

The mathematics of cancer

Disease induced by radiation can appear either immediately or after long delay. The immediate type comes from a massive dose of radiation to the whole body and has physiological effects similar to those of a massive burn. The delayed variety usually involves some form of cancer. An example is a group of women who had been employed during the 1920's painting radium on watch dials: At the time they did the work they appeared healthy; 20 years later all were dead of bone cancer.

For the last 20 years dogs at the University of Utah in Salt Lake City have been irradiated with radium. Comparing what happened to the dogs with things that happen to nonirradiated people as they grow older has led Betsy Stover and Dr. Henry Eyring to formulate a mathematical theory of mutation and death connecting the aging process and the onset of cancer. Dr. Eyring reported the work at last week's meeting of the American Chemical Society in Chicago.

At the time they reached maturity, about a year and a half to two years after birth, the dogs were given doses of radium or chemically similar radioactive elements. After 11 years the dogs began to die of bone cancer. Four years later all were dead.

Radium acts chemically like calcium: It is deposited in the bones. The radioactivity lasts for years. Thus, in the dogs and in the women, radiation was continually delivered to the bone cells for many years. Yet cancers did not develop until a decade or more had passed.

Nonirradiated populations seem to have a similar connection between time and the development of cancer. Cancer appears most in older people.

When radiation penetrates a cell, it dissociates the water in the cell into hydrogen ions, hydroxyl ions and hydrated electrons. All of these are chemically highly reactive. They enter chemical reactions with the chromosomes of the cell and break the chromosomes, destroying some of the information carried by them. The destroyed information may range over any part of the genetic message, but sometimes it is that which controls the replication of the cell, says Dr. Eyring. In that case uncontrolled replication of mutated cells may begin, and one of the 100 or 200 known varieties of cancer is on its way.

Cancer does not set in every time a chromosome is broken in the appropriate way. However, its chances of doing so increase as the dog or the person grows older. The body has the ability to repair the chromosome damage, but

the stresses of living erode it.

This circumstance leads Dr. Eyring and Mrs. Stover to suggest that the situation is what in chemistry is called a steady-state reaction. That is, in general, a process that builds up a particular compound is going on at the same time as one that destroys it. If the two are in balance a steady amount of the compound will be present. If the balance is tipped to one side or the other, the compound will increase or decrease.

In the dogs' case, radiation was breaking chromosomes and the body was repairing them. Mathematical equations were derived that took into account the number of cells in danger of starting a cancer at any given time, the body's ability to repair the damage and the decline of that ability with age. The equations predict the probability of death or survival, but not the fates of individuals. "Chemistry always happens by chance," says Dr. Eyring. "It hits one molecule but not another."



American Chemical Society

Eyring: Balancing damage and repair.

Dr. Eyring believes these same equations will work for human populations, and for other carcinogens than radiation. Since people are continually ingesting a large variety of substances that break chromosomes, the theory gives cancer a certain grim inevitability. To old people Dr. Eyring says: "If you don't die of other degenerative diseases, just wait and you'll get cancer. It's coming. The best insurance against dying of cancer is to get run over by a car."

From studies like these, however, there is some hope of effective chemical prevention. Some substances apparently enhance the body's ability to repair chromosome damage. If research on them succeeds, they could be introduced to keep the balance on the side of repair. They might prove effective both in preventing cancer and slowing the aging process, Dr. Eyring says. □

Fish protein progress

Earlier this year, the fate of fish protein concentrate (FPC) was uncertain (SN: 1/24, p. 91). Although the substance promised to be a major cheap source of protein for underdeveloped nations, as well as for hungry people in the United States, legal and technological problems had bogged down progress in its development.

The Agency for International Development, for example, had rejected FPC manufactured by Alpine Marine Protein Industries, Inc., because Alpine's product did not meet the 100 percent protein efficiency ratio (based on the protein efficiency of casein) required by the Food and Drug Administration. In addition, FDA had imposed other limitations, such as refusing to allow fish other than hake to be used.

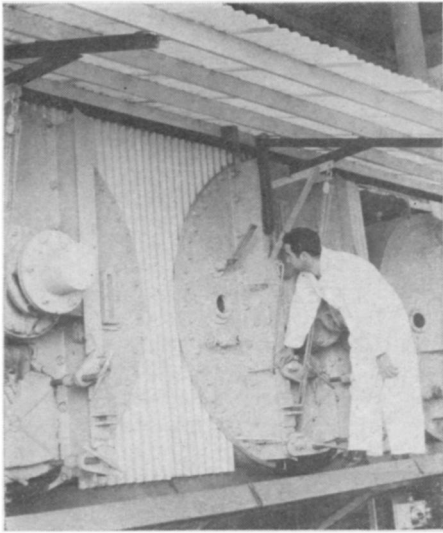
Since then, there has been progress. Although AID and Alpine have mutually agreed to terminate their earlier contract, Alpine continues to have faith in its product. It recently began a marketing program in the United States, legal under present law if the product is sold in individual packages of less than one pound.

In the meantime, FDA has relaxed its requirements on fish species; now menhaden and herring of the genus *Clupea* (including the common Atlantic and Pacific herring) may also be included. But FDA clearances are still a major roadblock to the Bureau of Commercial Fisheries' FPC program. FDA requires that when the viscera of fish are included in the final product, extensive toxicological data must be submitted to preclude any possibility that toxic materials from organisms eaten by the fish would be included in the protein concentrate.

"This is primarily a problem of time," says Roland Finch of the bureau's National Center for Fish Protein Concentrate. "It requires a great deal of work in the library, reading biologists' accounts of the diets of the fish."

