

as large as the control groups. Developing *Tribolium* eggs are about 10 times as sensitive to heavy ions as pupae. (b) *Phycomyces* has been found suitable for clinostat and radiation studies, and development of basic techniques for culturing and handling is in progress. (c) Using density-gradient centrifugation, labeling, and survival studies of naked DNA in phage, we find that radiation damage can be classified into three distinct groups; double-strand scission, single-strand scission, and molecular alteration. (d) Study of the biological effects of ultrasound was continued in mammalian cells, yeast, and *Tribolium* pupae. (e) ESR measurements of free radicals induced in L-valine and bacterial spores by accelerated heavy ions indicate that at stopping powers greater than 2.5×10^3 MeV cm²/g and at low doses, the maximum signal intensities obtainable at the peak of the power saturation curves increase depending on the irradiation and observation temperatures.

02:448 BIOLOGICAL EFFECTS OF HEAVY IONS ON THE NERVOUS SYSTEM WITH SPECIAL REFERENCE TO VISION. Tobias, C. A. (California Univ., Berkeley. Donner Lab.; California Univ., Berkeley. Lawrence Berkeley Lab.) Contract W-7405-ENG-48.

The aim of this program is to elucidate the biological processes whereby astronauts observe visual light-streak effects while exposed to cosmic-ray particles in space flight, and to assess pathological effects that may be the consequence of exposure to heavy ions. The experimental approaches include: exploration of visual sensations induced in humans by individual accelerated ions; cooperation with the medical research team and astronaut teams at the Houston Manned Space Flight Center in preparing and executing Apollo space flights; primates and other mammals will be studied with varying doses of radiation in order to elucidate hazards, if any, of heavy-ion exposures of retina and brain and to obtain data on performance decrement due to heavy ion irradiation.

In a series of experiments at the Berkeley and Seattle accelerators, human subjects have observed light flashes in neutron beams of 640-MeV peak energy (2 subjects); light flashes and dim but definite streaks in neutron beams of 25-MeV peak energy (6 subjects); light flashes and streaks due to individual accelerated helium ions impinging on human retina (2 subjects). We have also cooperated with the astronauts on Apollo 14 and helped to obtain additional information on the light flashes in spaceflights.

It appears that the light flashes observed in space are due to heavy primary cosmic ray particles of $Z = 6$ and higher [and, occasionally slow protons (high LET) and He ions].

02:449 STUDIES OF HEAVILY IONIZING PARTICLES AND SPACE BIOLOGY. Leith, J. T. (California Univ., Berkeley. Donner Lab.; California Univ., Berkeley. Lawrence Berkeley Lab.) Contract W-7405-ENG-48.

This program is concerned with the quantitative assessment of the biological effects of space radiation. The approach is first to dissect space radiation into its components, then to simulate these components using the cyclotrons, Bevatron, and the HILAC and study their specific effects. The investigations are producing an accumulating body of data which can be used to understand the basic interaction of radiations as a function of their linear energy transfer at the cellular and tissue levels; obtain special effects of radiation on localized system in multicellular organisms, particularly mammals; relate (where applicable) cellular control mechanisms to radiation carcinogenesis; and to aid in assessment of space radiation hazards to astronauts in space flights of short and long duration.

Some of the experiments are on a cooperative basis with other laboratories, e.g., Brookhaven National Laboratory and the Ames Laboratory of NASA.

After whole-body irradiation with helium ions, mice showed the following physiological changes: First, a progressing desiccation, rapidly decreasing skin temperature, decreased blood flow to the skin and kidney, decreases in plasma bicarbonate and sodium levels, and an increased organic-acid production. Second, an acute inflammatory phase shown by a rapid rise in skin temperature and blood flow, and observable skin damage as epilation and moist desquamation; also a large increase in fluid consumption and a major change in the content of plasma proteins. After 30 days, a recovery phase where physiological parameters return toward pre-irradiation values. Radiation damage to skin sufficient to produce epilation and desquamation will also shorten life. Survival of skin cells at a penetration depth of 120 microns is significantly greater than survival at greater penetration depths.

02:450 BOVINE LYMPHOCYTIC LEUKEMIA: STUDIES OF ETIOLOGY, PATHOGENESIS, AND MODE OF TRANSMISSION. Sorenson, D. K. (Minnesota Univ., St. Paul. Coll. of Veterinary Medicine.) Contract AT(11-1)910.

