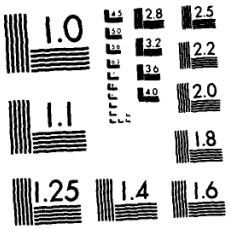
0589 THE USE OF THE DENHAM EXTERNAL FIXATOR IN CONJUNCTION WITH ELECTROMAGNETIC INDUCTION OF FRACTURE HEALING (MEETING ABSTRACT). (Eng.) Simonis, R. B. (Rowley Bristow Orthopaedic Hosp., Pyrford, Woking, Surrey, England); Good, C.; Cowell, T. K. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:27; 1982.

Results are presented using pulsed electromagnetic fields (PEMFs) combined with Denham external fixation (compressed to provide rigidity) in the treatment of bone fractures. Eleven patients had non-union of tibia, 2 of the forearm and 1 had a failed fusion the knee. The average time of non-union was 27 (10 to 55 mo). The stimulator consisted of a wa form generator, high current output stage and tr ment coil. The coil was in two flat circular tions of diameter 18 cm, mounted so that the spa could be adjusted from a few cm to approximately cm maximum. The waveform generator provided a p train of prf 4 kHz, duty cycle approximately modulated by a second pulse train of prf 25 Hz, cycle 7.5%. This provided a composite waveform sisting of 3 msec duration bursts of the 4 kHz pu at intervals of 40 msec. During each cycle of t kHz pulse train, the output stage produced a magn field in the coil rising linearly to a peak value around 3 mT in 230 usec, followed by decay to zer approximately 20 usec. All the cases, except united within an average of 4 mo (3 to 8 mo). one failure was due to human error in over compr ing the fixator and refracturing the non-union. use of an external fixator allows adjacent joint be kept mobile and the skin to be treated, while patient undergoes PEMFs. Subsequent to this re the technique has been used successfully for nonun in most long bones including the femur and the hu us. This method has become the basis of a do blind controlled trial to determine the effective of PEMFs.

0590 THE COMPATIBILITY OF METALLIC FIXATION PULSED ELECTROMAGNETIC FIELDS (MEETING STRACT). (Eng.) Bassett, C. A. L. (630 W. 168th New York, NY 10032); Schink, M. M.; Mitchell, S. In: Transactions of the Second Annual Meeting of Bioelectrical Repair and Growth Society, held 20-22 September 1982 in Oxford, England; 2:28; 1

The compatibility of metallic fixation with pu electromagnetic fields was investigated in 540 c of non-union. Each patient treated with pulsed e tromagnetic fields (PEMFs) had a history of at l one failure to achieve union after the use of pla screws, intramedullary rods, or pins. No pat had a concomitant surgical attempt at repair. series included loosened, broken and distracting tallic devices. PEMFs, alone, or in combination plaster casts and non-weight-bearing were used the nearly 200 surgeons who contributed patie The overall success rate was 75% and ranged from for the tibia to 60% for the humerus. Twenty-percent had a history of infection and union occu in 70% of these. Patients with a long disabi time (2 yr) and atrophic lesions had the lowest cess rate (except for the tibia). Union was de mined, in part, by patient management. When hard was loose or broken and a sound plaster cast used, (and non-weight-bearing for lower extremiti the success rate for all lesions (except humerus) 93%. In the humerus, good management principles proved the percentage of union from 60% (gencra to 75%. Furthermore, patients, in whom plantg


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graphic evidence of loosening appeared, around screws or rods (e.g., radiolucent zones), manifested in increasing radiodensity in these regions of bone resorption. No clinical evidence of corrosion was found and devices removed after union appeared "clean." The median time to union for all anatomical sites was 5 mo, essentially equal to that in a series of 1078 non-unions in which only 200 patients had metal in place during PEMF treatment. This study confirms the proposal that PEMFs and non-magnetic devices are compatible.

0591 THE EFFECT OF PULSED MAGNETIC FIELDS ON cAMP METABOLISM IN CHICK EMBRYO TIBIAE (MEETING ABSTRACT). (Eng.) Jones, D. B. (Strangeways Res. Lab., Cambridge, England) In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:29; 1982 (1 ref).

The effect of pulsed magnetic fields (PMF) on cAMP metabolism was studied as a mechanism of transducing electrical stimulation into cellular metabolic effects. cAMP was extracted from the separated shafts and cartilages of whole rudiments which were cultured in serum free medium for up to 8 days. PMF were applied, after the first 24 hr, in a cycle of 6 hr ON, 6 hr OFF. Although PMF had no effect on the DNA content of shafts or cartilages, PMF treated cAMP values showed large fluctuations when measured half way through the OFF period. When PMF switched OFF after 186 hr of culture, cAMP levels in shafts rose by up to 200% within 5 min, dropping to 150% over control by 30 min, and then fluctuated widely around control values for the rest of the OFF cycle. Cartilage responded to PMF OFF by dropping sharply in cAMP content to 60% of control by 5 min and then returning to a wide fluctuation around control values over the rest of the OFF period. When PMF swithed ON at 192 hr, shaft cAMP values rose 150% by 5 min and then fell rapidly after 15 min to 30% of control content at 30 min, after which cAMP content flucuated widely around control values. Cartilage showed a reverse response, dropping below control at 5 min and then increasing to a fluctuation averaging above control after 30 min. Inhibitors of phosphodiesterase (PD) were used to calculate the relative activities of PD and adenylate cyclase (Ac). These studies showed that although in shafts at 30 min into the ON period cAMP content was at 30% of control, Ac activity had risen from 0.1 pmole min per ug DNA to 3.6 pmoles min ug DNA, but this activity was exceeded by the rate of PD activity, resulting in a net loss of cAMP. Other changes in cAMP content could be explained in terms of the relative activities of Ac and PD. Trifluoperazine, an inhibitor of calmodulin was used to study the action of PMF on calmodulin in the activation of Ac and PD, and indicated that the activation of Ac and PD was calmodulin dependant. These results indicate that PMF affects cAMP metabolism through the activation of adenylate cyclase and phosphodiesterase, and effect that is entirely consistent with the hypothesis that cal levels in the cells are being affected. The res ing change in cAMP metabolism and the inferred ch in calcium levels are also consistent with the viously reported effects of PMF on chick em tibiae.

0592 ELECTROMAGNETIC MODULATION OF CALCIUM TAKE IN EMBRYONIC CHICK TIBIA IN VITRO: PENDENCE ON INDUCED CURRENT WAVEFORM PARAME (MEETING ABSTRACT). (Eng.) Pilla, A. A. (Bioe trochemistry Lab., Dept. Applied Chemistry and Ch tal Engineering, Columbia Univ., New York, NY 10 Colacicco, G. In: Transactions of the Second An Meeting of the Bioelectrical Repair and Growth S ety, held on 20-22 September 1982 in Oxford, Engl 2:30; 1982.

The relationship between induced current pulse p meters and short time Ca uptake in osteochron genic tissue was investigated. Paired tibiae dissected from 9 day white Leghorn chicken emb and placed in 1 cm^3 of a simplified culture me consisting of (mM) NaCl, 90; KCl, 5; $CaCl_2$, $MgSO_4$, 1.2 glucose, 120; $NaHCO_3$, 10; NaH_2PO_4 pH adjusted to 7.0, containing 0.5 uCi of One of the tibiae of each pair was placed (at 3 between Helmholtz coils and exposed for 60 mi several induced current waveforms. Ca uptake assessed by scintillation counting of the me after exposure. All induced current waveforms bipolar and approximately rectangular having p widths of 2-400 usec. The signals were peri consisting of repetitive single or pulse burst terns. The peak induced current per pulse va between 0.1 and 10 uA/cm^3 as measured in the me using specially constructed electrode probes. uptake in the treated tibiae ranged to a peak of 7% above controls and was clearly dependent signal parameters. A dose effect existed we pulse amplitude and/or repetition rate. For exam the peak response was observed for a 5 msec burs 200 usec main, 20 usec opposite polarity pulses peating at 15 Hz, falling off below and above repetition rate at a constant induced current am tude of 2 uA/cm^3. In addition, pulse width c be predictably varied within the range of this s provided amplitude and repetition rate were ap priately modified with little effect on the response. All of the results obtained in this s showed a remarkable degree of correlation with quency analysis of the induced current waveform b upon the ion binding pathway.

0593 PHYSICAL FACTORS INVOLVED IN BIOLOGICAL SPONSES TO PULSED MAGNETIC FIELDS (MEE ABSTRACT). (Eng.) Jackson, S. F. (Strangeways Lab., Worts Causeway, Cambridge CB1 8RN, Engla Marsland T. P.; Barndale R. W.; Boutle, A. P.

Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:31; 1982.

Data accumulated from studies of tibiae grown in organ culture under the influence of various PMF were correlated with information about (a) time responses and (b) amplitude and frequency content of the signals as defined by classical Fourier analysis. The processes used as yardsticks of the effects on osteogenesis and chondrogenesis included morphology, DNA metabolism/cell proliferation, changes in amounts of collagen and proteoglycan constituents and mineralization. Studies of the effect of treatment time have shown two types of response: linear increase/decrease with time, indicating a cumulative effect; or a discontinuous effect in that prolonged treatment reduced increases obtained with shorter exposure times. When different pulse train waveforms were applied under the same experimental conditions, different levels of response of one process were obtained. This finding may be related to the different energy and/or frequency content of the waveforms used. A major difference lay in the range 15-65 kHz (3 dB band width), while both 15 Hz and 4.4 kHz harmonics were common to all signals used. Comparison of the effects of repetition rates in the range of 6-133 Hz with SP waveforms, in which the signal level was maintained at a constant value, showed that a 15 Hz rate achieved the best balance between the various processes measured. Since the frequency content of the signals was similar, the observed changes may be related to differences in the harmonic spacing of the signal and/or changes in amplitude, resulting in reductions of energy. Consideration has also been given to possible field effects, so as to provide information about the relative importance of polarization phenomena versus the effects of small diffusion currents. Results also suggest that the organization/nature of the tissue may play an important role.

0594 EFFECT OF PULSED ELECTROMAGNETIC FIELDS ON CELLULAR INFILTRATION AND COLLAGEN FORMATION IN IMPLANTED VISCOSE SPONGES (MEETING ABSTRACT). (Eng.) Jolley, W. B. (1329 Pacific St., Redlands, CA 92373); Knierim, K.; Ham, J. M.; Hinshaw, D. B. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:32; 1982.

The effect of pulsed electromagnetic fields (PEMF) on cellular infiltration and collagen formation was investigated in viscose sponges implanted sc in the rat living in PEMF for a period of 7 days. The PEMF was generated in bursts of pulses, each burst lasting 5 msec with a repetitive rate of 15/sec. The pulse rate within each burst was 3 KHZ. Individual pulses had a duration of 200 usec in their principal deflection followed by a smaller deflection of opposite polarity lasting 18 usec. These pulses were applied to two Helmholtz coils. The coils were spaced a apart and each had 501 turns with a circumferen 40 cm. The induced current density was about uA/cm^2 and established an electrical gradient o proximately 3.0 mV cm. Four viscose sponges of ly equivalent wt and size were implanted sc rats. The rats were randomly divided in two g A (controls) and B (field, experimental). The were placed in plastic tube restrainers for pe of 20 hrs/day. Group B rats were placed betwee coils of the pulsed field. Group A was kept identical conditions except for the field. days later, the rats were weighed and sacrif The sponges were removed and weighed. Histolo reactions of the sponges were compared for the n of macrophages, neutrophils and fibroblasts pr by counting 10 high power oil immersion fiel each section. Both groups of animals showed id cal weight loss of 56 g during the experi There were no statistically significant change the weight of the sponges (control = 25.4 g field on 24.9±5.1). A statistically signif ($p < .05$) increase in the number of fibroblasts i PEMF (71.7 vs 54.8) was observed. The numbe neutrophils and macrophages showed no statis difference. Spectrophotometric scanning sho qualitative difference in the collagen present ing trichrome stained sections. The result these experiments confirm data obtained by o that PEMF affect certain cells which are involv wound healing and/or collagen formation. Fu studies are in progress to define the exact anisms involved.

0595 MEASUREMENT OF SKIN POTENTIAL PAT (MEETING ABSTRACT). (Eng.) MacDonal (Dept. Electrical Engineering, Univ. Wales, Swa SA2 8PP, England); Watson, J. In: Transactio the Second Annual Meeting of the Bioelectrical R and Growth Society, held on 20-22 September 19 Oxford, England; 2:33; 1982 (3 refs).

Very low drift direct current silver/silver chl electrodes were used to produce a quasi-three-d sional display, with the axes of voltage, posi and time. An indifferent electrode was refer to a position over the mid-diaphysis of the t and eleven other electrodes were positioned pro and distal to it. All the electrodes were inter to a microprocessor-controlled electrometer-type suring instrument, and every 15 min, the set of ings was sampled. The microprocessor then pl each point using an X-Y plotter, and interpo continuous lines from each point in the previou to produce the quasi-three-dimensional format. choice of the skin surface over the mid-diap as the reference or indifferent point, was ma the empirical grounds that potentials both pro and distal to this point were normally posi The potential pattern itself appeared to consi "electrobiological noise" some 5 to 10 mV high, slowly-changing peaks up to 35 mV superimposed

has been noted that this pattern can be markedly altered (even to polarity reversal) by both physical and mental disturbances on the part of the subject. Plots from healthy volunteers and others are presented.

0596 THE EFFECTS OF PULSED ELECTROMAGNETIC FIELDS ON PROTEIN SYNTHESIS AND MEMBRANE TRANSPORT IN RAT SKIN (MEETING ABSTRACT). (Eng.) Delport, P. H. (Faculty Medicine, Univ. Louvain, Louvain, Belgium); Cheng, N.; Hoogmartens, M. J.; Mullier, J. C.; Sansen, W.; De Loecker, W. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:34; 1982 (1 ref).

