"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).