discovered that sole secretion two decades ago. While early studies revealed the secretion's toxicity to certain fish, it was not until the 1970s that scientists began to focus on the shark-repelling property of the substance, which is stored in ampule-like glands located along the dorsal and anal fins of the Red Sea flatfish. Now, Naftali Primor of New York University Medical Center and colleagues have isolated the toxic component, called pardaxin, and have begun to detail its mode of action.

Pardaxin is an acidic protein composed of a single chain of 162 amino acids with four disulfide bridges — bonds between the sulfur groups on the amino acid chain. In studies using dogfish sharks, Primor and co-workers discovered that pardaxin affects the permeability of the gills, resulting in a greater movement of ions between the shark's blood and seawater. In related studies, Primor's group observed pardaxin-induced shark behavior. When sharks are exposed to pardaxin, they first exhibit an "escape response," immediately turning away from the source of the toxin. Primor and co-workers also observed secondary responses, from rapid opercular (gill-covering) movements to loss of equilibrium — the shark sometimes turns upside down or on its side.

Whether the shark's split-second escape and various secondary responses to pardaxin are related to that chemical's effect on its gills is just one of several mysteries researchers must solve before an effective shark repellant can be developed. "It's a long step between knowing that something seems to act as a kind of repellant and having an effective shark repellant that can be used practically," Bernard J. Zahuranec reported at an AAAS symposium on the topic. "Even if you know some material acts as a repellant, like the Moses Sole milky secretion, you can't use that by going out and harvesting Moses soles and milking their material and bottling it," said Zahuranec of the Mississippi detachment of the Office of Naval Research. Instead, he explained, researchers must pin down the material's precise mode of action so that chemists can mimic it with a cheaper, more convenient synthetic compound.

Then, "Shark repellant research ... can serve as a useful paradigm for research on other biologically active substances from the sea," Zahuranec said. Researchers could isolate, for example, a chemical compound certain sea creatures use to repell the shipworm, a clam that causes millions of dollars worth of damage each year by boring into the underwater portions of piers and waterfront warehouses. Another marine compound of interest is the biological adhesive that masking crabs secrete to glue camouflaging shells to their backs. This "wet environment" glue could be useful in dentistry, says William O. McClure, director of the Marine Bioactive Substances Program at the University of Southern California.

Jeff Albertson/NOVA

McClure's researchers — who recently isolated a group of anti-viral compounds, dubbed didemnids, from marine tunicates —focus on the pharmaceutical band of the wide-ranging marine chemical spectrum. While the interest in marine pharmaceuticals dates back to the ancient Sumerian medications made from the pulverized skins of venomous water snakes, the field is only now maturing, says McClure, because it previously lacked chemists to isolate the relevant compounds, determine their structures and synthesize chemical copies of "tomorrow's drugs from the sea." Such drugs, says McClure, may "provide entirely new medications and alternatives to existing ones that may be overexpensive because of scarcity or undereffective because of bacterial resistance." □

High-powered electron microscopy

Looking directly at biological specimens is one experimental approach that can provide increasingly sophisticated answers to scientific questions. Electron microscopy now extends vision down to the level of individual atoms (SN: 10/21/78, p. 277). F. Peter Ottensmeyer and D. P. Bazett-Jones of the Ontario Cancer Institute in Toronto are focusing the electron beam on biological materials. With modifications of standard electron microscopy, they directly observe the structure of proteins, and with the addition of filters, they map, on a nanometer scale, the elemental composition of cellular components.

Electron microscopy of small biological molecules has been limited by the necessity of coating specimens with heavy atoms to make them visible against the background carbon film. "The stain is needed for contrast, but it robs us of resolution," Ottensmeyer says.

Ottensmeyer circumvents the staining procedure by three modifications of microscopy procedure. He employs a trick of light microscopists to double resolution by arranging lenses, slits and focus so that the specimen is viewed against a dark, rather than a bright, field. He supports the specimen on an extremely thin (20 angstrom) carbon film, to reduce the contribution of that material, and he compensates for the film's random background noise by using computer techniques to average the images of different copies of a molecule. With these methods, for example, he can clearly demonstrate the shape of a benzene ring.

A low level of electron bombardment is another key to success, Ottensmeyer says. Other scientists have argued that radiation damage would destroy biological specimens before useful data could be collected. Ottensmeyer minimizes the radiation dose by recording as the first electrons hit the sample. "The camera opens on a virgin molecule," he says. "It dies as we look at it."