The effects of pulsed electromagnetic fields (PEMF) on protein synthesis and membrane transport in the skin of rats was investigated. Skin from the back of locally inbred male Wistar R rats, during the rest phase of the hair-growth cycle at 21 days of age was used after plucking of the hair. During incubation at 37 C for 5 min to 120 min a PEMF was applied to one skin sample of each rat while the other half was identically incubated outside the reach of the electromagnetic field. Driving voltage varied from 5 V to 20 V, pulse frequency from 50 Hz to 10 kHz, pulse width from 10 usec to 150 usec, pulse burst frequency from 1 Hz to 70 Hz and the number of pulses from 20 to 100. The in vitro stimulation of the skin by PEMF resulted in an increased incorporation of [2-14C] glycine and of L-[U-14C] alanine into the proteins only with a specific combination of parameters. The incorporation of [2-14C] glycine or L-[U14C] alanine into the protein was increased by 40% to 90% with the PEMF characteristics: 10 V, 5 kHz (pulse frequency), 10 usec; 20 Hz (pulse burst frequency) and 20 pulses per burst. Increasing either the pulse width to 20 usec or the pulse burst frequency to 20 Hz, equally stimulated protein synthesis. The amino acid transport was enhanced by 30 to 60%. A related time curve (5:120 min) was established. Only specific combinations of pulse parameters resulted in stimulatory effects on metabolism. Thymidine incorporation to evaluate DNA metabolism did not show any clear evidence of stimulation by PEMF nor did ATP generation increase. These observations suggest that the metabolic effects of electromagnetic stimulation are probably based on mechanisms different from those observed with the direct electric currents.

0597 THE EFFECTS OF DIRECT ELECTRIC CURRENTS ON INTRACELLULAR pH AND TRANSMEMBRANE POTENTIALS IN RAT SKIN (MEETING ABSTRACT). (Eng.) Cheng, N. (Faculty of Medicine, Univ. Louvain, Belgium); Preneu, J.; Carmeliet, E.; Hoogmartens, M. J.; Mullier, J. C.; Sansen, W. M.; De Loecker, W. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:35; 1982.

The effects of direct electric currents on intracellular pH and transmembrane potentials in rat s were investigated. After the removal of the hair plucking, the skin from the back of 21-day-old m Wistar R rats was isolated and longitudinally halv One half served as control and the other half stimulated by constant direct electric curre varying from 10 uA to 10,000 uA. The tissue fl were clamped between two adjustable stainless st electrodes and placed in Krebs-Ringer bicarbon buffer to be incubated for 2 hr at 37 C with without direct electric currents supplied by a s bilized power supply. By cutting the skin in str parallel to the electrodes, protein synthesis, generation intracellular pH and transmembrane pot tials were measured as a function of the distan from the cathode and the anode and as a function the current intensities. With direct electric c rents of 100-750 uA, protein synthesis was stimula by up to 75% ($p<0.001$) and ATP generation increa 4-5x about the non-treated controls. The nigh levels of stimulation were obtained adjacent to cathode. Near the anode the stimulatory effects protein and on ATP synthesis were decreased by ($p<0.01$) and by 68%, respectively. After elect stimulation with 500 uA for 2 hr, a pH gradient measured from 7.68 ± 0.04 near the cathode 7.05 ± <0.001) near the anode. When currents pa ed through the tissue, the resting membrane pot tial was depolarized at the cathodic area, whil hyperpolarization occurred at the anode. The cha on transmembrane potential was a function of distance from the electrodes and the intensities the current. During treatment of skin with a dir electric current, a higher anabolic activity nea the cathodic interface appeared to be conditio by a proton gradient and a membrane potential gra ent. Proton transfer leading to ATP generation se ed to occur by a repetition of elementary pro jumps resulting in a charge transport.

0598 CHANGES IN MEMBRANE PERMEABILITY AND INT ACTIONS BETWEEN CONNECTIVE TISSUE MAC MOLECULES INDUCED BY AN APPLIED ELECTRIC CURR (MEETING ABSTRACT). (Eng.) Eisenberg, S. R. (Cont uum Electromechanics Lab., Dept. Electrical Engine ing and Computer Science, Massachusetts Inst. Tech logy, Cambridge, MA 02139); Grodzinsky, A. J.; Fe ner, P. Y. In: Transactions of the Second Ann Meeting of the Bioelectrical Repair and Growth So ety, held on 20-22 September 1982 in Oxford, Engla 2:36; 1982 (4 refs).

Changes in membrane permeability and interactions tween connective tissue macromolecules induced by applied electric current were investigated. Cor collagen membranes, approx. 150 micron thick, w placed in a transport cell with gradients in NaCl pH. Collagen is nearly isoelectric at neutral pH has (+) charge at low pH. Application of approx. mV (applied current density [J] = 6.6 mA/cm2) acr the membrane produced a change in intermolecu

swelling forces and concomittant isometric tensile force measured by the load cell. The possibility that matrix swelling is linked to changes in solute permeability was tested via measurement of radionuclide tracer flux (^3H_2O and ^{14}C-sucrose double tracer) before and after membrane pH or ionic strength was changed directly or by means of J. The force kinetics and polarity observed suggested that an electro-diffusion process controls intramembrane NaCl concentration. Hence, changes in intermolecular spacing which affect permeability occurred in approx. 10 sec for a membrane thickness of approx. 150 um. The fact that ^3H_2O permeability was not significantly altered by J suggests that electroosmotic entrainment of solutes could not be the only cause for observed changes in sucrose flux. Rather, small changes in matrix intermolecular spacing can have a significant effect on the diffusivity of a larger solute (sucrose) whose size is not small compared to membrane pore radius.

0599 NERVE REGENERATION IN VITRO: CORRELATION OF CURRENT/POTENTIAL LEVELS WITH NEURITE OUTGROWTH, NEURONAL CELL NUMBER AND AREA (MEETING ABSTRACT). (Eng.) Sisken, B. F. (Wenner Gren Res. Lab. and Dept. Anatomy, Univ. Kentucky, Lexington, KY); Barr, E. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:38; 1982.

Evidence is presented that correlates the morphological parameters of neurite outgrowth (NO) and maintenance of the neuronal population (neuronal cell areas and numbers of cells) with different direct current levels. Trigeminal ganglia, obtained from 8-day-old chick embryos, were placed in 60 mm tissue culture dishes (Falcon 3002) containing 6 ml culture media. The tops of these dishes were modified to hold either platinum electrodes, tantalum electrodes, or agar salt bridges. Potentials of -200, -400, -600, and -800 mV were imposed on dishes by employing an agar salt bridge to a saturated calomel reference electrode connected to a potentiostat. Current/voltage curves were first obtained for each metal electrode and current values alone for the agar salt electrode in the tissue culture medium. In vitro experiments on the ganglia (control cultures, cultures treated with various levels of direct current, or cultures treated with NGF, 10^{-8} M) were conducted for 3 days. Neurite outgrowth was determined semi-quantitatively in all cultures. Neuronal preservation was assessed quantitatively by counting the number of neurons in 2 micron sections of the explants on three levels and determining neuronal cell area on these sections. Neurite outgrowth was correlated with current levels rather than potential difference, i.e., maximum NO with tantalum was at -400 mV (10 nA) while platinum was at -200 mV (12 nA). Numbers of cells in ganglia treated with current (1-20 nA, any electrode) and mean neuronal cell areas were all comparable. Increased levels of current decreased both parameters. NGF treatment produced higher numbers with larger cell areas. A compar of each treatment to 8-day uncultured trigem ganglia is presented graphically. It is concl that current levels of 1-20 nA using any elect system (platinum, tantalum, or agar salt electro stimulate nerve regeneration in vitro.

0600 ELECTROMAGNETIC INDUCTION OF NEUROTR MITTER RELEASE FROM A NEURONAL CELL LIN TISSUE CULTURE (MEETING ABSTRACT). (Eng.) Rein (St. Bartholomew's Hosp., Dept. Medical Electron West Smithfield, London, England); Dixey, R.; Wat B. In: Transactions of the Second Annual Meetin the Bioelectrical Repair and Growth Society, hel 20-22 September 1982 in Oxford, England; 2:39; 1

The effect of low frequency electromagnetic (1 fields on calcium-dependent neurotransmitter rel was investigated using a neuronal cell line. P chromocytoma (PC12) cells grown in monolayer cul were placed in a CO_2 incubator between two concen coils connected in parallel to a driving circuit pulse generator producing a train of square pulses. A pulse width of 0.6 msec with a 1.4 gap between each pulse was used for all experime giving an overall frequency of 500 Hz. The magni of the resulting magnetic field applied to the c varied from 1.6 to 8.5 G with the electric f strength in the medium ranging from +0.038 to -0 V/m. Noradrenaline (NA) release was measured in arithmic phase PC12 cells by preloading synaptic s age vesicles with ^{3}H-NA taken up from the mec After an extensive washout period to reduce cytop mic stores of NA, the spontaneous efflux curve determined by measuring radioactive NA in the me for 12 sequential 15-min periods. For the exp mental runs, two culture dishes were removed their protective Numetal shield and placed bet the coils in the incubator during the 7th and time periods. Release values were expressed percentage of total vesicular stores and normal for direct comparison between dishes. Release va observed during LFEM field stimulation were 28% h er than control values obtained at the correspon time points ($p<0.001$). This elevation was attrib to increased release of NA from the cells since a tional experiments have ruled out the possibi that LFEM fields cause cell detachment. The addi of 15 mM Mg^{++} to the medium during the experime periods completely inhibited the LFEM field inc release. Since magnesium is known to be a spec calcium antagonist and inhibits depolarization duced release in PC12 cells, LFEM field induced release is likely to be dependent on extracell calcium. However, it remains unknown whether the lease observed occurred via the same exocytotic anism as conventional depolarization induced rel Nonetheless, the magnitude of the effect was of same order of magnitude as release previously to be induced in these cells by certain type cholinergic stimuli. The results indicate that cells can be used as a model system for studyin

effects of electromagnetic field on neuronal function and more specifically for studying their effects on neurotransmitter release mechanisms.

0601 THE EFFECTS OF EMBRYONIC NERVE TISSUE AND DIRECT CURRENT ON AMPUTATED RAT LIMBS (MEETING ABSTRACT). (Eng.) Sisken, B. F. (Wenner Gren Res. Lab. and Dept. Anatomy, Univ. Kentucky, Lexington, KY); Fowler, I. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:40; 1982.

The use of neural tissue implants combined with the application of direct current using bimetallic electrodes to induce partial limb regeneration in a non-regenerating vertebrate species was investigated. The right fore-limbs of male rats (inbred Harlan Fisher F344, 21-28 days old) were amputated at the mid-humeral level. Experimental animals received implants of fetal (14 day) brain or spinal cord obtained from pregnant Harlan Fisher F344 mothers. Twenty-six animals received nervous tissue implants alone; 10 animals received implants strung on tantalum wire, and 11 animals received implants strung on platinum/silver bimetallic electrodes that generated direct current. Control animals received no implant or implants of heart tissues obtained from the same rat fetuses. After implantation, the animals were housed separately. At intervals of 1, 2 and 3 mo, animals from each group were sacrificed and the limbs were x-rayed to determine the presence of new bone structures and prepared for histological examination. In the experimental groups, 13 of 26 rats which received the neural tissue alone demonstrated a positive response (presence of accessory bones with epiphyseal plates). Of the 10 rats that received the implant with tantalum wire alone, only 3 contained new bones adjacent to the original humerus. Of the 11 rats with bimetallic electrode plus neural tissue implant, none contained new bones, but 7 exhibited excessive growth of the humerus consisting of bone and cartilage. In all cases, increased amount of host nervous tissue was observed. In the control animal without neural tissue or electrodes, neither excessive growth of the host humerus or peripheral nerves, nor accessory bones were observed. The preliminary results indicate that the addition of bimetallic electrodes with neural tissue implants appears to stimulate excessive bone formation of the amputated humerus.

0602 EFFECT OF ELECTROMAGNETICALLY INDUCED PULSATING CURRENTS ON THE GROWTH CYCLE OF CHICK EMBRYO CHONDROCYTES IN CULTURE (MEETING ABSTRACT). (Eng.) Corvol, M. T. (Unite de Recherche sur les Maladies du Metabolisme chez l'enfant Inserm U. 30 Hop. Enfants Malades, 149 rue de Sevres, 75015 Paris, France); Monet, J. D.; Dautigny, N.; Assailly, J. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:41; 11 ref).

The effects of electromagnetically-induced pulsed currents (EIPC) on chondrocyte multiplication were studied in vitro using cultured cartilage cells from 15-day old chick embryos. The metaphyseal cartilage of tibial epiphysis was isolated by microdissection under sterile conditions and submitted to enzymatic digestion. The subsequent chondrocyte suspension obtained was added to 25 ml culture flasks, each containing 120,000 cells in 4 ml Dulbecco's medium supplemented with 15% fetal calf serum. At each stage of the growth cycle a group of 5 flasks was exposed to EIPC (mean induced current density = 2 uA) between two air gap electrical coils for 2 or 3 days. Between day 3 and day 10, chondrocyte number and DNA content was not modified by a 2-day exposure to EIPC as compared to controls. On the contrary, when stimulation between day 12 and day 20, there was a 15% increase in cell number and 33% increase in DNA per flask. The ratio of DNA per cell was not changed as compared to control flasks. Three-day as well as two-day exposure to EIPC gave a similar stimulating effect. However, this increase in the two parameters studied was never observed when the cells were continuously exposed to EIPC during the last 10 days of culture. It is concluded that short exposure to EIPC can increase cell number and DNA content in embryonic chondrocytes in culture only after these cells have initiated their DNA synthesis. No such effect was observed in non-dividing cells.

0603 SELECTED ELECTROMAGNETIC FIELD EFFECTS ON CELLULAR REGULATORY PROCESSES (MEETING ABSTRACT). (Eng.) Goodman, R. (Dept. Pathology, Columbia Univ., Coll. Physicians and Surgeons, New York, NY 10032); Bassett, C. A. L.; Henderson, A. S. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:42; 1982.

