impossible for even the fastest of computers to examine all moves very deeply because of what is known as the exponential explosion," Berliner says. If, for example, 35 moves are possible at each turn for each opponent, then examining one move for each side involves searching through $35^2$, or 1,225, terminal situations. Although computer scientists have improved the efficiency of these searches, the computers still are unable to make judgments about the ever-changing situation in complicated games such as backgammon.

Berliner set out to give his computer the ability to make those judgments by providing it with complex "real-world knowledge." All of the knowledge of artificial intelligence is stored in formulas. Sometimes the formulas are simple, linear functions: A=2B, for example, can represent, "Oranges are twice as valuable as apples." But simple, linear formulas rarely represent complex situations. (During a glut of oranges on the market, A=2B may no longer represent the orange-apple relationship.) Instead, Berliner says, the backgammon-playing computer needs SNAC: a Smooth, Non-linear function with Application Coefficients — the slowly varying items in each term of the formula that can represent subtle changes in a situation.

The equation "Value = $C_1A_1F_1 + C_2A_2F_2 + \ldots C_nA_nF_n$" illustrates some of the characteristics of a SNAC function. The $F_i$'s (where i is 1 through n) represent the number of items of a certain type that exist in a particular situation, the C's represent their unit cost or value and the A's represent "the importance of the term i given certain global information about the present situation."

Using a modification of this SNAC program, a Berliner computer has retired from playing backgammon to coach — analyzing players' moves and explaining whether they are good. The general public "firmly believes" that it is impossible for a computer to conduct such analyses, Berliner says. "This is partly because no such machines have existed, and because it is generally thought that machines operate in an all-or-none mode where they can deal with black and white, but have trouble with shades of gray. However, this is a faulty view as this research demonstrates." □

# Antiobesity drug may counter cancer, aging

A drug that counters obesity, prevents cancer and retards aging sounds too good to be true, but it just might become a reality if research reported at the AAAS meeting by Arthur Schwartz of Temple University Medical School in Philadelphia pans out. The wonder drug would be the adrenal gland product dehydroepiandrosterone (DHEA), or an analog thereof.

A great deal of animal and clinical studies have suggested that undereating can both prevent cancer and extend life span, the latter perhaps resulting from the former. Obesity, for instance, is believed to be a causative factor in certain types of cancers because it produces an increase in hormones known to be associated with those cancers. As for research on DHEA, it has been found that women who secrete subnormal levels of DHEA breakdown products are predisposed toward breast cancer. When DHEA was given to a genetically obese strain of mice, it kept them from becoming obese, and levels of DHEA have been found to drop off markedly when humans age. Pulling all this evidence together, Schwartz and his colleagues developed a fascinating hypothesis: DHEA might have not only an antiobesity effect but also anticancer and antiaging effects because it appears to counter cancer and aging just as caloric restriction does. They tested their hypothesis with two experiments.

The first was on mice of the same age with a genetic predisposition toward both breast cancer and obesity. Twenty-five mice got DHEA three times a week for a year; 25 did not. At the end of the year, the DHEA-treated mice had far fewer breast cancers than did the mice that did not get DHEA. What's more, the DHEA-treated mice looked younger — their coats were glossier and less gray than those of the control animals. The second experiment was conducted on mice of the same age with a genetic predisposition toward breast cancer but not obesity. Seventy-five mice got DHEA three times a week for a year; 75 did not. At the end of the year, the DHEA-treated mice had a much lower incidence of breast cancer than did the nontreated mice — even lower than for the DHEA-treated mice with a predisposition toward obesity. Once again, the DHEA-treated mice looked younger than did controls. The results of both studies, Schwartz and his colleagues conclude, "suggest that DHEA treatment may duplicate the antiaging and anticancer effects of caloric restriction."

Schwartz told SCIENCE NEWS that he and his team are now collaborating with a drug company to make DHEA analogs that are even more effective than DHEA. If they find an ideal one, they will attempt to get Food and Drug Administration clearance to test it in a clinical trial to see whether it can prevent breast cancer in women. The trial would probably be conducted on women at particularly high risk of breast cancer because of genes or other risk factors.

