doubled then the number of cancer cases will rise by an amount equal to the natural incidence of that cancer. Thus, if one population shows a natural cancer rate of 70 cases per million and another has 700 per million, doubling the dose would produce 70 new cases in the first instance and 700—not 70—new cases in the second.

A situation exists today that can be studied to test the concept. Americans have relatively little stomach cancer when compared to the Japanese. As a consequence of the atomic explosions at Hiroshima and Nagasaki, a large increase in the incidence of stomach cancer should be seen among the Japanese as compared to the Americans if the doubling-dose concept is valid.

"There are no extra cases from the bombings," says Dr. Evans.

"The stomach cancers are just now coming in," says Dr. Tamplin. "We haven't been able to get all the data. We'll have to wait another 10 to 15 years for the whole story to come in. I'm sure you will find some doubling dose."

It is this kind of contradictory evidence that is bound to divide the council in their efforts to come to grips with a safe level—if there is one. □

NUCLEAR ENERGY

Disposing of the waste

Ever since the beginning of the atomic age the Atomic Energy Commission has had the problem of safely disposing of its lethal nuclear garbage. And the problem will grow as more facilities are built and as more nuclear power plants go on-line. Right now, for example, 48 nuclear power plants are being built that will produce 38 million kilowatts, nine times the present nuclear capacity.

According to a report of a National Academy of Sciences Committee, the AEC is plodding along with its old waste-disposal methods. The report revealed some real shortcomings—in the handling of three basic radioactive waste classifications: high, intermediate and low levels. The survey was done four years ago. The procedures have not changed.

High radioactive liquid waste is disposed of by storage in 85-foot diameter steel tanks buried about eight feet below ground.

The concern is that the tanks will leak—as has happened several times at the Hanford, Wash., plant—and the radioactive liquid will seep into the water-table system. Newer tanks are built on concrete saucers to prevent this kind of leakage.

As for low- and intermediate-level solid wastes, the present method of disposal is burial in trenches in which,

AEC

Waste tank: Storage, not disposal.

says the NAS report, "there is always the danger of a build-up of concentrations in the soil."

Disposal of low-level liquids is done in streams—a practice the report found apparently harmless, if constantly monitored. Low- and intermediate-level liquids are disposed of by injecting them into evaporation ponds or into the ground. The NAS committee says that, in the long run, this would "lead to a serious fouling of man's environment.

". . . None of the major sites," the NAS report concludes, "at which radioactive wastes are being stored or disposed of is geologically suited for safe disposal of . . . other than very dilute, very low-level (radioactive) liquids. . . ."

The AEC maintains that it is storing, not disposing. "We do regard these sites as safe places for the processing and storage of the wastes while developing programs and facilities for final disposal," says John Erlewine, assistant AEC general manager for operations.

In anticipation of problems, the AEC is looking at such alternatives as hydraulic fracturing (SN: 2/8/69, p. 143), by which radioactive wastes are introduced into cement, which is forced into horizontal rock strata where the cement hardens in a thin layer. But this method is just for intermediate wastes and requires such special geological conditions as layered shale.

Better results are expected from calcining, in which high-level liquid wastes are converted to lower-volume solids by heating. Safer for transport and easier to dispose of, these solid wastes would be put in steel containers and stored indefinitely in abandoned salt mines. Salt mines are considered the best choice because they are isolated from water. Their capacity also appears to be no problem. "It should last for a long, long time," predicts James Pollock of the AEC's production division. □

CANCER THEORY

Charges on the cell membrane

Cancer research is, by and large, descriptive.

Research has for years focused on the nature of the cancer cell's aberrant behavior, the things in the cells or its environment that trigger that behavior and what, if anything, can be done clinically about it.

Out of this have come several general hypotheses. One is that viruses cause cancer (SN: 10/4, p. 308). There is undeniable evidence that they induce some types of animal tumors, and a growing body of circumstantial evidence exist linking them to some human cancers.

A second explanation of the cause of cancer stresses the role of chemicals in the environment. Additionally, radiation is known to induce tumors. And deficiencies in the immune system have been implicated in the occurrence of malignancies (SN: 5/10, p. 457). In all likelihood the cause of cancer is related not to one or the other of these possibilities but to each of them, alone or in combination. Further, the genetic constitution of an individual appears to play a role in his susceptibility to cancer.

Each of these probable factors linked to malignancy was discussed by scientists this week in San Antonio at a seminar sponsored by the American Cancer Society.

Each contributes pieces to the incomplete jigsaw puzzle of cancer. None of them draws a single thread of biological theory to tie the pieces together.

Cancer theorists recognize the lack of such a thread in their work, and consider studies of the cell membrane as a likely source of the answer—the defective mechanism that allows a tumor cell to proliferate and spread.

So the participants in the symposium were understandably stimulated by one such attempt, the presentation of a general hypothesis which, right or wrong, seemed to be a biophysical stab at least in a promising direction. It was the observations of Clarence Cone, a chemical engineer at the National Aeronautics and Space Administration's Langley Research Center in Hampton, Va.

Cone, who began studying the effects of radiation on human cells, ended up with the suggestion that electrical changes in the surface of cells may account for both uncontrolled proliferation and metastasis. His theory, he believes, will contribute to understanding of the fundamental changes occurring in tumor cells and fits with previously explored descriptions of cancer causation.

"The electrical voltage which normally exists across the surface membrane," Cone says, "acts to exert precise control over division in body cells." Cells that are usually nondividing, such as nerve and muscle, have high negative membrane voltages—on the order of minus 90 millivolts—he finds from experiments with mammalian cells. Those that divide more routinely have lower voltages. Tumor cells have voltages in the minus 10 millivolt range.