The relationship of the functional and temporal pattern of biological events in the cell to changes in the cell's electrical environment were investigated. Both biochemical and cytological methods were used to follow alterations in the pattern of genetic activity resulting from the use of pulsing electromagnetic fields (PEMFs) alone or in combination with other conditions including hormonal induction of proliferation, elevated temperature (heat shock) and variations in the ionic environment. Alterations in transcription and translation were observed. These were monitored by sucrose gradient centrifugation, gel electrophoresis, isopycnic centrifugation, cytological "pulse translation" and transcription autoradiograms. Specifically, both single pulse (SP) and pulse train (PT) used over a series of time points, induced effects associated with transcription. The effect of PT was a general increase in all RNA classes following

min of pulse. The most dramatic effect was observed using SP, where approximately a ten-fold increase in the specific activity of fractions of mRNA size was induced in a biphasic manner at 15 and 45 min of pulse. This was reflected in the electrophoretic pattern. These data were supported by cytological studies using either transcription autoradiograms or "nick-translation" of DNase I-sensitive regions of chromosomes. A synergistic effect was observed when SP or PT were used in combination with heat shock or hormonal induction. The results suggest that the two signals evoke distinctly different cellular responses. The role of Ca^{++} on RNA transcription patterns induced by PEMFs was determined since PEMFs are used clinically in treating avascular necrosis and non-unions. Salivary gland chromosomes incubated in Ca^{++} free media during SP or PT induction showed a dramatic increase in RNA transcriptional activity as compared with identical preparations containing Ca^{++}. The presence of Ca^{++} had no effect on RNA transcription in control preparations. The results suggest the effect of PEMFs can be directly related to transcriptional events. The induction was influenced by the type of pulse administered, as well as the cellular environment. The recognition of mediating factors in the use of PEMFs should allow a more specific determination of those conditions which are most beneficial for clinical use, as well as lead to an increased understanding of the effect of electrical fields in the normal function of the cell.

0604 ACTIN POLYMERIZATION INDUCED BY PULSED ELECTRIC STIMULATION OF BONE CELLS IN VITRO (MEETING ABSTRACT). (Eng.) Laub, F. (Dept. Membrane Res., Weizmann Inst. Science, Rehovot, 76100 Israel); Korenstein, R. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:43; 1982 (7 refs).

Actin polymerization induced by pulsed electric stimulation of bone cells was studied in vitro. Cells were stimulated after reaching confluency, with a series of rectangular voltage pulses (25 usec width, 3 Hz-repetition rate, 54 V/cm-amplitude in the medium) lasting for 5 min. Three types of actin could be detected on the basis of DNase I inhibition: monmeric G-action, polymeric F-action and a form not accessible to DNase I, which was assumed to be actin filaments integrated into some higher supramolecular network. This form is tentatively termed 'N'-actin (network-actin). In unstimulated cells, the following were obtained: 55% G-actin; 8% F-actin; and 37% 'N'-actin. Upon stimulation, this distribution changed to: 40% G-action; 12% F-actin; and 48% 'N'-actin. These cytoskeletal changes were related to the early changes in Ca^{2+} and cyclic AMP and suggest a possible role for the cytoskeleton in the process of stimulus transmission.

0605 ELECTROMAGNETIC MODULATION OF ENZYME TION: APPLICATION TO Na-K ATPase IN ERYTHROCYTES (MEETING ABSTRACT). (Eng.) Pil A. (Bioelectrochemistry Lab., Columbia Univ. York, NY 10032); Gary, K. In: Transactions Second Annual Meeting of the Bioelectrical and Growth Society, held on 20-22 September 1 Oxford, England; 2:44; 1982.

The relationship between the electrochemical pa at a cell surface and the necessary signal para of pulsating electromagnetic current (PEMIC) to the rate of active transport in human red blood (HRBC) was quantitated. A previously reported trochemical technique for the direct evaluati cell membrane impedance has revealed the existe an ion binding pathway having a time constant range of 10 usec. The dependence of this upon K^+ concencration strongly suggested that this tion process involved Na-K ATPase. These result vided guidelines for PEMIC configuration via th sideration that a pulse width of 20 usec would b ficient to excite (i.e., get enough current int Na or K ion binding pathways. A current dens 1-10 uA/cm^2 was chosen on the basis of real-tim response. The repetition rate selected was base the actual Na/K exchange transport rate which is in 0.1-1 sec. Experimental measurements using flux efflux rates from fresh HRBC into Na-free at 37 C showed that the pulse width and the amp range were sufficient to modulate Na-K ATPase ac with a peak increase in Na efflux of 35% at ap mately 2 Hz. This enzyme is clearly the target the PEMIC effect is ouabain inhibitable. The correlation between the PEMIC effect and cell me impedance studies was achieved using frequency sis. The results showed that all PEMIC signal structed on the basis of a desired power into t binding pathway are effective for Na-K ATPase a tion. The generality of this approach was sug by similar correlations for many in vitro and i studies, including the clinical application to u ed fracture repair.

0606 STIMULATION OF MATRIX PRODUCTION BY MAGNETIC FIELDS (MEETING ABSTRACT). Farndale, R. W. (Strangeways Res. Lab., Camb England) In: Transactions of the Second Annual ing of the Bioelectrical Repair and Growth So held on 20-22 September 1982 in Oxford, England; 1982 (3 refs).

Pulsed magnetic fields (PMF) were applied to tw logical systems to examine their potential effe matrix turnover in skeletal tissue. Pig art cartilage, which has served as a model of degra processes in skeletal tissue, was maintained in culture for up to 14 days. Generally, PMF had fect on glycosaminoglycan (GAG) release from th sue, estimated spectrophotometrically in the use ture medium and the tissue, or on the incorpo

of $^{35}SO_4$ into GAG. However, when depletion of GAG from the tissue was induced by catabolic factors in the sheep serum used to supplement the culture medium, the application of PMF substantially prevented ($p<.02$) the release of GAG into the medium. This effect could not be stimulated by the addition of known catabolic factors, e.g., retinol, to the culture medium, and it appears that PMF has enabled the tissue to overcome GAG depletion by increased synthetic activity. A second series of experiments used bone marrow stromal fibroblasts to determine osteogenic events could be induced by PMF in vitro. PMF did not induce these events but did stimulate the production of GAG in these cells also. Controls produced 382 ug in 5 wk, compared with 493 ug from PMF-treated cells ($p<.005$).

0607 THE EFFECTS OF PULSED ELECTROMAGNETIC FIELDS UPON PERIOSTEAL AND OSTEOBLAST-LIKE CELLS GROWN IN CULTURE (MEETING ABSTRACT). (Eng.) Hanley, K. J. (Univ. Connecticut, Sch. Dental Medicine, Farmington, CT 06032); Norton, L. A.; Rodan, G. A. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:46; 1982.

The dependence of the pulsed electromagnetic field (PEMF) effect on the cellular make-up of differing calvarial cultures was examined. Cell cultures were obtained through three 30-min sequential digestions of 19-21 day fetal Sprague-Dawley rat calvaria. Through hormonal analysis, those cells obtained in the first digestion were found to be periosteal in nature, while those cells from the third digestion were osteoblast-like in nature. The periosteal and osteoblast-like cells were grown in culture in F-12 medium supplemented with 10% serum and 1% antibiotic antimycotic. Upon reaching confluency, the cell cultures were exposed for 24 hr to one of two PEMFS: Field C, a 5-msec train of 200-usec pulses, 13 usec apart repeating every 66 msec at 15 Hz, or Field D, a 5-msec train of 225 usec pulses, 28 usec apart repeating every 66 msec at 15 Hz. The two fields differed mainly in the duration and depth of the negative polarity of the signal generated, Field C having the deeper negative polarity and shorter duration. DNA synthesis was estimated by ^{3}H-thymidine (^{3}H-Tdr) incorporation. Neither PEMF had any effect upon the periosteal cell cultures. In osteoblastlike cell cultures under identical conditions, Field C enhanced DNA synthesis by 32-100% ($p<.01$). Field D had no effect upon "osteoblast-like" cell cultures. Further experimentation suggested that this effect may be due to differences in the endogenous growth rates. In "osteoblast-like" cells exposed to the PEMF under growth-limiting conditions (serum starved 48 hr prior to exposure to the PEMF), ^{3}H-Tdr incorporation was enhanced from 664 to 1285 cpm/ug DNA ($p<.01$). In the same cell population exposed to the PEMF under growth stimulatory conditions (serum fed immediately prior to exposure to the PEMF), ^{3}HTdr incorporation decreased from 1143 to 860 cpm/ug DNA ($p<.02$). From these experiments it was concluded: 1) the ele trical perturbation of PEMF C has a direct effe upon osteoblast-like cells in culture; 2) the PE perturbations act as secondary growth regulators; the effects appear to be cell and growth state sp cific; and 4) the PEMFs can exert bimodal effe upon DNA synthesis.

0608 MICROENVIRONMENTAL CHANGES ASSOCIATED W ELECTRICAL STIMULATION OF OSTEOGENESIS DIRECT CURRENT (MEETING ABSTRACT). (Eng.) Baranows T. J. (McKay Lab. Orthopaedic Surgery Res., Dept. thopaedic Surgery, Univ. Pennsylvania, Philadelph PA 19104); Black, J.; Brighton, C. T. In: Trans tions of the Second Annual Meeting of the Bioelect cal Repair and Growth Society, held on 20-22 Sept ber 1982 in Oxford, England; 2:47; 1982.

The possibility of correlating the degree of oste genesis stimulated by direct current (DC) with sp cific faradic changes in the microenvironment n the cathode was investigated in vivo. New Zeal White adult male rabbits (n=34) underwent bilate implantation of a 26-guage, 1-cm, bare, PTFE-coat 7-stranded 304 stainless steel wire cathode wit each tibia, a 1.5 cm on edge, square, 304 stainl steel mesh anode near each shoulder, two Ag/AgCl re erence electrodes, and a constant DC power supp The electrodes and DC power supply were connected a percutaneous multi-pin assembly that permitted terruption of the circuit and monitoring of the v ious electrical parameters. Finally, a device-- Multi-Puncturable Silastic Closure (MPSC)--was planted transcortically at each tibial cathode to low for insertion of needle microelectrodes thro the skin and into the medullary canal. All electro remained for 4 wk to reduce the influence of surgi trauma. Then, the power supply was connected to cathode and anode pair as the experimental in e animal. Three direct currents were selected: 1 (n=10), 50 uA (n=13), and 20 uA (n=11) to exam effects of, respectively, currents below, above, within the optimum range of 5 to 20 uA previou found to stimulate osteogenesis with stainless-st electrodes. The needle microelectrodes were coup with an Ag/AgCl reference to produce a potential pH and a polarization current for pO_2 determinatio The results are expressed as the ratio of experimen to control mean pH and pO_2 for wk 1, 2, and 3 and final day of monitoring. Significant elevation of ($p<0.05$) occurred at 50 uA in all time periods a to a lesser extent, as 20 uA in wk 3 and on the fi day. Significant reducion of pO_2 ($p<0.05$) occur at 20 uA in all periods and, to a lesser degree. 50 uA in wk 3 and on the final day. No signific changes of pH or pO_2 were found at 1 uA. The la reduction of pO_2 was associated with osteogenesis 20 uA while significant elevation of pH was coup with necrosis at 50 uA. This investigation verifi in vivo a strong association between pO_2 and pH lev and osteogenesis stimulated by DC.

0609 AN IN-DEPTH SCANNING ELECTRON MICROSCOPY STUDY OF ELECTRONICALLY STIMULATED BONE GROWTH (MEETING ABSTRACT). (Eng.) Chen, T. (Penn-sylvania Coll. Podiatric Medicine, 8th and Race Sts., Philadelphia, PA 19107); Harrington, D. B.; Frasca, P.; Walter, T.; Walter, J.; Darigan, M. In: Trans-actions of the Second Annual Meeting of the Bioelec-trical Repair and Growth Society, held on 20-22 Sep-tember 1982 in Oxford, England; 2:48; 1982.

Results of a scanning electron microscopy study of electronically-stimulated bone growth are presented. Tissues were taken from experimentally induced non-union canine fractures and from freshly osteotomized primate metatarsals. Some had received electrical stimulation (20 uA) and some had dummy electrodes placed at the fracture site. The electronically-stimulated samples showed a greater amount of osteoid than control samples. Newly developed bone contained more calcium and other inorganic matrix components in experimental samples than in control groups. Gold and zinc appeared in greater abundance in experimen-tal samples than in controls. Bone appears to devel-op intramembraneously from existing boney traebecu-lae, or in situ from fibroblasts within the internal fracture callus. In sections taken through the elec-trode, electrically stimulated bone appears to begin laydown in areas away from the electrode, and sub-sequent osteogenesis takes place in a pattern moving toward the electrode.

0610 IN VIVO GROWTH PLATE STIMULATION IN A CA-PACITIVELY COUPLED ELECTRIC FIELD (MEETING ABSTRACT). (Eng.) Brighton, C. T. (Dept. Orthopaedic Surgery, Univ. Pennsylvania Sch. Medicine, 425 Medical Education Bldg., 36th and Hamilton Walk, Philadelphia, PA 19104); Pfeffer, G. B. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Ox-ford, England; 2:49; 1982 (1 ref).

In vivo growth plate stimulation in a capacitively coupled electric field was investigated. Seven-wk-old New Zealand white rabbits (n=20) were selected for uniform growth and were randomly distributed into two equal groups. A pair of 1.8 x 1.8 cm stainless steel capacitor plates was placed in parallel over the shaved right proximal tibial epiphyses of both experimental and control rabbits. All animals re-ceived 3 mg/kg iv oxytetracycline at the onset of the experiment (day 0) and again exactly 2 days later. Commencing with the second injection of oxytetracy-cline the experimental animals received a continuous 10 V pulse-pulse, 60 kHz symmetric sine wave signal for 2 days (days 2-4). The control animals received no electrical stimulation. Current RMS across each pair of plates was 0.54 ± 0.44 mA (0.082-1.40) at the start of stimulation and 1.49 ± 0.2 mA (1.42-1.53) 36 hr later. All animals were sacrificed on day 4. Longitudinal growth in 100 micron thick sagittal sections of the proximal tibia was quantified. Longitudinal distance between the first and sec oxytetracycline labels (days 0-2) and the second o tetracycline label and the bone-cartilage junct (days 2-4) was measured in both control and expe mental animals. Each distance was calculated f the mean of twelve separate measurements taken equal intervals across the growth plate. An eyepi grid was used to ensure uniform specimen alignme Ratios of right-to-left leg growth (for days 0-2 2-4, respectively) were established for each ani During the 2-day stimulation period (days 2-4) in increase in length (p<.02, n=4, group t-test) demonstrated in the experimental group. A mean increase in length was seen (p<.05, n=2, paired test) when stimulated growth (days 2-4) was compa to non-stimulated growth (days 0-2) in the same of each animal. Although several rabbits devel pedal edema there was correlation between the ama of edema and the acceleration of growth. In conc sion, this was the first evidence that a capaciti coupled electric field can accelerate longitudi growth in vivo. The optimal voltage, frequency current parameters of the signal remain to be det mined. It remains clear, however, that the low v tage requirement for stimulation is promising both safe and efficient clinical application.