Schwartz is also optimistic that DHEA, or an analog thereof, might eventually be used as an antiaging drug in humans. He and his co-workers are now testing DHEA in rodents that are not predisposed to breast cancer or obesity to see whether it can extend their life spans. Preliminary results, he says, look promising. □

# Proper diet saves lives, land, oil . . .

Eat more fruits, vegetables and whole grains and consume less animal fat, meat, cholesterol, salt, sugar and other highly refined foods. Nutritionists have been telling us this for years, and their major argument has been the beneficial health effects of a proper diet. At the AAAS meeting, a session titled "National Impacts of Recommended Dietary Changes" reviewed the health consequences of a good diet and then went on to conclude that changes in our eating habits can have significant beneficial effects on everything from land, water, fuel and mineral use to the cost of living, employment rates and the balance of international trade.

The session was arranged by Alex Hershaft of the MITRE Corp. in McLean, Va. He traced our current eating habits and tendency toward overconsumption of meat to the post-war economic situation that demanded that productivity (including farm productivity) be kept at a war-time level in order to forestall a major depression. Consequently, Hershaft explains, the U.S. Department of Agriculture found itself saddled with vast, perishable and costly stores of grain, legumes and other staple foods that had been purchased to support farm prices. To alleviate this storage problem, the USDA encouraged the expansion of animal agriculture and the establishment of feedlots where the grains and legumes could be used. The next step was a massive promotional campaign that eventually doubled the per capita consumption of beef—to about 95 pounds per year.

The well-known health effects of this increase in animal agriculture and increased consumption of beef, milk and eggs were discussed by J. A. Scharffenberger of the San Joaquin Community Hospital in Bakersfield, Calif. Citing a number of studies, he concluded, among other things, that: Elimination of animal products from the diet can reduce the rate of coronary heart disease by as much as 88 percent; dietary changes can possibly reduce the incidence of cancer by as much as 50 percent (the three major dietary factors in cancer causation are obesity, animal fat and lack of fiber, or whole grains); proper diet can help control weight and thus help reduce the risk of hypertension, coronary heat disease and cancer.

Going beyond the health effects, Georg A. Borgstrom of Michigan State University in East Lansing urged that the effects of land and water use be included in dietary debates. The United States, he says, has climbed to the pinnacle of the world in terms of per capita consumption of animal proteins and along the way has strained land and water resources to the point where we now hold the world record for the consumptive use of water for food

production — with animal products accounting for 85 percent of the total. The adverse impacts of this, he says, include soil degradation, desertification, groundwater depletion and water pollution. Hershaft adds that production of animal foods uses 95 percent of all U.S. agricultural land and is largely responsible for the extensive abuse of rangeland and forestland, for the extensive destruction of wildlife and for the loss of soil productivity through erosion and mineral depletion.

Energy consumption should also be included in dietary debates, says David Pimentel of Cornell University in Ithaca, N.Y. The average person in the United States, he says, consumes approximately 600 pounds of meat, eggs and dairy products per year. This provides 70 grams of animal protein per person per day in addition to the 32 grams of plant protein consumed. If consumption of animal proteins were cut in half, he says, total protein intake would be 67 grams — still well in excess of the 56 grams suggested for the 70 kg man by the 1980 RDA (recommended daily allowance). A 50 percent reduction in consumption of meat and other animal products, he says, could save half the energy, mineral resources and land and one-third the water used in animal production. "If Americans switched to the healthier diet," Pimentel concludes, "up to 30 gallons of oil per person would be saved each year, or one percent of the entire energy consumption of the nation."

Pimentel offers two specific energy-saving suggestions: Raise chickens instead of beef and grass feed livestock (dairy, beef and sheep). Only one-half the energy required to produce beef protein is required to produce broiler protein, he says, so a shift to chicken could greatly reduce the energy input. Grass feeding of livestock, he says, could save 135 million tons of grain per year (ten times as much grain as the U.S. human population consumes) and save up to 60 percent of the energy used. He further notes that the grain, valued at $20 billion, would be available for export.

And the economic argument goes on. Because the growing, processing and distribution of food represents the largest sector of the U.S. economy, any changes in national dietary patterns are certain to produce important shifts in the economy, particularly in the areas of employment, consumer prices and international trade, explains J. B. Penn of the USDA. A dietary shift from animal products to fruits, vegetables and grains, for example, would involve some relocation and retraining of agricultural workers. The associated reduction in the cost of food would shift personal spending into other sectors of the economy. Meats, for instance, cost five to six times as much as foods containing an equivalent amount of vegetable protein, and consumption of animal foods adds approximately $4,000 to the average household's annual budget — including the cost of increased medical care. The lower demand for foreign oil, minerals and farm machinery and the greater availability of grains and legumes for export would reduce the U.S. trade deficit and political dependence on foreign suppliers and strengthen the value of the dollar abroad.