Among the molecules Ottensmeyer has visualized as they crumple under the electron beam are the hormones vasopressin, glucagon and ACTH. The shape of some enzymes, such as myokinase, which is 50 angstroms in diameter, also has been determined at a resolution of 5 to 10 angstroms. The configuration agrees well with that determined by X-ray crystallography.

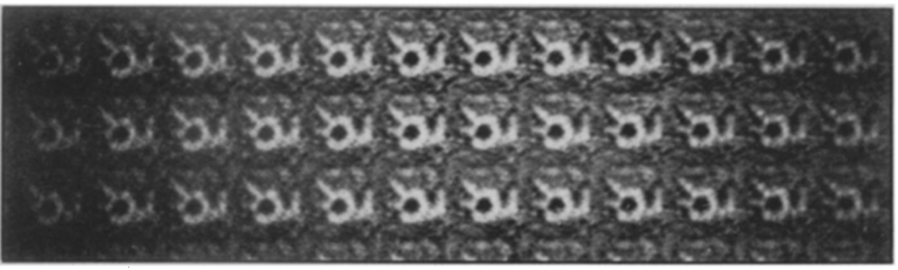
In other cases, the microscopists propose a structure based on shape and biochemical data, then must wait for crystallography to confirm it. For example, from the many-fingered shape of protamine, an enzyme that wraps up DNA in sperm, they have been able to propose a detailed three-dimensional structural model. "We now frequently observe the fine structure of proteins with remarkable detail, which can be meaningfully interpreted on a near-atomic biochemical level," Ottensmeyer says.

Teasing further information from electron microscopy is possible by filtering electrons on the basis of their energy. Electrons lose energy by exciting atoms and molecules as they pass through the specimen; the amount of energy an electron loses depends on what atom or molecule it has excited. Ottensmeyer built a device that spreads the electrons into a spectrum like a prism and produces an image with the electrons of a selected energy range. This addition to the microscope "permits the direct selective visualization of the location of specific kinds of atoms in the specimen," says Ottensmeyer. "In one fell swoop, we've analyzed the entire image."

Growing bone is one biological system the microscopists have been examining. They make an image of the region where mineralization is underway. By comparing the images derived from electrons in the energy ranges indicative of calcium, phosphorus and sulfur, they find that a matrix of phosphorus and sulfur is laid down before precipitation of calcium occurs.

The configuration of genetic materials complexed with proteins in bead-like structures called nucleosomes also is amenable to electron microscopic analysis. "With our microscope we can look inside a single bead," Ottensmeyer says. Because DNA has much more phosphorus than does protein, he examines the images made by the electrons indicative of phosphorus. Most of the images can be inter-

Ottensmeyer, Ontario Cancer Inst.



Array of electron micrographs of the hormone vasopressin shows a ring of six amino acids and a hooked tail (on the right) of three amino acids.

preted as different views of a DNA coil making approximately 1.75 turns within the nucleosome.

The scientists display the images in vivid colors — for example, the phosphorus of the DNA coil is rendered orange-red, the protein "bead" is yellow and the background is blue. Ottensmeyer says, "Although the technique is still in its infancy, results are very very exciting." He concludes, "The future looks bright and colorful." □

The food supply: Don't be fuelish

Powering vehicles with fuel derived from grain has become a technologically, if not economically, practical proposition. While on the surface the conversion into ethanol fuel of such clearly renewable resources as corn, sugar cane, sorghum and beets may seem a sensible answer to the energy shortage, a sobering concern has arisen. Will this approach take food out of the mouths of hungry people to put fuel into automobile tanks?

At a symposium on future food-fuel conflicts, agricultural economists compared predictions of the impact of agricultural biomass energy programs on food supplies. The speakers pointed out that fuel from food crops is a relatively minor part of the proposed energy plans. While the U.S. potential for biomass energy in the next 20 years is likely to be up to 20 percent of 1979 U.S. energy consumption, grain comprises only 4 percent of that potential, and other food or feed crops, such as sugar, represent far less potential, says Wallace E. Tyner of Purdue University.

Grain's conversion to a gasoline substitute however, makes it the most immediate biomass fuel material. "Grain alcohol should be thought of as a small component of our energy system, and as an opening wedge to prepare the ground for larger biomass sources, such as silage crops and wood," says Folke Dovring of the University of Illinois at Urbana.