0611 EXPERIMENTAL BONE HEALING INFLUENCED ELECTRICAL PROPERTIES AND LOCATION OF TEOSYNTHETIC DEVICES (MEETING ABSTRACT). (Eng.) gey, C. L. R. S. (Univ. Hosp., Catharynesingel 1 3500 CG, Utrecht, Holland); Roelofs, J. M. M.; Viss W. J.; Lentferink, R.; Duursma, S. A. In: Trans tions of the Second Annual Meeting of the Bioelect cal Repair and Growth Society, held on 20-22 Sept ber 1982 in Oxford, England; 2:50; 1982 (2 ref

The results of a study to determine whether osteos thetic devices (i.e., stainless steel, or other el trical conductors or insulators) can influence cal formation are presented. White Wistar rats (79) derwent operations upon both femora. In order avoid problems in reproducibility and reduction i diaphyseal fracture, the bone lesion was realized drilling four holes, one axial, by condylar approa and three sagittal holes at 11, 14 and 17 mm from intercondylar line. The diameter of each hole 0.7 mm except for the main hole which had a diame of 2 mm. The electrical perturbations caused by t special type of fracture were comparable to nor fracture potentials. A number of conductors and in lators were tested. Axial rods of stainless ste platinum, polyvinyl chloride (PVC) and glass were planted in 47 rats. Transversal transcortical pie of PVC and stainless steel of different dimensi were implanted in 32 other rats. Callus format was evaluated after the operation on fine grain X-r of the prelevated femora and on undecalcified (00 slices. Callus formation was enhanced by the press of each tested material in the medullary cavity. H ever, the bone gain was more pronounced when insu

tors were implanted. For the transcortical implants, however, the conductors caused more stimulation. An electrical explanation is proposed with reference to the known stimulating effect of depolarization of bone cortex versus fracture potentials.

0612 PREVENTION OF DENERVATION/DISUSE OSTEOPOROSIS IN THE RAT WITH A CAPACITIVELY COUPLED ELECTRICAL FIELD (MEETING ABSTRACT). (Eng.) Brighton, C. T. (Dept. Orthopaedic Surgery, Sch. Medicine, Univ. Pennsylvania, Philadelphia, PA 19104); Katz, M. J.; Pollack, S. R. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:51; 1982.

Inhibition of the development of denervation/disuse osteoporosis in the rat with a capacitively coupled electrical field was investigated. Forty (125 g) male Wistar rats underwent right-sided sciatic neurectomy (0.5-cm segment was excised) under Nembutal anesthesia. On the second post-operative day, stainless steel capacitor plates (1.5 cm in diameter) were placed over the medial and lateral aspects of the right mid-calf in each rat and held in place with tape. Lead wires from the capacitor plates were secured to the right hind limb and the abdomen by means of Velcro. The lead wires were brought out through the top of the cage and connected to a function generator in 32 of the rats and were not connected to a power source in eight control animals. The experimental animals were divided into four groups of eight rats each: group 1 was subjected to a 60-kHz, 2.5-V, peak-to-peak, symmetrical sine wave signal continuously for 12 days; groups 2, 3, and 4 were subjected to a similar signal at 5, 7.5, and 10 V, peak-to-peak, respectively. At the end of 12 days the animals were sacrificed and the tibiae and femora of each animal was excised. Results indicated that the control (neurectomized, non-stimulated) tibiae exhibited a 19% decrease in dry wt and a 17% decrease in ashed wt and control femora exhibited a 13% decrease in dry wt and a 15% decrease in ashed wt. Experimental tibiae (neurectomized, stimulated) exhibited a 6-19% increase in dry wt and a 2% decrease to 19% increase in ashed wt when subjected to signals of 5, 7.5, and 10 V, peak-to-peak. Experimental femora exhibited inconsistent prevention of osteoporosis. Mean total porosity of the tibia of non-neurectomized animals was 14%; for neurectomized, non-stimulated animals it was 31%; and for neurectomized, stimulated (10 V, peak-to-peak) animals it was 26%. It is concluded that a capacitively coupled electrical field can significantly inhibit the development of denervation disuse osteoporosis in the rat.

0613 THE EFFECT OF DIRECT CURRENT MEDIATED BY POROUS ELECTRODES ON BONE GROWTH (MEETING ABSTRACT). (Eng.) Zheng, M. (c/o Dr. Muller, Academic Hosp., Dept. Orthopaedics, B-41, Pellenbe Belgium); Delport, P.; Muller, J. C.; Mijs, J.; Weers, J.; Sansen, W. M.; Van Raemdonck, W.; Duche P. In: Transactions of the Second Annual Meeting the Bioelectrical Repair and Growth Society, held 20-22 September 1982 in Oxford, England; 2:52; 19

The effect of electrical stimulation on: (1) the r and extent of new bone formation; (2) bone gr into porous implant; and, (3) the early stability the interface between the implanted material and was investigated. Three groups of 5 sheep treated with constant direct current of 10 uA, 5 and 250 uA, respectively. A cathodic implant placed in a 3.5-mm hole drilled in the cortical m physis of the distal femur, while in anodic imp was inserted 2 cm proximally. The non-stimul control plug was implanted in the proximal ti metaphysis of the same leg. An insulated power connected to the cathodic and anodic implants Teflon-coated wires was placed sc. The animals sacrificed at the end of 4, 8 and 12 wk. The os genic responses to 10-uA, 50-uA and 250-uA cath were significantly enhanced above that of the i tive controls and the exostosis was more pronou than the enostosis. In most instances, osteonecr was observed at the anodic area. The greatest ca dic osteogenesis and anodic osteonecrosis was 250 uA. The cause of osteonecrosis was due to cytotoxic effect of metal ions which were rele from the anodic electrode after reduction in acidic environment. A gradient of new bone forma on the periosteal and medullary surface was obser This was related to the distance from the electro and the osteogenesis was always more pronounce the cathodic area at 8 and 12 wk. Similar res were obtained when specimens were analyzed for mineral content. Although the maximal osteog response was at 250 uA, the interfacial stre between bone implant was reduced significantly compared to the controls. The early stability the interface was not increased by any electr treatment, as confirmed by mechanical test Porous electrodes offer a large surface area thus provide a lower current density for a g current. It enables the use of a current hi than the conventional dose of 25 uA, and thus st lates more bone formation over a wider area.

0614 DIRECT CURRENT STIMULATION OF BONE INGR IN TITANIUM IMPLANTS (MEETING ABSTRA (Eng.) Albrektsson, T. (Lab. Experimental Biol Dept. Anatomy, Box 33031, Univ. Gothenburg, S-40 Gothenburg, Sweden); Buch, F.; Herbst, E. In: Tr actions of the Second Annual Meeting of the Bioe trical Repair and Growth Society, held on 20-22 tember 1982 in Oxford, England; 2:53; 1982.

The effect of direct current stimulation on bone growth into two canals of a titanium implant was vestigated. The bone growth chamber, a divis

titanium implant, was inserted into the tibia of rabbits and a platinum anode and a titanium cathode were anchored in the bone on either side of the implant's outer periphery. Both electrodes (screws of 2 mm diameter, inserted length 4 mm) were inserted at a distance of 6 mm from the chamber. They were connected via ec-placed electrode cables to a stimulator under the skin on the back of the rabbit. The same procedure was performed on the contraloteral side except that the electrode cables were not connected to the stimulator. Five chambers were stimulated with 5, 20 and 50 uA, resp., while 15 chambers served as controls. Evaluation of the microradiograms, using an IBAS I+II computer indicated that there was more bone in the test implants compared t/ the control ones in 13 of 15 cases. The increase in bone formation on the stimulated side was significant at the p=0.05 level. In the 5 uA-group, on the average average, there was a 79% increase of bone. All test implants contained more bone than did controls. In the 20 uA-group, four of the test implants had more bone than did the controls in the same animal. The average bone contents in the 5 animals stimulated with 20 uA was 202% of that of controls. In the 50 uA-group, on the average, there was 13% more bone on the test side. In this group two of the anodes were found poorly anchored in the bone, two were found loose immediately outside the bone and one anode was relocated in the muscular tissue at some distance from the insertion place. The latter animal showed less bone in the test side compared to the control. The remaining 10 electrodes on the test side and all 15 electrodes on the control side were quite stable in the bone 3 wk after insertion. In conclusion, stimulation with 5 to 50 uA gives a significant increase of bone formation in implants at 5 mm distance from the electrode surfaces. The experimental population was too small to determine which stimulation level gave the optimal bone response.

0615 BONE FORMATION AT PLATINUM, CO-CR, AND OTHER CATHODES (MEETING ABSTRACT). (Eng.) Spadaro, J. A. (Dept. Orthopaedic Surgery, State Univ. New York, Upstate Medical Center, Syracuse, NY 13210) In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:55; 1982.

The medullary bone response to six metal cathodes at two direct current (DC) levels was measured to investigate the reported metal-dependence of electrical osteogenesis. Seventy-four NZW rabbits were implanted with DC cathodes of Pt, Co-Cr(F-90), Ag, stainless steel (316L), Au or Ti. At least 6 animals received each type with current sources giving 0.02 and 0.2 uA.mm^{-2} current density. Each animal received an inactive control cathode of the same material on the contralateral side. The cathodes were inserted into the medullary canal of the femoral diaphysis via a small hole in the distal metaphysis. After 3 wk, the animals were sacrificed, radiographed and the medullary new bone measured by point-counting in microscopic cross-sections. Results which gi/ point counts for each case are presented graphic Statistical analysis (student's t-test) of the p data showed the most significant enhancement o bone growth near all active cathodes and specifi for Co-Cr at 0.02 uA.mm^{-2} for stainless steel a at 0.2 uA/ mm^{-2} ($p<0.05$). The activity of and Ag at 0.02 ($p<0.1$) was also noteworthy as the growth near controls in several cases. activity at stainless steel at higher current a with previous reports, but the behaviors of P Co-Cr seem to be new observations. In general, formation at the lower current seemed to be inve proportional to the electrode potential (as deter from polarization curves), whereas this correl was less evident at the higher level. The re strongly suggest that current-dependent, metal s ficities for electrically-enhanced bone formati exist; expansion and repetition of this initial is needed to verify and interpret this benavi bone and other tissues.

0616 THE ROLE OF ELECTRODE MATERIAL AND CU DENSITY IN ELECTRICAL STIMULATION OF O GENESIS (MEETING ABSTRACT). (Eng.) Black, J. (Lab. Orthopaedic Surgery Res., Dept. Orthopaedic Univ. Pennsylvania, Philadelphia, PA 19104); D. S.; Jones, S. B.; Dymecki, S. M.; Baranowsk J.; Brighton, C. T. In: Transactions of the S Annual Meeting of the Bioelectrical Repair and G Society, held on 20-22 September 1982 in Ox England; 2:56; 1982.

The role of electrode material and current densi electrical stimulation of osteogenesis was inv gated. Twelve adult male New Zealand white ra received bilateral implantation of constant cu power supplies previously adjusted to produce 1 uA. Each animal received a 26 AWG, 1 cm, ba strand 304 stainless steel cathode in one t medullary canal and a 2.25 cm^2 304 stainless mesh anode in the back as an active control. 1 (n=6) received the same power supply with a mm diameter, 1 cm bare platinum cathode in the tralateral canal, coupled to a 2.5 cm^2 platinum anode. Group 2 (n=6) received 0.81 mm diameter, bare platinum cathodes and anodes identical to 1. Current (I), interelectrode potential (IP), anodic as well as cathodic potentials (CP) wit ference to an implanted Ag/AgCl electrode were tored 3x/wk until sacrifice on day 21. At sacri the tibial medullary contents were decalcified the percentage of new bone in the canal was qu tated. Statistical analysis (student's t-test) cated that bone growth on the control side wa significantly different in the two groups (p and the grand mean (24.1%) was not significantly ferent from the historic mean for this model (.8 $p<0.25$). In group I, with equivalent geometric rent densities, the platinum electrodes stimu 28% more new bone growth than the controls ($p<$ paired) supporting the observations of others o

greater osteogenic efficiency of electrodes more noble than stainless steel. Bone growth with platinum in group 2 was significantly less than that for the controls ($p<0.02$, paired). More important, group 2 platinum electrodes elicited 41.2% less bone than those in group 1. This follows the change in the geometric current density (-53.1%) rather than in the cathodic potential (-5%), suggesting that current density dominates osteogenic efficiency of a particular electrode metal, given that the cathodic potential is below the limit for cellular necrosis.

0617 EFFECTS OF PULSED ELECTROMAGNETIC FIELDS ON CULTURED CHICK EMBRYONIC FEMORA (MEETING ABSTRACT). (Eng.) Noda, N. (Dept. Dental Technology, Tokyo Medical and Dental Univ., 5-45, 1 chome, Yushima, Bunkyo-Ku, Tokyo 113, Japan); Sato, A.; Isobe, Y.; Furuya, K.; Ishida, A. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:37; 1982.

The effects of pulsed electromagnetic fields (EMF) on cultured chick embryonic femora were investigated to elucidate the mechanisms and biological effects of electromagnetic stimulation. One-hundred and twenty-two pairs of femora were excised from 10- or 11-day-old chick embryos and cultured at 37 C in an atmosphere of 5% CO_2 and 95% air. One of each paired femora was exposed to EMF, with the other used as a control. The medium adopted was modified F-12 supplemented with 10% calf serum. On day 10 of cultivation, femora were measured, weighed, and examined histologically. At the end of the culture period, several femora were pulse-labelled with ^{3}H-thymidine, ^{3}H-proline, or ^{35}Ssodium sulphate supplemented to the medium and radioactivities were analyzed by liquid scintillation counter. The EMF were characterized by a pulse train signal composed of 18-20, 200 usec long, quasitriangular pulses lasting accumulatively 5 msec and repeated at 11 Hz with magnetic flux density of 0.5 to 30 G. Exposures to EMF were performed continuously except in cases of ^{3}H-thymidine incorporation. In those experiments, three different exposure modes were compared: (1) continuous; (2) 6 hr on/off; and (3) 24 hr on/off. Incorporation of ^{3}H-thymidine and ^{3}Hproline was promoted significantly ($p<0.05$), whereas incorporation of $^{35}SO_4$ was unaffected. Among the three modes, incorporation of ^{3}H-thymidine was promoted more in the continuous and 6 hr on/off group than in the 24 hr on/off group. It is concluded that pulsed electromagnetic fields promote DNA and protein synthesis when applied continuously. Other results suggest that continuous or intermittent stimulations with shorter (6 hr) on/off intervals may promote DNA synthesis more than those with longer (24 hr) on/off intervals.