Despite the numerous arguments put forward, we are not likely to witness an immediate, massive shift from Big Mac's to Vegiburgers. But considering the numbers —including these: 90 percent of our grains and legumes and 50 percent of our fish catch is fed to livestock while 800 million people are going hungry—the session did offer food for thought. □

# Bacterical blubber: Fueling the future?

Canadian researchers have struck oil in purple blossoms on a Saskatchewan salt lake. These purple flowers, Morris Wayman and colleagues of the University of Toronto have discovered, house a bacterial partnership that can convert carbon dioxide to chains of hydrocarbons —the components of crude oil.

The bacterial oil is the end-product of an extended version of photosynthesis. That process consists of a light-driven splitting of water and a second step that uses the energy gained from splitting water to convert carbon dioxide to energy in the form of organic compounds, such as the simple sugar glucose. But the bacteria pair takes photosynthesis one step further. After one bacterium converts carbon dioxide to the energy-rich organic compounds, the other bacterium feeds on those compounds and accumulates "very high concentrations of oily material."

While Wayman and colleagues first investigated such a process in the purple-flower bacteria —*Chromatium warmingii* and a *Desulforistella* — they since have discovered more efficient algae-bacteria combinations. A hectare of these growing microbes "could produce the equivalent of 50,000 barrels of crude oil a year," providing "an alternative fuel source with greater potential than the currently popular gasohol," Wayman reported at the AAAS meeting.

Wayman explains that while both potential fuel alternatives — crop-based ethanol, or gasohol, and microbial oil — use sunshine, surface area and carbon dioxide, the microbial energy conversion may be more efficient since some of the bacteria can utilize weak light. Moreover, whereas gasohol crops must be grown on arable land, oil-bearing microbes can use land and sea surfaces. "Finally, there is no conflict with food production in microbial oil production," Wayman says, "while there is always a concern about the impact of the gasohol program on food prices (SN: 1/10/81, p. 21)." □

# Antibodies tie up malaria parasite

Pure and mixed antibodies are being found effective in fighting malaria-causing protozoa. The trick is to focus the immune system defenses on parasites in a specific stage of their complicated lives, say scientists from New York University School of Medicine. Ruth S. Nussenzweig reports that protozoa inactivated in the infective stage of their life can provoke an immune response that will protect mice, monkeys and humans from infection. Pure antibody to a specific surface component that appears only during the parasite's infective stage also can protect mice, Victor Nussenzweig says.

Mature sporozoites, the form of the malaria parasite *Plasmodium berghei* that is transferred from mosquito to mouse, can be inactivated by X-irradiation. An injection of the inactivated sporozoites then protects mice against active sporozoites, but the vaccinated mice remain susceptible to infection with merozoites, the form of the protozoan that infects red blood cells, Ruth Nussenzweig explains. Mice also become immune to the parasite after repeated bites by X-irradiated infected mosquitoes. Immunity to other species of malaria-causing parasites has been conferred by injecting Rhesus monkeys with inactivated protozoa and by exposing human volunteers to the bites of infected, irradiated mosquitoes.

The sporozoites of the mouse-infecting protozoan, *P. berghei,* were used to raise pure (monoclonal) antibodies to a surface component. This protein, called Pb-44, is uniformly distributed on the infective parasite but is not present on most immature sporozoites and disappears soon after the sporozoites penetrate liver cells of the mouse. Victor Nussenzweig suggests that Pb-44 is involved with a sporozoite-specific function, such as penetration of host cells. When injected into mice the antibody, like the X-irradiated sporozoites, protects against the infective protozoa, but it does not protect against the blood form of the parasite. In separate research at the Wellcome Research Laboratories in Kent, England, other monoclonal antibodies have been developed specifically against the merozoite.

Ongoing work is identifying antibodies effective against sporozoites of other malaria-causing species, and Nussenzweig reports that monclonal antibodies against a monkey-infecting form, *P. knowlesi,* recently were shown to inactivate the parasites in laboratory culture. These results, reported at the AAAS meeting, raise the hope of malaria control through vaccination where control with drugs and mosquito eradication have failed. "Despite major expenditures for its control, malaria is still a major public health problem," Nussenzweig says. □