"Most significantly," he reports, "the experiment showed that high negative voltages block cell division by preventing synthesis of DNA." Thus a reduction in negative voltage across the membrane and a corresponding initiation of DNA synthesis fits with the fact of abnormal cell division.

Carrying the theory a step further, Cone followed the well-established principle that the molecular structure of the surface membrane determines both the nature and degree of a cell's ability to bond with other cells. That ability is intimately involved in determining the electrical voltage level.

Normal cells respond to a phenomenon known as contact inhibition. When the surface of one comes into physical contact with the surface of another, division ceases in both. Malignant cells, however, possibly because of aberration in the molecular structure of their membranes, fail to react in this way, and continue to divide and pile up. Says Cone, "Malignant cells may have molecular amnesia of the membrane, making them unable to recognize and relate to their cellular environment."

This could account for the fact that they metastasize. A normal muscle cell for example, is bound to other muscle cells. A malignant muscle cell, lacking the ability to bind, wanders through the body invading other types of tissues and spreading cancer.

Emphasis on the membrane surface as the mechanism of malignancy fits with ideas that chemicals and viruses trigger cancer, Cone believes. He finds it likely that these agents alter the molecular architecture of the surface membrane, thereby disrupting its normal electrical voltage and blocking its ability to recognize and bind to other cell surfaces. □

SUPERCONDUCTORS

Theory versus experiment

For more than a decade physicists have had a theory of superconductivity, the ability of certain metals at very low temperatures to pass electric currents without resistance. The theory explains how superconductivity works, predicts which metals should have the property and under what conditions. Most physicists consider it quite successful. It won the 1962 Fritz London Award for one of its originators, Dr. John Bardeen of the University of Illinois.

Despite the theory's general acceptance, however, Dr. Bernd T. Matthias of the University of California at San Diego and Bell Telephone Laboratories at Murray Hill, N.J., has spent years giving experimental demonstrations of superconductivity in metals where the theory has said it should not be. His experiments have been instrumental in gradually raising the temperature at which superconductivity is known to appear, from about 9 degrees above absolute zero to slightly more than 20, and in gradually raising the maximum magnetic-field strength of superconducting materials.

These activities are necessary steps toward making practical use of superconductivity in magnets and other electric circuit elements that could then be made to operate without loss of power and without heating. Of the theory Dr. Matthias says, "That theory has been so consistent in predicting the wrong results that I never paid any attention to it."

The latest antitheoretical development doubles the maximum magnetic fields under which superconductivity can appear. It stems from a collaboration among Dr. Matthias and Drs. Ronald H. Willens and Ernest Corenzwit of Bell Telephone Laboratories, Simon Foner and Edward J. McNiff of the National Magnet Laboratory in Cambridge, Mass., and Theodore H. Geballe of Stanford University and Bell Telephone Laboratories.

Magnetic fields tend to destroy superconductivity. That is, a metal that is superconducting at a given temperature will lose that property, the temperature notwithstanding, if it is subjected to a magnetic field stronger than a certain limit. Thus a magnet made of any superconductor will have a built-in field limit.

The theory predicts what this limit will be for different materials at different temperatures. It explains the situation by reference to the effect of magnetic field on the superconductor's conduction electrons.

For superconductivity to occur, the conduction electrons must form pairs, and in these pairs the spins of the two electrons will be oppositely aligned. The limiting magnetic field is one strong enough to reverse the spin of one electron in each pair. This destroys the pairs and the superconductivity.

In certain superconductors, however, this simple explanation does not fit. As Dr. Willens puts it, the electron pairs are not isolated objects drifting freely in space and influenced only by the magnetic field. They are scattered by other elements in the metal structure. This scattering complicates the alignment of their spins in such a way that the magnetic field cannot destroy the pairs as easily as the theory says that it can.

There have been many experimental examples of cases where this simple limiting theory does not apply, says Dr. Matthias, "but people tended to ignore them." The present case, he feels, is too spectacular to ignore.

Experiments reported to the meeting of the American Physical Society in Dallas this week show that, at the condensation temperature of liquid helium, 4.2 degrees K., a particular alloy of niobium, aluminum and germanium will remain superconducting under a magnetic field of 410,000 gauss, and an alloy of niobium and aluminum will remain superconducting under 300,000 gauss at the same temperature. The previous high field was 220,000 gauss for an alloy of niobium and tin.

To test these materials a conventional magnet cooled with liquid nitrogen and capable of producing fields up to 450,000 gauss in short pulses was built at the National Magnet Laboratory. Conventional magnets cannot operate continuously at these high fields because the heat they generate would melt them.

Whether the niobium-aluminum-germanium material can be used in a magnet depends on whether it will stand the electric currents necessary to generate the fields and how difficult it is to work. There is some evidence that it will stand high currents, says Dr. Willens, and it is about as difficult to work as the niobium-tin alloy. The niobium-tin presents formidable problems, but has been made into ribbons that can be wound into coils.

Other materials with even higher magnetic fields might also be found. "I intend to look," says Dr. Matthias, but he is pessimistic about practical results of the work.

There are some laboratory applications of superconductivity, such as research magnets and waveguides for high-energy particle accelerators. These are proceeding slowly, but to show that such things as superconducting motors, generators and transmission lines will work, says Dr. Matthias, pilot plants will have to be built. This is not being done in the United States, he says, though it is going on in the U.S.S.R. and other countries (SN: 3/30/68, p. 318).