0618 BONE RESISTIVITY (MEETING ABSTRACT). Rinaldi, R. A. (Louisiana State Univ Medicine at Shreveport, Anatomy Dept., P.O. Box Shreveport, LA 71130); Goodrich, J. In: Transa of the Second Annual Meeting of the Bioelectric pair and Growth Society, held on 20-22 September in Oxford, England; 2:58; 1982.

The electrical parameters of rabbit femur bone i ing resistivity were studied. Polarization of nur electrodes embedded in both cortical and lary bone was performed. A four-point method wa wherein the outer electrodes introduce current (1 V alternating current at selected frequencie 0 to 5000 Hz) into the bones while the two inner trodes monitor the current. The elc odes wer bedded in bone cement (Surgical ex) wi electrodes insulated from fluids su nding th with Neoprene "O" rings. The elec es were num (0.5 mm diameter). Measuremen e mad a high impedance voltmeter and a l urrent a which utilized minimal amounts of y in th surements. Polarization of the out rode ed resistance values that were err r dif electrode configurations. Studies aced th ohmic resistance of both cortical and medullary bone performed at 1000 Hz and <7 V minimized c tive reactance and Faradaic reactions at the izing electrodes. Cell constant measurement 1000 Hz) before and after death of rabbits c vented the geometry difficulty and allowed a r able ohmic resistance value (minimum capaciti actance) to be obtained. The ohmic resista both cortical and medullary bone was approxi 900 ohms/cm3. Phase angles of 0 degrees at <0 creased to 0.8 degrees at 1000 Hz and remained tant to 7000 Hz before increasing. This corres to 95 ohms at 4 Hz, an error of <1% of the impedance between polarizing electrodes at 10 Resistance values obtained for both cortica medullary bone resulted in an increase of ne after post mortem. Bone resistivity for both cal and medullary bone increased following de the rabbit. During anesthesia there was a decrease in resistance. However, upon sacr heart and breathing cessation, the resistivity climbed to the values of the live subject. Wi hr of death and with temperature of the animal tained at 29 C, there was a notable (20%) incre bone resistivity. The results indicate the exi of a physiological state which is important in mining bone resistivity.

0619 GROWTH OF CHICK EMBRYO MODULATED BY ELECTROMAGNETIC STIMULATIONS (MEETI STRACT). (Eng.) Saha, S. (Biomechanics Lab., Orthopedic Surgery, Louisiana State Univ. Medica ter, Shreveport, LA 71130); Pal, A.; Reddy, Albright, J. A. In: Transactions of the Seco nual Meeting of the Bioelectrical Repair and Society, held on 20-22 September 1982 in Oxford land; 2:59; 1982 (3 refs).

Incubating fertilized chicken eggs were used in an evaluation of the effect of different pulsing electromagnetic fields on bone growth. This model system was chosen due to its low cost and ease of operation, compared to an animal model. The goal was to obtain a dose-response curve for pulsed electromagnetic fields based on the criterion of skeletal growth of chick embryo. Pulsing electromagnetic field (PEMF) of several desired shapes, amplitudes, and repetition frequencies could be produced with three specially designed and fabricated tunable pulse generators. A pulse generator was used to supply current to a rectangular coil (39 cm x 31 cm, 90 turns of 24 AWG coated copper wire) surrounding a test group of 60 fertilized chicken eggs in an incubator. These eggs were exposed to a particular pulse shape (measured by a sensitive probe) throughout their incubation period. The control group consisted of an equal number of fertilized eggs incubated separately in an adjacent room. Several embryos from both groups were examined from days 7 to 21 of incubation. The embryos were measured, weighed and their bones stained. Altogether, seven batches of eggs were examined, each batch exposed to a different pulse shape. One pulse shape with pulse width of 0.7 msec, a duty cycle of 40% and a repetition rate of 205/sec produced an increased rate of growth for the embryo and its skeletal system. However, for all other pulse shapes examined, the test group in general showed a decreased rate of growth. Bones from these test groups of embryos were also smaller compared to controls. Similarly, the bending strength of tibiae and femora from these electromagnetically stimulated embryos was less than that of the control group. The results indicate that embryonic growth can be modified by electromagnetic stimulation.

0620 OBSERVATIONS ON THE EFFECTS OF PEMFS ON IN VITRO MACROMOLECULAR MODELS (MEETING ABSTRACT). (Eng.) Anderson, A. M. (Bio-Medical Engineering Unit, c.o The Medical Inst., Hartshill, Stoke on Trent, Staffordshire, England); Hastings, G. W. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:60; 1982.

An in vitro macromolecular system developed to model collagen at a fracture site in bone is described. The aim was to study the effect of static and pulsed magnetic fields on the orientation of simple, well-characterized macromolecules during polymerization and thereby investigate this aspect of non-union treatment. This study will be extended to more complete synthetic collagens, and to regenerated collagen gels. Acrylamide or mixtures with methyl methacrylate, styrene or dimethylamino ethylmethacrylate, in aqueous or alcohol solution, were cast to give thin films of homo or copolymers on glass slides following initiation of polymerization by ultraviolet radiation. The samples were subjected to static or pulsed electromagnetic fields (PEMFs) before and during the polymerization process. Conventional light microscopy revealed inherent gross differences between and non-field samples. Polarized light microsc x-ray diffraction were used to provide more qua tive data concerning orientation and inter-mole spacing. The range of morphologies in both cat high, and therefore interpretation of changes complex. However, there may be at least one change in low angle x-ray diffraction pattern samples exposed to PEMFs.

0621 COMPUTER ANALYSIS OF DATA ON MORE 11,000 CASES OF UNUNITED FRACTURE TED FOR TREATMENT WITH PULSING ELECTROMAG FIELDS (MEETING ABSTRACT). (Eng.) Goldberg, A. (Electro-Biology International (UK) Ltd., 12 Southampton St., Reading, Berkshire, RG1 2 RA, land); Gaston, S. R.; Ryaby, J.P. In: Transac of the Second Annual Meeting of the Bioelectrica pair and Growth Society, held on 20-22 September in Oxford, England; 2:61; 1982.

A study initiated >7 yr ago and designed to pr detailed information on the value of pulsed ele magnetic fields (PEMFs) in the treatment of non-u is presented. The treatment protocol comprises application of a plaster cast to control movement selection of appropriate coils and driving vol correct placement of the non-union within the re ant field; treatment periods of 10-12 hr daily; s non-weight bearing for lower limb fractures durin initial stages of therapy, and a graded exercise gram once signs of healing were evident. Inform on every case treated with PEMFs was stored on c ter to permit subsequent regular analysis of a iety of functions. Data are presented on 1 ununited fractures which have completed or are rently being treated with a course of PEMF the The accumulation of data on a series this larg provided a unique opportunity to evaluate not the overall success rate of this treatment mod (75%), but to examine in depth the influence of factors as reactivity of the lesion, infection the presence of hardware on healing rates, an ultimate outcome of PEMF therapy. The success in the subgroup of patients who had not unde any operative intervention prior to the initi of PEMF therapy was compared with that in rep series of non-unions treated solely by surgical ods and established a case for the initial app tion of PEMFs as a reasonable alternative to procedures.

0622 ELECTROMAGNETIC TREATMENT OF NON-U A EUROPEAN MULTICENTER STUDY MEETIN STRACT). (Eng.) Hinsenkamp, M. (Service d'Ort die-Traumatologie, Hopital Univ. Erasme, Rout Lennick 808, 1070 Brussels, Belgium); Ryaby, J. ny, F. In: Transactions of the Second Annual M ing of the Bioelectrical Repair and Growth Soc

held on 20-22 September 1982 in Oxford, England; 2:61; 1982.

The European experience using pulsed electromagnetic fields (PEMFs) in the treatment of nonunion is discussed. Since 1977, more than 300 cases of non-union have been treated with PEMFs in various European orthopedic centers. One of the most significant factors affecting treatment outcome is the type of nonunion, with a success rate of 87.8% reported for hypertrophic nonunion as compared with 58.1% for atrophic nonunion. Also, the anatomical location and sex of the patient appeared to have a determinant effect. The age of the patient or other historical data, however, had no important effect on treatment outcome. A comparison of the treatment response of the nonunion population of the U.S. with that of European countries indicates few differences.

0613 CHANCES AND PROBLEMS OF THE SUPPLEMENTARY TREATMENT OF CONGENITAL PSEUDARTHROSES OF THE TIBIA WITH ELECTRIC AND ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Eng.) Aschert, R. (Inst. Experimental Surgery, Technical Univ. Munich, Ismaninger Strasse 22, D-8000 Munich 80, W. Germany); von Finkenstein, A.; Lechner, F.; Blumel, G. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:63; 1982.

The benefits of electric and/or electromagnetic stimulation in cases of congenital pseudarthroses of the tibia are evaluated. Eight patients with congenital pseudarthroses were treated by means of electric stimulation. The cases were considered to be true congenital pseudarthroses; none of the patients suffered from neurofibromatosis or fibrous dysplasia. In seven of these cases the Kraus-Lechner system was applied in addition to surgery. One patient had been treated with pulsed electromagnetic fields. The leg of one of the patients operated on by internal fixation (electrified I.M.-rod) had been amputated; after an initial satisfying callus formation pseudarthrosis recurred again. One female patient was also retreated because of a recurrence of the pseudarthrosis. In two further cases a beginning osteolytic reaction was observed exactly in the region of the former pseudarthrosis, although after the initial treatment the bone was stable and consolidated. These patients are under therapy by means of the external pulsing magnetic field which seems to be able to prevent progressing osteoresorption. Usually the electric treatment takes much longer than in cases of acquired pseudarthroses. Four cases healed after only one further surgery followed by electric stimulation. In cases of congenital pseudarthroses additional treatment by electric fields seems to be helpful, but is not as successful as in cases of non-unions.

0614 TREATMENT OF CONGENITAL PSEUDARTHROSIS THE TIBIA USING A CONSTANT DIRECT CURRE (MEETING ABSTRACT). (Eng.) Paterson, D. Dept. thopaedic Surgery, Adelaide Childrens Hosp., 72 Kl William Road, North Adelaide 5006, South Australi Simonis, R. B. In: Transactions of the Second Ann Meeting of the Bioelectrical Repair and Growth Soc ety, held on 2022 September 1982 in Oxford, Englar 2:64; 1982.

A method of treating congenital pseudarthrosis of t tibia using a constant direct current (DC) is d scribed. During surgery the pseudarthrosis and normal bone are excised leaving some shortening. T tibia is aligned and held with an intramedulla nail (Steinman Pin), passing through the ankle joi into the os calcis. The cathode of a DC battery inserted into the pseudarthrosis site which is th bone grafted. The implantable battery supplies uA for a minimum of 5 mo, after which it is remove Of the 20 cases treated so far, 14 have united and are still undergoing treatment. In several of t patients it has proved necessary to implant 2, a in one patient, 3 batteries before union could achieved. One child refractured after the intramedullary nail was removed at 1 yr; it is now reco mended that the nail be left in situ for at least yr. The shortening of the affected leg corrects spontaneously once union has been obtained.

0625 ELECTRIC RESISTANCE AND IMPEDANCE OF B TISSUES (MEETING ABSTRACT). (Eng.) Ohas T. (Dept. Orthopaedic Surgery, Murakami Memori Hosp., Gifu Coll. Dentistry, 1-1 Hakamiya-cho, Gif Japan 500); Inoue, S.; Kajikawa, K.; Ibaragi, K Sasaki, H. In: Transactions of the Second Annu Meeting of the Bioelectrical Repair and Growth Soc ety, held on 2022 September 1982 in Oxford, Englar 2:65; 1982.

Electric resistances of tissues of bone, muscle blood of adult dogs were determined by measuri interelectrode potentials in vivo using a 20-uA c stant electric current stimulator which had been us in clinical cases for non-union. The resistance bone was 62 kOhm (1.23 Y), muscle 40 kOhm (0.78 and blood 52 kOhm (1.04). The interelectrode pote tial using skin electrodes was much higher than th using bone electrodes. The impedances of tissu were obtained with a Kohlrausch bridge of 800 The impedance of bone was 140 Ohm/cm, muscle 10 Oh cm, blood 73 Ohm cm, kidney 42 Ohm/cm and liver Ohm/cm. Electric stimulator electrodes should inserted into bone and insulated from soft tissu such as muscles to avoid short circuit, since musc has a higher conductivity than bone. In this wa electric current can be obtained along the bone, the current is effective for new bone formatio When the skin electrode is used, it should be lar enough and also should have good contact to redu electric resistance and interelectrode potential

0626 EXPERIMENTAL STUDY F BONE REMODELLING INFLUENCES BY DC CURRENTS (MEETING ABSTRACT). (Eng.) Lagev, Z. L. R. S. Dept. Experimental Surgery, Chirurgische Klinik, Catharynesinaal 101, 3500 GG, Utrecht, Holland); Roelofs, J. M. M.; Kenferink, R.; Akkermans, L. M. A.; Janssen, L. H. M.; Wittebol, P. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:66; 1982.