Corn is currently the most practical feed and food crop in the United States for conversion to fuel. Speakers disagreed on the extent to which the corn crop could be increased by bringing into production land currently idle. Tyner says 2 billion gallons of alcohol could be produced with less corn land than was diverted from production in 1978. Milton L. David of Development Planning and Research Associates, Inc., in Manhattan, Kan., predicts, however, that bringing idle land into use would add direct production costs and produce environmental damages. Another difficult factor to predict is how much land would be switched to corn from other crops, such as soy beans and wheat. Such changes would depend in part on corn prices. According to Dovring, within three years, if current investment plans materialize, grain alcohol production could make an impression on the grain market.

David predicts a 1 billion gallon ethanol program (equivalent to 1 percent of gasoline consumption) will require 5.4 percent of current corn acreage, or, Tyner calculates, 2 million acres of new land in corn production. The cost of alcohol from corn would range from $1.21 to $1.55 per gallon, depending on the size of the production plant, Tyner estimates. Considering the increasing price of gasoline, Tyner says, "Even if alcohol from corn is not quite economic today, it will be within 18 months." Simulations of market conditions predict 1 to 2 billion gallons of ethanol could be produced in the United States without raising corn and soy bean prices. Increasing that ethanol production to 4 billion gallons would increase corn prices only 6.6 percent, says Marilyn Herman of the U.S. National Alcohol Fuels Commission. David agrees that the economy can handle a 4-billion-gallon program. "Beyond that, it's anybody's guess," he says.

Increased corn prices would affect the diet of meat-consuming populations, because most U.S. corn is used as feed rather than food. "Use of feed grains for alcohol involves trade-offs in the price and quality of meat, poultry and dairy products, but [does] not directly [involve] the issue of food for starving humans, at least at low to moderate levels of alcohol production," Tyner says.

Governmental policies that encourage or discourage crop use for fuel production can influence dramatically the market and the distribution of crops into food and fuel. Janos Hrabovszky of the United Nations Food and Agricultural Organization warns that such a policy must be flexible, adjusting to developing market conditions. □

A French ear on Jupiter

An astronomical telescope is a multipurpose device, often focused not merely on stars but on planets, moons, asteroids, gas clouds, comets and more. In France, however, about 200 kilometers south of Paris, some 8,000 square meters of the pine-dotted countryside around Nançay is now the site of a telescope dedicated almost entirely to the study of a single planet: Jupiter.

It is a radiotelescope, consisting of 144 helical antennas, each several meters high, electronically linked together to form the equivalent of a single huge instrument. The primary goal of the array is the long-term monitoring of the powerful decametric radio emissions that make Jupiter the strongest planetary beacon in the solar system. Built by the Group for Decametric Radio Astronomy of France's Meudon Observatory, the facility began operating in January of 1978, when only half of its antennas were connected. Now the entire array is on the job.

It is by no means the first Jupiter-only radiotelescope to be built. In the three decades since Jupiter was discovered to be a radio source, "probably several dozen" such devices have been constructed, according to James Warwick of Radiophysics Inc., one of the first researchers to "listen" to the giant planet. But the French group, Warwick notes, has "significantly advanced the state of the art."

Describing the instrument in the forthcoming ICARUS (43:399), André Boischot and colleagues assert that four qualities are necessary for such a device: wide bandwidth, to cover the full range of frequencies; high time and frequency resolution, to measure subtle but often critical changes in the emissions; high sensitivity, for detecting the signals' weaker components; and long tracking time—the ability to keep Jupiter in view for many hours each day. Previously built installations, according to the authors, have all been limited in one or more of these areas. An array in Tasmania, for example, offers excellent resolution, but can only pick up Jupiter for about five minutes at a time. A facility at Oulu, Finland, scores moderately well in most categories, but has a bandwidth of only 2 megahertz.

The new French instrument, by comparison, covers a band from 10 to 120 MHz, more than sufficient to cover the roughly 10-to-40-MHz Jovian emissions detectable from earth. Though the device cannot be physically rotated, the electrical phase of its individual antennas can be shifted — the equivalent of steering a single, dish-type antenna — in a way that allows the planet's signals to be recorded for as long as 10 hours a day, about the time it takes Jupiter to turn once on its axis. (It was the