However, this problem may be bypassed if a process being developed in Sweden turns out to be successful. Astra Nutrition Corp., in combination with several other firms, has a small experimental plant at Bua, Sweden, which eviscerates and debones fish before they are converted to FPC. Presumably, says Finch, FDA might not require the extensive toxicological data if viscera are removed.

The interesting thing about the Swedish process is its projected cost. The company estimates FPC might be produced at a selling price of 49 cents a pound. (Alpine's contract with AID would have given the company 42 cents a pound.) At this price, the FPC would



Alpine

Mass-producing FPC: Some progress.

be highly competitive with other proteins. The price might go down further as capital investments are amortized, says Finch. The product would also no longer have the stigma—even though it is more illusory than real—of including the viscera.

A possible major spur to development may be the Nixon Administration's commitment to provide an adequate diet for every school child in the United States. Because the Federal Government must bear most of the cost of feeding the needy children and because 70 cents of every dollar spent for a school meal goes to pay for the protein in it, the cheap FPC may become more and more attractive.

Finch agrees that a major problem has been and will be public acceptance of fish protein products. The Swedish project may show the way. An important step might be an FDA waiver on the one-pound-package requirement so that FPC could be used in school meal programs. And industry continues to be interested; although Alpine is still the only United States producer, Cardinal Proteins, Inc., expects to be on stream with a 200-ton daily capacity plant in Nova Scotia soon. □

GUN DETECTOR

Searching for weapons

Last Oct. 15 Transportation Secretary John A. Volpe dramatically announced to the press that, following many months of tests, an anti-hijacking system developed by the Federal Aviation Administration had gone into operational airline use at key locations in the United States.

The so-called system he referred to consisted of a \$600 off-the-shelf magnetometer built by Infinetics, Inc., Wilmington, Del., modified by research engineers in the FAA, and a kind of

check list of behavioral traits considered by psychologists to be common or peculiar to potential hijackers. The instrument senses disturbances in the earth's magnetic flux caused by ferrous-metal masses in proximity to the device.

Since the announcement, only four airlines have acquired and installed the weapon detector: Continental, Eastern, Pan American and Trans World Airlines. The reluctance of the airlines to use the device stems not from its ability to detect weapons but from its intolerable propensity for false alarms. The trouble, says one airline representative, is that it detects too much, including the wires and stays in female undergarments. FAA field trials showed about a 50 percent false-alarm rate; users report it runs as high as 87 percent.

The recent rash of hijackings in the Middle East has spurred new efforts to develop weapons detectors. Tested without fanfare at Dallas' Love Field last week, with FAA observers present, was a new magnetometer-type detector that appears to offer better discrimination than the Infinetics device. The system, built by SPS, Inc., a three-month-old Garland, Tex., electronics manufacturer, reportedly produced a false-alarm rate below 40 percent.

Like previous developers of similar systems, SPS officials are reluctant to reveal design details. Tom I. Allen, consultant to the SPS president, says the WD-100 will detect items of a specified minimum mass containing gun metal, and claims: "There is no practical method for covering or concealing a weapon to prevent triggering the alarm."

Some cameras and all portable radios (because of the speaker magnet) will cause a false alarm, he admits, but few other items normally carried on the person will trigger the system. There are some modern guns assembled largely of nonferrous metals, says Allen, but even these are readily detectable because they must contain gun metal for the chamber, barrel and firing pin.

The \$1,000 system (plus installation) can be located anywhere and the sensors may even be buried in concrete for invisibility, Allen says. Coverage is spherical to at least a 10-foot radius.

He also emphasizes that during its installation the effects of nearby ferrous metals can be effectively nulled out. For example, Allen says that a WD-100 has just been installed by SPS in the Garland Post Office to detect parcels with potentially dangerous contents. There, the detector is mounted 22 inches above a steel table overlooking a steel conveyor belt, yet it is able to detect gun metal in any package passing beneath.

Although not yet in production, the firm expects early sales to airports and airlines, post offices and banks. □

SCIENCE NEWSBRIEFS

Geneva Protocol

At its meeting in Chicago last week the American Chemical Society reversed its 45-year-old stand opposing United States approval of the Geneva Protocol outlawing chemical and biological weapons. In 1925, when the protocol was formulated, the society had opposed it on the ground "that nonlethal but temporarily incapacitating chemicals could make warfare more humane than it had been." That reasoning no longer convinces the society's Board of Directors and Council, who have now sent a resolution to the Senate Foreign Relations Committee urging ratification of the protocol. In asking the Senate to ratify the protocol last month (SN: 8/29, p. 166), President Nixon emphasized that in the United States' interpretation the protocol did not prohibit the use of riot-control agents. □

Medical devices

Last December the Secretary of Health, Education and Welfare appointed a task force to study the problems surrounding the increasing number of medical devices being introduced for diagnosis and treatment, some of which have been found unsafe and ineffective (SN: 5/23, p. 500).

In a just-published report, the committee recommends new legislation to vest control of such devices in the Secretary of HEW. This would mean the creation of a new regulatory facility like that now represented by the Food and Drug Administration. The committee also asked for an immediate start on review of the estimated 5,000 devices now in use. This would be done by organizing a group of experts and might take two years, according to the task force chairman, Dr. Theodore Cooper, director of the National Heart and Lung Institute. □

Auto pollution

By a vote of 73-0, the Senate this week passed Sen. Edmund Muskie's (D-Me.) bill requiring that new cars built after Jan. 1, 1975, emit 90 percent fewer pollutants than permitted for 1970 models (SN: 8/29, p. 163).

The bill now goes to conference with a less stringent House-passed bill. It is expected to face a stiff challenge. The Automobile Manufacturers Association claims the legislative deadline is unacceptable.

The legislation also includes wide-ranging provisions to set national air-quality standards, require all major new industrial plants to install the best pollution-control equipment available and permit citizens' suits (see p. 273) to force compliance with standards. □