The influence of direct current (DC) energy on bone remodelling was studied in 94 white Dutch rabbits using DC current of varying intensities and polarities. The currents were applied by platinum electrodes, the first in, the second either around the femoral diaphysis, or implanted at some distances. Currents of 20 or 3 uA were used, with potentials varying between 1.5 and 3.2 V. The maximum current density was calculated at 0.3 uA/mm^2 electrode surface. The results were evaluated on fine grain X-ray film, and on decalcified histological slices of ± 100 thickness by an image analyzer. The amount of bone found at the stimulated side was expressed as percentage of its heterolateral control. In the group of medullary anodes faced by circular cathodes a significant increase of the amount of total bone in the stimulated femur was found in the vicinity of the electrodes and also more proximally, especially for the low current density. Periosteal and endosteal bone formation were stimulated equally. However, in the groups of medullary cathodes faced by periosteal anodes, an insignificant inhibition was noted. The group of medullary anodes with distant cathodes showed no significant difference. Again a significant ($p<0.05$) stimulation of both endosteal and periosteal bone formation was observed in the group with a medullary cathode in combination with a distant anode, as well as in the group of circular cathodes with distant anodes. It is concluded that the orientation of the electrical field versus the polarity of the electrodes was not an exclusively determining factor in DC bone stimulation because both stimulation and inhibition were observed adjacent to the cathode depending on the location of the anode. However, stimulation never occurred with the cathode at a distance. The tested potentials and current intensities stimulated in a similar way. The densitometric evaluation was in accordance with the histological findings. The latter had the advantage of allowing a precise location of the bone remodelling.

0627 ELECTRICAL STIMULATION OF FREEZE-DRIED BONE ALLOGRAFTS (MEETING ABSTRACT). (Eng.) Brannan, G. B. (Dental Res. Branch, Stop #18, Naval Medical Res. Inst., Bethesda, MD 20814); Triplett, R. G.; Yuan, J.; Liboff, A. R.; Yeandle, S. S. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:67; 1982.

Electrical stimulation was evaluated as a method enhancing the repair of freeze-dried allogeneic bone to reduce the complexity of surgical reconstruction. Two-mm full-thickness defects were created laterally in the mandibular body of 12 adult male beagle dogs (Canine familiaris). The bone grafts consisted of a freeze-dried allogeneic U-shaped shell filled with freeze-dried allogeneic crushed cortical particles 1.0-1.5 mm in diameter. In one side active platinum electrode was implanted which delivered 20 uA supplied by a constant current generator implanted beneath the skin on the dorsal surface of the neck. The contralateral side received a dummy platinum electrode without current. Output from the power pack was recorded 1x/wk through a percutaneous lead. Bone repair was assessed by sequential fronto-occlusal radiographs and quantitative radionuclide imaging with ^{99m}Tc-methylene diphosphonate interfaced with a medical computer at 1, 2, 4, and 8 wk. End-point evaluation of repair included quantitative and subjective mobility determination and histology. Eight of 12 animals were free of complications and suitable for data analysis. Although the overall degree of healing, as evidenced by the uptake of radio-labeled diphosphonate, was only marginally improved for the electrically stimulated defects as compared to the controls, there was a clear trend in the data suggesting a peak in the effectiveness of the electrical stimulation postoperatively at 4 wk. This effect was also observed in changes in the effective resistance of the defect which reached a minimum between 3 and 4 wk following surgery. It should be stressed that the use of ^{99m}Tc uptake in bone defects, coupled with computer aided analysis to obtain relative levels of diphosphonate uptake, may represent the most precise method yet developed to assess the effects of electrical stimulation in bone.

0628 FLUORESCENT MICROSCOPIC INVESTIGATIONS OF THE BONE HEALING UNDER STIMULATION WITH BIPOLAR PULSE CURRENTS AND INTERFERENCE CURRENT IN ANIMAL EXPERIMENT (MEETING ABSTRACT). (Eng.) Siebert, Th. (Orthopadische Klinik der Medizinischen Akademie "Carl Gustave Carus", DDR-8019 Dresden, Fetscherstrasse 74, E. Germany); Kleditzsch, J.; Wolf, J.; Beer, L.; Hellinger, J. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:68; 1982.

The effect of stimulation with bipolar pulse current and interference current on bone healing was investigated. Cross-bred rabbits of either sex were osteotomized on the left proximal third of the tibia. The animals were stimulated using the bipolar square topped pulse current procedure (1 Hz and 10 Hz, respectively ± 25 and ± 50 A, respectively, intensity, permanent stimulation) or the interference current procedure (oscillation frequency 100 Hz, intensity 1 mA, 4 hr daily). An osteotomized group served as control. The undecalcified bone sections

quantitatively measured in the area of the periosteal and endosteal accumulation seams as well as in the area of the Haversian canals and compared by means of multiple variance analyses. A consensual reaction was found in all animals within the region of the opposite side intracortically. A delay in the Haversian remodelling within the first 2 wk was found in the animals which were osteotomized only. This delay could not be detected in all electrically stimulated groups. In the interference current procedure, there were saving reactions within the region of the periosteal and endosteal areas of the opposite side with massively increased accumulation within the stimulating region. The electrical stimulation lead to a shortening of the fracture healing period by skipping the physiologically occurring delay of the Haversian remodelling in fractures and osteotomies.

0629 TECHNICAL PROBLEMS OF THE IMPLANTABLE BONE STIMULATORS (MEETING ABSTRACT). (Eng.) Suttler, P. (MTE, Medizinische Akademie "Carl Gustav Carus," DDR-8019 Dresden, Fetscherstrasse 74, E. Germany); Kleditzsch, J.; Hellinger, J. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:69; 1982.

Technical problems encountered in the use of implantable bone stimulators are discussed. Implantable stimulators and the electrodes attached thereto must be tissue-tolerated and corrosion proof. The geometrical construction of stimulators and electrodes is very important as well as the optimal construction of the isolation of the fixing plates and screws when they are applied. Problems in the choice of suitable batteries are discussed.

0630 THE ELECTRICAL ENVIRONMENT PRODUCED AT BONE FRACTURE SITES BY INDUCTIVE COUPLING (MEETING ABSTRACT). (Eng.) Hart, F. X. (Dept. Physics, Univ. South, Sewanee, TN 37375); Marino, A. A. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:70; 1982.

The results of a calculation to yield the dependence of the electric field and current density upon the electrical properties of the bone and adjacent soft tissue, bone and soft tissue geometry, and characteristics of the applied magnetic field are presented. Application of Faraday's Law of Induction and the requirement of continuity of the total current density (conduction plus displacement) at the bone soft-tissue interface yields an expression for the electric field of the form, $E = A\sin\omega t - B\cos\omega t$, for the case of an applied sinusoidal field, and, $E = C(\exp[-t/\tau])$, for pulsed-field applications, where A, B, and C are complicated functions of the conductivities and permittivities of the bone, soft tissue, and overall geometry, and τ is the pulse rise time. The solution of the electric field, and the resulting current density have been calculated for a variety applied magnetic fields. The data demonstrate effect of frequency and pulse rise time on the electrical environment at the fracture site. The na of the changes in the electrical environment (a fixed treatment procedure) as the gap narrows healing will also be described. It is hoped the results will lead to a better understandin how the electrical environment at the fracture depends on the parameters of the applied field, thus to improved treatment procedures for patie

0631 LOW FREQUENCY PULSING ELECTROMAGN FIELDS IN THE TREATMENT OF DELAYED UN AND ACQUIRED PSEUDO-ARTHROSIS (MEETING STRACT). (Eng.) Cadossi, R. (Center Experime Hematology, Univ. Modena, Policlinico, Via del Po 41100 Modena, Italy); Giancecchi, F.; Fontanesi In: Transactions of the Second Annual Meeting of Bioelectrical Repair and Growth Society, held on 22 September 1982 in Oxford, England; 2:71; 198 refs).

The use of low frequency pulsing electromagn fields (LFPEF) for the treatment of delayed uni acquired pseudo-arthrosis and trophic ulcers is cussed. The unit utilized has high impedance o supplied with 200-V electrical tension. The shape used has the following characteristics: 0 75 Hz frequency, 3 msec impulse length, square shape, rising edge in the order of magnitude usec. Patients were admitted to the protocol o only if the fracture lasted at least 6 mo with healing. Home treatment was performed 12 hr The mean length of treatment was 5 mo. Of 45 tients who completed the treatment, 41 healed w 4 had no benefit. LFPEF therapy can be consid very useful in traumatology, particularly in case of delayed unions and acquired pseudo-arthro No significant side effects were observed. The h ing process appears to be mediated by a strong st lation of periosteal callus formation.

0632 ELECTROMAGNETIC STIMULATION OF FREEZE-D CORTICAL BONE GRAFTS IN RABBITS (MEE ABSTRACT). (Eng.) Zenner, J. B. (340 Salem-Woods Rd., P.O. Box 137, Salem, NJ 08079). In: Transact of the Second Annual Meeting of the Bioelectrical pair and Growth Society, held on 20-22 Septe 1982 in Oxford, England; 2:72; 1982.

The effects of electromagnetic stimulation of fre dried cortical bone grafts were studied in rabb The cortical bone of rabbit femurs was stained vivo with tetracycline, then harvested and fro

dried and used to make matched cortical grafts. Grafts were surgically implanted into adult New Zealand rabbits and "on-layed" over the lateral cortex of the uninjured femoral diaphysis. In the control group, the animals were placed in dummy coil cages 5 days wk for 9 hr day for 10 wk. In the treatment group, the animals were placed in cages with active electromagnetic stimulation coils calibrated to give a standard wave form to the area of the femoral diaphysis. The animals were treated for the same time period as controls. The grafts were harvested and studied histologically by light microscopy, ultraviolet microscopy and scanning electromicroscopy of non-decalcified cross sections of the recipient femurs with attached cortical grafts. Comparison of matched pairs revealed a significant increase in bone bridges from the cortex of the recipient to the endosteal surface of the cortical grafts and a significant advancement of the stages of "creeping invasion" and "osteogenic regeneration" of the cortical grafts.

0633 IN VIVO SKELETAL MODIFICATIONS OF CHICKEN EMBRYOS INDUCED BY ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Eng.) Rooze, M. (Laboratoire d'Embryologie et d'Anatomie Humaine, Hopital Universitaire Erasme, Route de Lennick 808, 1070 Brussels, Belgium); Hinsenkamp, M.; Duchateau, J. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:73; 1982.

Skeletal modifications of chicken embryos induced by electromagnetic fields were investigated in vivo. After 4 days incubation, chicken eggs were exposed to a permanent pulsed electromagnetic field for 100 or 150 hr. Both wing and leg ossification patterns were examined. On calibrated pictures total length and length of primary ossification points of the stylopodal and zeugopodal bones were measured. The results indicated: (1) no edema and no malformation in embryos submitted to electromagnetic fields; (2) electromagnetic-field-induced increase of the embryonic wt with more pronounced wt gain in cases of prolonged exposure; (3) increase in bone length, especially of the more distal segments mainly in the leg; (4) earlier onset of infection in activated embryos compared with controls; and, (5) larger ossification points of the activated embryos. The results also indicate that the position of the eggs between the coils is important and seems to illustrate a specific effect of the electric field.

0634 REPAIR OF NON-UNIONS BY ELECTRICALLY PULSED CURRENT STIMULATION (MEETING ABSTRACT). (Eng.) Zichner, L. (Dept. Orthopaedic Surgery, Univ. Frankfurt, Marienburgstrasse 2, D 6000 Frankfurt a.M. 71, W. Germany); Scale, D. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:74; 1982.

Results in five congenital and 52 acquired non-un of bone, stimulated using an invasive device, reported. The unit delivered a constant but pu right-angled current of positive polarity, measu 20 to 25 uA (750 mV) at a frequency of 20 Hz. power pack encapsulated in epoxy resin was imple at the time of operative fragment stabilization. cathode was inserted at the site of the non-union After 2 to 12 mo, all but two of the acquired unions and one of the congenital pseudarthroses h ed. In the unsuccessful cases, the bone ends often totally necrotic. Four cases required reimp tation because of broken wires or expiration of battery, and two cases failed owing to purulent in tion. Electrostimulation is an adjuvant treat to fragment stabilization in hyporeactive and h vascular or congenital pseudarthroses. Electr stimuli may be assumed to simulate conditions w are essential for bone healing.

0635 ELECTROSTIMULATION AND BONE LENGTHE (MEETING ABSTRACT). (Eng.) Scale (Dept. Orthopaedic Surgery, Univ. Frankfurt, Mar burgstrasse 2, 6000 Frankfurt, W. Germany); Zich L. In: Transactions of the Second Annual Meetin the Bioelectrical Repair and Growth Society, hel 20-22 September 1982 in Oxford, England; 2:75; 1

Clinical and experimental findings concerning e trostimulation of bone growth are reviewed and liminary results of one ongoing study, which ass polarity to be the active principle underlying e trostimulation, are presented. In an investiga employing rabbits, the anode was inserted into epiphysis and the cathode into the metaphysis vice versa. Retardation of bone growth (7/10 rabb was observed in both experiments, while two ani showed accelerated bone growth and one, no differe

0636 TREATMENT OF NON-UNION OF THE FEMUR PULSED ELECTROMAGNETIC FIELDS (MEETING STRACT). (Eng.) Delport, P.; (Univ. Hosp., B Pellenberg, Belgium); Mulier, M.; Cheng, N.; Mul J. C. In: Transactions of the Second Annual Mee of the Bioelectrical Repair and Growth Society, on 20-22 September 1982 in Oxford, England; 2 1982 (2 refs).

The results of a study using pulsed electromagn fields in the treatment of non-union of the femur presented. Two Helmholtz coils were placed on outer surface of a cast. Treatment was applied 10-14 hr/day until clinical and radiological evid of union was present. Controlled axial compres

exercises with progressive loading started when osseous bridging of the gap was observed radiologically. Treatment was applied to 15 difficult fractures of the femur in which non-union had been present for at least 3 mo with an average duration of 1 yr. Sepsis was present in six patients and most had undergone the operations. Union was achieved both clinically and radiologically in 13 of the 15 femur fractures with a mean time of 10 mo treatment with PEMF. Two were failures (1 amputation and 1 after radiotherapy). It is concluded that PEMF therapy is simple, safe and avoids hospitalization. This method is preferred in cases of recalcitrant non-unions of the femur.

9637 PHYSICAL ASPECTS OF PULSED MAGNETIC FIELD STIMULATION (MEETING ABSTRACT). (Eng.) Marsland, T. P. (Strangeways Res. Lab., Wort's Causeway, Cambridge CB1 4RN, England). In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 1:77; 1982.

