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EPA Research Needs in Radiofrequency and Microwave Radiation

Prepared for Phase I of the Biological Effects of

Nonionizing Electromagnetic Radiation (BENER) Task Force

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I. Instrumentation and Dosimetry

1. Develop non-perturbing electric-field and magnetic-field probes which can be implanted in animals. Ideally, systems are needed to measure fields in live, unrestrained animals during exposure to radio frequency fields.

2. Develop non-perturbing, implantable physiological probes for measuring temperature, cardiovascular parameters, brain wave activity, etc., in animals. Ideally, these systems would measure physiological parameters in live, unrestrained animals during exposure to radio frequency fields.

3. Develop instrumentation to monitor environmental electric and magnetic fields from continuous wave and pulsed sources, including electromagnetic fields which are frequency and amplitude modulated.

4. Develop standardized exposure systems for long-term, low-level studies of animals at environmental frequencies.

5. Determine the equivalence of circularly polarized, waveguide, cavity and anechoic chamber exposure systems in terms of biological effects, energy deposition, and electric and magnetic fields.

6. Develop human thermal model for predicting physiological responses resulting from the absorption of radio frequency energy.

   6.a. Determine local rates of energy deposition in human models for a variety of frequencies and conditions, e.g., far-field exposure with and without ground plane, near-field exposures, and body orientations (standing, sitting, lying).

   6.b. Develop human models incorporating realistic thermal regulatory mechanisms for determining localized heating patterns.

   6.c. Determine the biological effects of localized heating patterns in man.

7. Develop animal thermal models for predicting physiological responses resulting from the absorption of radio frequency energy to aid in the extrapolation of animal bio-effects to possible human responses.

   7.a. Determine local rates of energy deposition in animal models for a variety of frequencies and conditions, e.g., far-field exposures with and without contact with ground planes, near-field exposures and body orientations.

   7.b. Develop animal models incorporating realistic thermal regulatory mechanisms for determining localized heating patterns.

   7.c. Determine the biological effects of localized heating in laboratory animals.

8. Develop instrumentation to identify specific frequencies and intensities at which electromagnetic fields interact with biological systems.

II. Mechanisms of Interaction

1. Determine the mechanism of action by which radio frequency waves affect the central nervous system.

2. Determine the mechanism of action by which the non-uniform distribution of radio frequency energy results in biological effects.

3. Determine the mechanism of action by which radio frequency waves affect the physiological response of drugs.

4. Investigate the mechanism of interaction of radio frequency waves with basic biological systems such as proteins, nucleic acids, membranes and cells.

5. Investigate the interaction of radio frequency radiation with biological water, that is, the water associated with bio-molecular components, to determine if interaction with this type of water structure can cause changes in cellular physiology.

6. Support theoretical studies of the mechanisms of interaction of radio frequency waves with biological systems.

7. Support theoretical studies which attempt to develop a mechanistic basis for current phenomenological theories.

III. Long-Term, Low-Level Studies

1. Conduct multi-generation studies in laboratory animals incorporating non-invasive testing protocols, e.g., biological end points are body weight, reproduction parameters, survival, and causes of death.

2. Conduct long-term, low-level studies on laboratory animals at exposure conditions similar to general population exposures. Important biological parameters to be measured include effects on the developing embryo, immune defense and hematopoietic system, central nervous system, behavior, chromosomes and possible cumulative effects on the eye lens and the male reproductive system.

3. Conduct long-term, low-level studies with animal models of human clinical states.

IV. Human Studies

1. Conduct prospective clinical studies of radio frequency exposed workers (e.g., radar technicians, radio tower maintenance and repair workers, diathermy operators, microwave oven operators, and RF sealer workers).

2. Determine the thermal response of humans occupationally exposed to radio frequency fields.

3. Conduct feasibility studies to determine possible sensitive populations exposed to significant levels of radio frequency fields, including HVTL fields.

   3.a. Environmental population.

   3.b. Occupational population.

4. Perform epidemiological studies in those sensitive populations which are found to be exposed to significant levels of radio frequency fields, including HVTL fields.

5. Determine the populations that may live or work in the vicinity of high-power pulsed RF systems which radiate fields characteristic of those that induce human auditory responses.

6. Conduct feasibility studies to determine the human populations exposed to significant levels of radio frequency fields, including HVTL fields.

   6.a. Environmental populations.

   6.b. Occupational populations.

7. Perform epidemiological studies in those populations which are found to be exposed to significant levels of radio frequency fields, including HVTL fields.

8. Measure induced body currents in humans exposed to environmental radio frequency fields.

9. Evaluate the effects of radio frequency radiation on human behavior with standard psychological intelligence and performance tests in occupationally and environmentally exposed populations. In addition, evaluation of reaction time, vigilence (attention), highly specific memory tasks, sensory thresholds, and rapid motor performance is important.

10. Evaluate the effect of radio frequency radiation on human neurophysiological responses (e.g., sensory evoked potentials, nerve conduction velocity, and REM sleep duration) in occupationally and environmentally exposed populations.

V. Combination of RFR or HVTL Field with Other Agents

1. Determine the effect of temperature, humidity, air velocity and level of work activity on radio frequency field effects.

2. Determine the effect of CNS-active drugs on radio frequency exposed animals.

3. Determine the effect of infectious agents on radio frequency exposed animals.

4. Determine the effect of drugs which affect the cardio-vascular system on radio frequency exposed animals.

5. Determine the effect of chemicals which affect temperature regulation in animals exposed to radio frequency fields.

6. Determine the effect of toxic substances (pesticides, heavy metals, etc.) on radio frequency exposed animals.

7. Determine the effect of multiple frequency exposures.

VI. Important Biological Effects Studies

1. Determine the dose-response relationship of known biological effects caused by exposure to radio frequency fields.

2. Delineate the physiological effect of changes in behavior and in the central nervous system caused by radio frequency radiation.

3. Delineate the physiological effect of teratological changes caused by radio frequency radiation.

4. Determine the radio frequency field characteristics which cause changes in the blood-brain-barrier.

5. Determine the effects of radio frequency fields on ecological systems which are important to the food-chain.

6. Investigate the effects of high frequency radio waves ($\geq$ 20 GHz) on biological systems.

7. Perform confirmatory experiments of results reported in the Soviet and East European literature.

VII. Beneficial Applications