The primary objectives will be the elucidation of the etiology and factors involved in the transmission of bovine leukemia. The studies will include further work on the C-type virus isolated from cattle during the previous year's study and its relationship to bovine leukemia. Transmission studies involving the inoculation of newborn calves and fetuses with C-type virus will be initiated. Studies will continue to adapt serologic procedures such as complement fixation, immunodiffusion, and immunofluorescence to this C-type virus to determine infection rates in cattle. Studies will also be continued on high incidence herds to obtain epidemiologic data in defined populations of cattle.

The most exciting result is the isolation and demonstration of C-type virus from both leukemic and lymphocytotic cows. C-type virus was not demonstrated in apparently normal, nonlymphocytotic control cows. High incidence herd studies continue to show that 90% of all tumor cases of leukemia have a persistent lymphocytosis prior to the development of tumor.

02:451 BIOLOGICAL EFFECTS OF IONIZING RADIATION AT THE MOLECULAR, CELLULAR, AND HUMAN LEVEL. Hempelmann, Louis H. (Rochester Univ., N. Y. (USA): Dept. of Radiology.) Contract AT(11-1)3501.

A cell cycle analysis of the incidence and repair of radiation-induced single and double strand DNA breaks will be done with LS178Y and HeLa cells. The repair of single and particularly of double strand breaks will be compared with the ability of the cell, at the same age, to repair sublethal damage. Lange (Int. J. Radiat. Biol., 17, 61 (1970)) has already shown that in synchronous HeLa cells, repair of sublethal damage occurs to a much greater extent, if not exclusively, during G₁ and late S than during other stages of the replication cycle. Since the progression component of Elkind-Sutton type recovery had been taken into account, any molecular repair responsible for the repair of sublethal damage should also occur to a much greater extent at these stages.

The planarian will be used as a model system for the study of stem cell population kinetics, particularly with regard to the loss of differentiative integrity and the animal's mechanism(s) for the control of differentiation. Lang (Int. J. Radiat. Biol., 13, 511 (1968); *ibid.*, 14, 119 (1968); *ibid.*, 373 (1969); *ibid.*, 539; *ibid.*, 15, 51) has already shown the usefulness of the planarian for such studies and work will continue along the same lines.

A study of former plutonium workers with plutonium body burdens will be continued and thorough medical examination, including urine analysis and lung counts, of as many of these men as possible will be performed.

A system for automated gradient analysis has been developed and constructed, such that experimental points may be taken every two hours about the 24 hour HeLa cell cycle. Experiments with LS178Y and HeLa cells are now in progress. A planarian laboratory has been outfitted and a relatively local source of *Dugesia lugubris* has been found.

02:452 STUDY OF THE LIFETIME HEALTH AND MORTALITY EXPERIENCE OF EMPLOYEES OF AEC CONTRACTORS. Mancuso, Thomas F. (Pittsburgh Univ., Pa. Dept. of Occupational Health.) Contract AT(11-1)3428.

A 1-year (1965) feasibility study determined availability of amounts and kinds of data for a radioepidemiologic study of atomic energy workers in selected AEC facilities with a total of 176,000 employees. A 5-year pilot study was then initiated to begin a limited study of these facilities. The study is directed at the presence or absence of effects on human populations of low-level occupational radiation exposures received by atomic energy workers. Previous reports discussed in detail project objectives, design, and data abstracting procedures. All personnel and radiation exposure data available at Hanford and three plants at Oak Ridge are now on magnetic tape. Most of the other environmental and job identification data have also been taped. Those who died among the 35,000 employee population and 20,000 sibling control populations for Hanford have been identified together with dates and places of deaths. Preliminary comparisons have been run of mortality rates of employees versus various controls, for cohorts from 1943 to 1969. Death certificates are being requested from states and will enable analyses by cause of death; subsequent analysis will be by disability.

02:453 STUDIES OF THE PHYSIOLOGY OF MARINE ORGANISMS USING RADIOISOTOPES. Ebert, James D. (Marine Biological Lab., Woods Hole, Mass.) Contract AT(11-1)3325.

This contract is in partial support of a continuing service facility maintained to provide a wide variety of requirements— isotopes, chemicals, equipment, research space—for the radio-biological research of about sixty-five senior scientists each summer.

02:454 EXPERIMENTAL STUDIES ON REGENERATION IN THE CILIATE PROTOZOAN, BLEPHARISMA INTERMEDIUM:

02:710 BIOLOGICAL EFFECTS OF HEAVY IONS ON THE
NERVOUS SYSTEM WITH SPECIAL REFERENCE TO VISION.
Tobias, C. A. (California Univ., Berkeley. Donner Lab.;
California Univ., Berkeley. Lawrence Berkeley Lab.) Contract
W-7405-ENG-48.

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