The electric and magnetic fields generated by field coils driven by pulsing currents were investigated. Study of the free space field problem divides into two areas: spatial dependence and time dependence. The spatial dependence of the magnetic and electric fields was studied theoretically using a vector potential treatment. The resulting integral equations were evaluated with a computer program, and the fields plotted for various coil geometries. Experimental measurements of the magnetic fields were made with a Hall probe. They are in close agreement with the calculated values--of the order of 1-20 mTesla (peak). Electric field values were derived from search coil measurements on Helmholtz-aiding field coils which also are in good agreement with calculated values. The time dependence of the voltages induced in a small search coil were studied, and the waveforms were further characterized by their frequency domain representation via classical Fourier analysis. This analysis has formed the basis for the design of a series of new pulsed field generators, whose biological effects are currently under investigation. The fundamental question of the interaction between the fields and the biological material was approached. Small perturbation models were used to approximate the induced current distribution within materials exposed to pulsed magnetic fields.

9638 SEM OF S. AUREUS ON CURRENT-ACTIVATED SURGICAL PINS COATED WITH SILVER AND SILVER STEARATE MONOLAYERS (MEETING ABSTRACT). (Eng.) Colmano, G. (Veterinary Medicine Res. Center, VPI & SU, Blacksburg, VA 24061); Painter, L. K.; Edwards, S. S.; Barranco, S. D. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 1:79; 1982.

S. aureus (3 x 10⁷ colony forming units), which had been introduced in the femurs of rabbits on the surface of stainless steel pins coated with monomolecular films of silver (Ag) stearate activated by positive direct current (mA² for 1 hr, were ki The effects in vitro (blood agar) on control, tive, and negative current treated pins and surrounding agar were observed by a scanning electron m scope (SEM) and showed that: (1) more bacteria present on positive than negative current-tr stainless steel electrodes; however, more bac appeared in the negative than in the positive rent-treated agar; (2) fewest numbers of bac were on the negative current-treated solid Ag trode and agar; bacteria on positive current-tr agar were in possible erythrocyte pits; and on positive electrode surface the bacteria appeared formed; (3) bacterial growth was heavy on contro negative current-treated solid tarnished (oxid Ag electrodes and agar; the growth was less hea the positive current-treated electrode and agar; bacterial growth was uniformly low on all Ag stea coated (by evaporation) electrodes and agar (gre on control); bacteria on negative current-tr electrode appeared swollen but not in negative rent treated agar; (5) greatest reduction of b rial growth was seen on the positive current-tr Ag stearate monomolecular films-coated electrod agar; (6) growth was sparse on all Ag electrop electrodes (no agar sample available); (7) bact growth was heavy on control Ag electroplated chlo electrodes and agar; pitted areas of positive cur treated electrode were free of bacteria while g on agar was heavy; both negative current-treated trode and agar showed minimal growth.

9639 SPECIFIC UHF FREQUENCIES FOR CELLS S LATION AND HEALING PROCESS (MEETIN STRACT). (Eng.) Fellus, V. M. (19 rue du Doc Arnaudet, 92190 Meudon, France). In: Transactio the Second Annual Meeting of the Bioelectrical R and Growth Society, held on 20-22 September 19 Oxford, England; 2:80; 1982.

A new electric current and/or electric field ge tor was developed, which employs the highest fre cy compatible with international specifications, tolerance during repeated long-term exposure, an timal effectiveness. The apparatus was designe deliver energy at 0.5 mW/cm², which is well withi respective safety standards of the U.S. and U.S The machine employs a UHF antenna and features a ble spiral antenna which can be applied directl the skin.

9640 ELECTRICAL STIMULATION OF THE SPINAL AFTER CORDOTOMY TO INCREASE SURFACE TE ATURE (MEETING ABSTRACT). (Eng.) Rinaldi, S

(Louisiana State Univ. Medical Sch. at Shreveport, P. O. Box 3392, Shreveport, LA 71130). In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:81; 1982 (2 refs).

The increase in surface temperature following electrical stimulation of the spinal cord was investigated. Complete cordotomies were performed at L2 in four adult rats (2 male, 2 female). One wk was allowed for animals to recover from surgery and hair was removed with a commercial depilatory agent from lower limbs and ventral body surface. Ten sites were selected for surface temperature measurements. The electrical stimulation was with platinum electrodes (0.5 mm in diameter) activated by a watch battery plus a resistor which produced a current of 0.5 to 4 uA at 0.5 to 3 V direct current. All selected temperature areas were measured with the stimulator on or off with a 30-min interval between to allow for adjustments of the subject to experimental or control conditions. A thermistor probe (YSI #4098) designed to be taped on the skin measures temperature change. This thermistor had a time constant of 1.1 sec, the time required for the thermistor to read 63% of a newly imposed temperature change. Approximately 5 "time constants" were required for the probe to determine 99% of the total temperature change. This thermistor was attached to a tele-thermometer (YSI #43TK) to obtain temperature readings. Each reading required approximately 5 min. The results are presented graphically. There was an average increase of temperature of the body surfaces measured from 0.27 to 0.91°C. This was the first study to measure direct electrical stimulation of the spinal cord and the resultant temperature changes on the body surface in animals.

0641 A PILOT STUDY OF A CASE OF LONG STANDING DEGENERATIVE O.A. (OSTEO-ARTHRITIS) OF BOTH HIPS (MEETING ABSTRACT). (Eng.) Rakshit, A. K. (128 Harley St., London W1, England). In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:82; 1982.

The use of very low frequency pulsating electromagnetic (EM) energy in the treatment of a case of osteoarthritis of both hips is presented. EM energy (field intensity, 100 G; 50 Hz) was applied initially for 20 min on alternate days, then 2x/wk, and toward the end of the course of treatment, 1x/wk. The radiological appearance of the left hip, which was the more affected, was significantly improved. In the right hip, the radiological appearance was almost normal. It is concluded that EM irradiation helps reverse the pathological changes of osteoarthritis in the early stage of its development.

0642 CLINICAL EXPERIENCE WITH ADDITIONAL OPERATIVE ELECTROMAGNETIC STIMULATI PSEUDARTHROSES (MEETING ABSTRACT). (Eng.) W H. J. (Unfallchirurgische Klinik Allgemeines Kr haus, D-8600 Bamberg, W. Germany). In: Transa of the Second Annual Meeting of the Bioelectric pair and Growth Society, held on 20-22 September in Oxford, England; 2:83; 1982.

Experience in the application of postoperative ulation with electromagnetic alternating fiel 67 cases of pseudarthroses of long tubular bone in 4 cases of osteotomies by use of an implante according to the Kraus-Lechner method is pres The cases include: 12 pseudarthroses of the f neck, 12 of the femur, 30 of the tibia, 5 of t merus and 8 of radius or ulna. In about a quar the cases there were infected pseudarthroses, with larger defects. A precondition of the tre was a regular osteosynthesis with plates, nail o ateur externe in the greater part combined with logous bone graft. Postoperative stimulation electromagnetic field was performed on the a of 6-8 wk for 4 hr daily, and in some cases l The 4 osteotomies healed quickly without pro In most of the pseudarthrosis cases there was plete consolidation of bone, especially in the lem cases such as pseudarthroses of the femoral or defect-pseudarthroses with inflammation. Se six percent of all patients had previously und one or more operations without success. In 90. the patients application of electromagnetic sti tion after surgery resulted in complete bone ing. In 4.7% of the cases success was obtained changing the procedure once more with renewed s ation. Only in 3 cases (4.7%) was the treatmen effectual.

0643 THE EFFICACY OF ELECTRICAL STIMULATI EXPERIMENTALLY INDUCED NON-UNION FR OF THE CANINE TIBIA (MEETING ABSTRACT). Harrington, D. (Pennsylvania Coll. Podiatric cine, Philadelphia, PA 19107); Walter, J.; Wa T.; Chen, T.; Bodamer, W.; Black, D. In: Transac of the Second Annual Meeting of the Bioelect Repair and Growth Society, held on 20-22 Sept 1982 in Oxford, England; 2:84; 1982.

A new method of creation of an experimental non-fracture model is presented and the results of a vestigation of the biological events in electric stimulated closure of a non-union fracture are re ed. Forty-five mature adult pure-bred Beagle were divided into three groups: Group A consist animals receiving bilateral tibial osteotomies in one leg served as a control and the other leg ed as experimental. Groups B and C each received lateral osteotomies with Group B serving as ex mental animals and Group C serving as a control initial surgical procedure (Phase I) was design create a non-union fracture, while in a second p

dure (Phase II), control or experimental electrodes were inserted into the non-union gap. The post-surgical duration of Phase I was 56 days, and the post-surgical period for Phase II was 28 days. Each surgical area was x-rayed immediately after creation of the non-union, at the end of Phase I, at the beginning and at the end of Phase II. Samples were retrieved at the end of Phase II and prepared for histology or scanning electron microscopy. Samples were studied microscopically to determine the quality and nature of the tissue-types appearing in the surgically created defect, degree of vascularity and the qualitative assessment of new osteoid and bone. Control sections showed only small amounts of bone formation, whereas new bone appeared extensively in the electrically stimulated samples. Samples prepared for scanning electron microscopy were observed for tissue morphology, type of new bone, level of ossification, and specific mineral concentration and localization. These studies confirmed a greater rate of osteogenic activity and ossification in experimental samples versus controls. X-ray studies throughout Phase I and II concurred with the histological and scanning electron microscopy data.

0644 THE EFFECT OF CROSS-LINKING ON STRESS-GENERATED POTENTIALS (SGPs) IN TENDON (MEETING ABSTRACT). (Eng.) Steinberg, M. E. (Dept. Orthopaedic Surgery, Univ. Pennsylvania Sch. Medicine, Philadelphia, PA 19104); Unger, A. S.; Jimenez, S. A.; Bashey, R. I.; Pollack, S. R. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:85; 1982.

The effect of cross-linking on stress-generated potentials (SGPs) in tendon was investigated using dry specimens to eliminate the role of streaming potentials. Thirty-two sections of canine flexor tendon were divided into two experimental and two control groups and treated for 24 hr at 22 C with formaldehyde (pH 7.3) or glutaraldehyde (pH 9.5), both active cross-linking agents. Controls were treated with the appropriate buffer alone. After thorough drying, specimens were subjected to 4-point bending in an electrically shielded climate chamber with serial deformations of 75 to 175 microns. Potentials were measured from opposite surfaces with platinum electrodes and were recorded simultaneously with load and deformation. There were no differences between the electrical waveforms or the polarity generated by treated and control specimens, both of which were similar to moist whole bone. The voltages, however, were significantly elevated by treatment with both formaldehyde and glutaraldehyde. Analysis of load/deformation curves showed that treated specimens were "stiffer" than controls. Increasing the number of crosslinks in tendon collagen by treatment with formaldehyde or glutaraldehyde caused a significant increase in SGP. It may therefore be postulated that the naturally occurring crosslinks of collagen play a role in the generation of potentials by tendon and bone. It cannot be determined from these [illegible] whether this is a direct or indirect effect, [illegible] is presumably independent of streaming potentials.

0645 FREQUENCY DEPENDENCE OF THE ELECTRICAL IMPEDANCE PROPERTIES OF COMPACT BONE (MEETING ABSTRACT). (Eng.) Saha, S. (Biomechanics Lab., Dept. Orthopaedic Surgery, Louisiana State Univ. Medical Center, Shreveport, LA 71130); Medoff, R. W. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:86; 1982. 8 refs).

A differential technique was employed for accurate determination of the specific resistance and capacitive properties of compact bone for a wide frequency range. A gain-phase meter (Hewlett Packard, Model 3575A) was used in a reference reading to estimate the wiring and cable capacitance. A second measurement was made with a bone specimen. From the difference of the two readings (magnitude and phase of an output to input voltage), it was possible to calculate the resistive and reactive components of bone impedance. These values were verified by taking another set of independent readings with an LCR meter (Hewlett Packard, Model 4262A). The measurements were repeated at several frequencies starting from 1 KHz to 1 MHz. At higher frequencies, the impedance values showed a decrease with increasing frequency. The specific resistance (R) was 7.56 kOhm/cm and the specific capacitance (C) was 0.166 nfarad/cm for fresh bovine longitudinal compact bone specimens. The impedance properties were direction dependent showing the anisotropic nature of bone. The calculated impedance was based on R and C values measured at one frequency agreed well with the measured values for other frequencies. The result indicates that by using a differential technique, errors due to stray capacitance can be eliminated while measuring the dynamic impedance properties of bone.

0646 ON THE MECHANISM OF BIOLOGICAL CONDUCTION (MEETING ABSTRACT). (Eng.) Cheng, N. (Biochemistry, Univ. Louvain, 300, Louvain, Belgium); Hoogmartens, M. J.; Mulier, J. C.; Sansen, W. M. Loecker, W. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:87; 1982.

The mechanism of biological conduction was investigated by examining the direct current (DC) conductivity of rat skin. Fresh skin strips from the back of rats were isolated, weighed and clamped at both ends with a pair of stainless steel electrodes. Resistance and voltage measurements were made immediately with an electrometer. Following the initial mea

ments a new set of readings of the skin strips were taken after drying and weighing. Similarly, the subsequent readings at different time intervals during drying were recorded. The resistivity of the skin was thus measured as a function of water content. The flow of current (charge transfer) was roughly estimated by the change of proton concentration (the rate of protonation and deprotonation) which was monitored by the pH change of cellular homogenate. It was found that the resistivity of the skin increased almost linearly as the wet wt of the tissue decreased. The DC conductivity observed was a function of water content of the skin. Protons were produced at the anodic area and consumed at the cathodic area during the passage of DC. The rate of proton production was equal to the rate of proton consumption as confirmed by pH measurement. The results of DC conductivity as a function of water content and the change of proton concentration after oxidation or reduction of H_2O at the interfaces suggest that water molecules are the most predominant electron donors or acceptors undergoing charge transfer reactions. It is likely that the conduction process following electrochemical reactions at the electrodes depends on the availability of water molecules. With the application of a weak direct current, water molecules are protonated ($H_2O + H^+ = H_3O^+$) after donating electrons to the anode and deprotonated ($H_2O - H^+ = OH^-$) after accepting electrons from the cathode. During a reaction at the the cathodic interface electrons are added and protons removed in equal numbers. Similarly protons are added and electrons removed at the anodic interface.

0647 A GENERALIZED THEORETICAL APPROACH TO THE DETERMINATION OF LOCAL FIELD PARAMETERS DURING CAPACITIVELY COUPLED ELECTRIC STIMULATION IN VITRO (MEETING ABSTRACT). (Eng.) Vresilovic, E. J. (Dept. Bioengineering, 119 Towne Bldg./D3, Univ. Pennsylvania, Philadelphia, PA); Pollack, S. R.; Brighton, C. T. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; p. 88; 1982 (2 refs).

A theoretical approach is presented, which allows the determination of the local field parameters (LFPs), electric field and current density, in vitro and in vivo, respectively. Fundamental electrical engineering principles from dielectric, circuit, and control theory were applied in the development. A generalized in vitro experiment includes a biological sample cultured in a vessel containing medium. Generally this vessel is placed between metal electrode plates, to which a driving signal is applied. While the driving signal is commonly given as the electrical stimulation parameter, the apparatus geometry and the electrical properties, the conductivity and the permittivity of the materials as a function of frequency have a determining effect on the actual values of the LFPs during an experiment. To calculate these LFPs, the experimental system must be modeled to allow solution of the Laplace equation with properly defined boundary conditions. Obviously, if electrical forces are to affect cell function, it is through their interaction with charge in the cell or in the local environment of the cell. LFPs are the fundamental quantifiable parameters, and they are the parameters to which cell should have a predictable response. After consideration of the geometry and the electrical properties, the relationship between the driving signal and the LFP is established by solution of the time dependent Laplace Equation using Laplace Transform methods enabling simpler frequency (s) domain solutions. This results in the definition of a transfer function, F(s), such that F(s) = LFP(s).DS(s) where LFP(s) is the local field parameter of interest and DS(s) is the driving signal. The time domain solutions of the LSPs are readily obtained by inverse Laplace Transformation. This theoretical approach was applied to an experiment where chick chondrocyte cell cultures are stimulated with a 1750-V peak square-wave. The resulting field and density have maximum values of 50 uV/cm and 0.75 uA/cm², respectively. A second application to the experiment in which rat costochondral junction tissue cultures were stimulated with a 5-V 60-kHz signal resulted in a 150 uV/cm field and a 2.4 uA/cm² density at 60 kHz. Although the driving voltages in these two experiments were separated by over two orders of magnitude, the calculated LFPs agreed to within a factor of 3 although their time dependences differed.

0648 THERMAL CONSIDERATIONS IN ELECTRICAL STIMULATION (MEETING ABSTRACT). (Eng.) Libe A. R. (Oakland Univ., Dept. Physics, Rochester, 48063). In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society held on 20-22 September 1982 in Oxford, England; p. 89; 1982.

Attempts are underway to determine the energy dissipation per unit volume J·E and the associated temperature increase using a commercially available stimulator (EBI/OSTEOGEN system) that generates a pulsed signal. In the initial series of experiments polystyrene flasks in different orientations containing 25 ml of culture medium (DMEM) were irradiated for periods of up to 10 min. The entire apparatus was totally enclosed in styrofoam. The temperature was monitored continuously using a fine fluoroptic probe which was completely non-metallic, thereby preventing any chance of direct magnetic induction, as may occur with thermocouples or thermistors. Results to date indicated that the temperature increase in the irradiated medium was no more than .05 C (the present temperature resolution) but that the inductive coils themselves were being heated to at least 0.1 C, for signal repetition rates of 25 Hz. It is expected that the temperature resolution will shortly be improved to better than .001 C. Additional experiments are planned on rats. It should be noted, however, that in vitro substances offer the possibility of more measurable change than might occur in vivo, even the additional tendency to temperature regula

resulting from the vascular system.

0649 THE EFFECT OF ORIENTATION OF HELMHOLTZ COILS ON NEURITE GROWTH OF NERVE GANGLIA IN VITRO (MEETING ABSTRACT). (Eng.) Sisken, B. F. (Wenner-Gren Res. Lab., Univ. Kentucky, Lexington, KY 40506); McLeod, B. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:90; 1982.

The effect of orientation of Helmholtz coils on neurite growth of nerve ganglia was investigated in vitro. Since the current density is minimal in the center of the culture dish in the horizontal orientation (HO) but maximal for vertical orientation (VO), data was collected comparing neurite outgrowth of ganglia located near the center of each dish with the ganglia in the periphery. The "center" was arbitrarily defined as the center one-third of the dish. It must be recognized that the distribution of the current density changes dramatically from HO to VO due to different boundary conditions, but on the bottom of the culture dish, some general comparisons can be made. For the HO the current density varied in a linear fashion from zero in the center of the dish to a maximum at the outer edge, while for the VO it varied nonlinearly from maximum in the center to zero at the edge. Dorsal root ganglia (5-7/dish) from 8 day chick embryos were placed in gelatinized culture dishes which were set between Helmholtz coils in the following manner: in the VO, five dishes were set one on top of the other; in the HO, two levels of four dishes each were set between the coils. The dishes were exposed to a single pulse waveform (15 mV, 325 usec positive, 20 usec negative, 72 Hz) for either 2 days (constant exposure) or for 2 days (12 hr on/off). After 3, 4, and 7 days in vitro the neurite outgrowth (NO) from the cultured ganglia were scored on a basis of 0 to +5 max. The results obtained appeared to depend not only on the orientation of the coils but also on the total time of exposure. After 3 days in vitro (3 DIV) ganglia in the center of the dishes in the VO experiments (where the current density is highest) had a higher NO score than ganglia located elsewhere. At 5 DIV, this situation was reversed, i.e., neurite outgrowth score of ganglia in the center decreased to a lower score than the rest of the ganglia. In the HO experiments, at 3 DIV, ganglia in the center of the dishes (where the current density is the lowest) exhibited a lower score there than found elsewhere. At 5 DIV this situation changed so that centrally located ganglia outscored those located in other areas. The data suggest that ganglia located in areas receiving high levels of current density from pulsatile electromagnetically-induced currents are stimulated to produce an immediate response which then decreases with time, while areas receiving lower levels of current demonstrate a slowly increasing response time. It is concluded that both current density and time serve as important parameters in deter... [illegible] ...tures.

0650 THE EFFECT OF DIRECT AND PULSED CURRENTS ON PARA... [illegible] ...TION (MEETING ABSTRACT). (Eng.) ...Bowman, B. (Dept. Biomedical Engineering, Duke Univ., Durham, NC 27706); Wachtel, H. In: Transactions of the ... Annual Meeting of the Bioelectrical Repair and ... Society, held on 20-22 September 1982 in Oxford, England; 2:91; 1982.

The implantable nerve cuff technique was used to ... the effects of applied direct currents and ... pulsed currents on regeneration in the rabbit ... nerve. Each nerve cuff was constructed by sewi... array of Pt-Ir electrodes into silastic tubing. ... longitudinally, the cuff was surgically impl... around the sciatic nerve. The cuffs were normali... 100% larger in diameter than the nerves to allo... nerve swelling as a result of dissection t... Stainless steel, teflon coated cables ran fro... cuffs to percutaneous connectors which e... through the skin on the animal's back. Each s... nerve was crushed before being loaded into the ... The point of crush was usually within the arr... electrodes so that periodic (every 3-10 days) s... lation and recording from the nerve could reveal ... trophysiological changes associated with regene... both proximal and distal to the crush site. ... the low impedance of nerve tissue, the system al... delivery of the current to the entire portion ... nerve within the insulating sleeve of the cuff, ... eliminated much damage to the nerve. Battery ... were plugged into the percutaneous connectors fo... ious lengths of time to allow direct current (1... 100 nA, 1 uA) to run from an electrode (anode) be... the connector to one of the electrodes in the ... surrounding the nerve. The contralateral nerve ... as a control with a dummy battery pack. Typi... the nerve was stimulated to elicit a maximal co... action potential. The electrophysiological dat... correlated with a muscle function test and histo... To date no significant difference in regenerati... detected between experimental and control n... This system can be used to study the effects on ... regeneration of induced currents from externall... plied fields. The use of such induced currents ... stantially decreases contamination from elec... products that occurs using direct current.

0651 EFFECT OF GAMMA-RADIATION AND HYPERTH... ON DNA REPAIR AND NAD+ TURN OVER IN C... ED LYMPHOCYTES (MEETING ABSTRACT). (Eng.) Jo... G. G. (Dept. Oncology, Univ. Hosp., S-221 85 ... Sweden); Pero, R. W.; Eriksson, L. In: Transac... of the Second Annual Meeting of the Bioelectric... pair and Growth Society, held on 20-22 Septembe... in Oxford, England; 2:92; 1982. (3 refs).

Unscheduled DNA synthesis (UDS) and cellular NAD^+ pools were investigated after exposing human lymphocytes to hyperthermia and gamma-radiation separately and in combination. UDS was measured using ^3H-thymidine, which is incorporated into the DNA during repair synthesis. Nucleotides were extracted using a perchloric acid-methanol procedure followed by KOH neutralization and analytic isotachophoresis with the aid of an ultraviolet detector. DNA repair synthesis was related to NAD^+ pools via the chromosomal enzyme poly (ADP-ribose) polymerase which was found to have a fundamental role in recognition and repair of DNA damage. UDS declined with increasing temperature. At 42.5 C the UDS was reduced to about 30% of the values determined at 37 C. Following gamma-radiation damage the NAD^+ pools dropped to very low levels, but recovered to the original level within 3 hr. Moderate hyperthermia (42.5 C) altered the kinetics resulting in slower and less effective recovery. Heat-treatment at 44 C prior to radiation killed the cells.

0652 IMMUNE RESPONSE AND ANTIINFLAMMATORY ACTIVITY OF PULSED 27 MHz WAVES (MEETING ABSTRACT). (Eng.) Tecca, L. (Dept. Pharmacology and Orthopaedics Clinic, S. Raffaele Hosp., Univ. Milan, Milan, Italy); Costi, P.; Dal Conte, G. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Society, held on 20-22 September 1982 in Oxford, England; 2:93; 1982.

Effects on blood, immune response and antiinflammatory activity were evaluated in rats and mice after exposure to pulsed electromagnetic radiation at 27 MHz (1 mW cm-). In rats treated 120 min per day for 20 days an increase in white cells ($p<.005$) and gamma-globulin concentration ($p<.01$) was observed. The percentage of lymphocytes decreased while that of neutrophils increased. When mice were exposed to gamma-rays (750 rad) only, the animals pretreated with the above-mentioned waves and those posttreated showed a substantially lower death rate as compared with controls. In mice treated before and after being subjected to gamma-rays, 58% survived >30 days. In another experiment, the inflammatory response to electromagnetic radiation was investigated. A group of animals was administered phenylbutazone, the other one was exposed to 27 MHz energy. In the irradiated group animals evidenced an inhibition of the inflammation rate ($p<.01$ versus controls) compared with the phenylbutazone-treated group. These results demonstrate the immunostimulatory and antiinflammatory effect of this low-intensity radiation.

0653 DIRECT CURRENT IN THE TREATMENT OF NON-UNION (MEETING ABSTRACT). (Eng.) Regling, K. (Dept. Orthopaedics [Charite], Humboldt-Univ., Scharnhorststrasse 3, 1040 Berlin, E. Germany); Lippel, H. In: Transactions of the Second Annual Meeting of the Bioelectrical Repair and Growth Soci Held on 20-22 September 1982 in Oxford, England; 1982.

Clinical results obtained using a self-made electr apparatus for constant direct current stimulatio non-union is described. A power source containi 9-V battery delivered a constant current from 1-2 As a cathode one to four Teflon-coated stai steel Kirschner wire electrodes were inserted the pseudarthrosis region. The stainless steel was fixed epicutane. The applied current was 12 uA for 12 wk. Ten patients with complicated p arthrosis who had undergone variable pretrea (5 tibia; 3 femur; 2 humerus) were treated with di current stimulation. At 1 yr post-treatment, cases of pseudarthrosis were healed. Two large d pseudarthroses were treated otherwise. Five case stimulated pseudarthroses are in progress. Base the authors' experience, direct current stimu appears to be an effective, inexpensive, and uncon cated method of pseudarthrosis treatment.

0654 PULSING ELECTROMAGNETIC FIELD EFFECT CULTURED FIBROCYTES (MEETING ABSTRA (Eng.) Loyd, R. D. (Baylor Univ. Medical Cen 3600 Gaston Ave., #303, Dallas, TX); Matthews, J. Newman, J. T.; Roa, R. In: Transactions of the ond Annual Meeting of the Bioelectrical Repair Growth Society, held on 20-22 September 1982 in ford, England; 2:95; 1982.

The effect of pulsing electromagnetic fields on tured fibrocytes was investigated. For a prelim study of the responsiveness of fibrocytes to p fields, a fibrocyte cell line that produces col in culture was selected for evaluation of the e of pulsed electric fields on the mitotic activit these cells for varying time periods using two that generate different signal configurations. ulator Unit 1 had a repetitive pulse burst si The primary (positive) pulse portion was a quasi- angular slope with a time duration of 200 usec positive peak amplitude of 1.5 mV/cm. This was lowed by a secondary pulse of opposite polarity a pulse duration of 15 usec and an inducted peak tage amplitude of 44.5 mV/cm. Unit 2 had a repeti pulse signal with the primary (positive) pulse a quasi-rectangular slope with a time duration o usec and a positive peak amplitude of 2.2 mV cm, lowed by a secondary pulse (negative) with a duration of 5.2 usec and an induced peak voltag .3 mV/cm. The fields of both units were mapped a search coil and were found to be homogeneous. were cultured in flasks which were positioned e parallel to or transverse to the coils within the ter of the field. Control flasks of aliquots o same cells were cultured in the same incubato least 3 m distance from the coils. Flasks were ed with 4 x 104 cells. Mitotic activity was d mined by counting tritium labeled thymidine inc

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ration in cells 18 hr after thymidine introduction to flasks. Proliferation was determined after either 7 or 13 days of continuous exposure to the fields. After 7 days, Units 1 and 2 showed a positive response (31% and +7%, respectively). After 13 days, cells showed a lesser response to Unit 1 (-5.98%) and a slightly positive response to Unit 2 (10.04%). The differences in response indicate that signal configurations play a significant role in determining the responsiveness of fibrocytes.

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