

theory insofar as presented ... lends substance to the predicted times, locations, and magnitudes of the earthquakes. The council regrets that an earthquake prediction based on such speculative and vague evidence has received widespread credence outside the scientific community."

Among the objections to the predictions voiced by the council and other earthquake researchers interviewed by SCIENCE NEWS are inconsistencies in the data and in the predictions themselves,

the "unrealistic" detail of the predicted magnitudes, times and locations and the fact that the theory has not been reviewed and published in the scientific literature. They add, however, that the region is very active seismically and has been identified as having the potential for a large quake. Even so, the council stated, "...none of the members of the council would have serious reservations about being present personally in Lima at the times of the predicted earthquakes." □

## A larger role for opiate receptors

When Candace Pert and Solomon Snyder of the Johns Hopkins Medical Institutions reported in 1973 the first evidence for opiate receptors in the brain, it was a landmark finding, since it not only indicated that the brain has neural receptors for morphine but led the way to the discovery of the brain's own natural "morphine," the enkephalins (SN: 11/22/75, p. 327).

But research into the opiate receptors is just beginning, it seems. Pert (who is currently with the National Institute of Mental Health in Bethesda, Md.) and colleagues are now finding that the opiate receptors seem to be involved in much more than the mediation of pain relief. Apparently, they are involved in the filtering of sensory stimuli into the brain.

In the September PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, Pert and Miles Herkenham of NIMH described a simple method for visualizing drug and neurotransmitter receptors in the brain. And in the same paper they reported evidence that opiate receptors coincide within the visual, auditory, olfactory and somatic nerve circuit of the brain and that these opiate pathways lead to the limbic area of the brain, which is known to be

involved in the processing of emotions. These findings suggested that the receptors control incoming sensory information and that this sensory information is ultimately processed in the limbic area of the brain. In fact, the receptors may even place incoming sensory information in an emotional context along a pleasure-pain continuum.

And in a paper now in press with SCIENCE, Pert, along with NIMH colleagues Michael E. Lewis, Mortimer Mishkin, Evgeni Bragin, Roger M. Brown and Agu Pert, reports that the opiate receptors are not only present in the brain's sensory circuits but that the receptors increase in number as they progress along these nerve pathways, ultimately ending up in the limbic area of the brain. So the receptors may very well be involved in the processing of sensory stimuli in the brain. In fact, Candace Pert and her team suggest that the opiate receptors may work in reverse as well — that is, convey emotional messages from the limbic area to the sensory nerve circuits. This way, they say, "emotional states essential for individual and species survival could influence which sensory stimuli are selected for attention." □

## Clues to anxiety: The inosine difference

Scientists recently mapped out specific areas in the central nervous system for the benzodiazepines, a group of chemical compounds used to reduce anxiety. Several naturally occurring inhibitors have been found for the most widely used of those compounds: diazepam, otherwise known as Valium. These natural chemicals, one of which is named inosine, bind to the same spots in the brain that Valium does. Large doses of inosine prevent seizures in mice, serving the same function as smaller doses of Valium. The effects of inosine, which is part of the purine group, have now been further defined by researchers at the National Institutes of Health. Jacqueline N. Crawley and colleagues report in the Feb. 13 SCIENCE that when mice placed in cages with lit and darkened sections are given Valium, they overcome normal fears of bright light and venture into the lighted cage areas. But

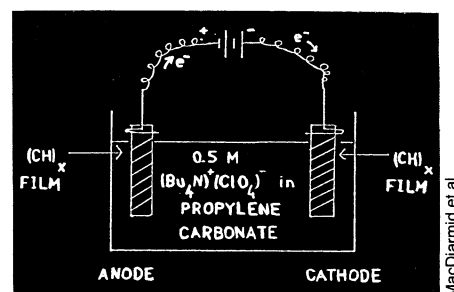
when the mice are given moderate doses of both inosine and Valium, the inosine blocks the effects of Valium and the mice stay in the dark.

Why does inosine inhibit Valium's effects in low doses and mimic the tranquilizer in high doses? Scientists do not know, but results so far suggest that inosine is involved in moderating emotional states and anxiety-related behaviors. "We want to determine a natural substance that is involved in anxiety," says one of the researchers, Paul J. Marangos. "We feel that the purines are good candidates for further research." Human applications, such as the control of anxiety by regulating the brain's large supply of inosine, are still years away. Researchers first must clarify inosine's effects on mice, pinpoint the binding site where inosine and Valium interact and make the jump from animal behavior models to human anxiety. □

## A salt and battery without any metals

In research that pushes the electric car one space closer to the road, scientists have developed a lightweight, rechargeable storage cell that involves no free metal or metal ions — an organic battery.

Operation of this battery, designed by Alan G. MacDiarmid and colleagues of the University of Pennsylvania at Pittsburgh, depends on the behavior of the simplest possible organic polymer, polyacetylene, which is composed of carbon-hydrogen units or  $(CH)_x$ . Polyacetylene, an organic semiconductor, can act as either an electron source or an electron sink. Moreover, upon losing or receiving electrons, its ability to conduct electrons increases about  $10^{12}$ , achieving the conductivity prowess of metals.



During charging,  $Bu_4N^+$  migrates to the cathode, and  $ClO_4^-$  migrates to the anode.

Its ability to donate and receive electrons, coupled with its metallic conductivity, makes polyacetylene the stuff of battery electrodes. Two thin pieces of polyacetylene film, about one-tenth millimeter thick, are immersed in a solution that contains tetrabutylammonium perchlorate in the organic solvent propylene carbonate. The tetrabutylammonium perchlorate is a salt that dissociates into the tetrabutyl ammonium ( $Bu_4N^+$ ) and perchlorate ( $ClO_4^-$ ) ions. These two ions play a special role when the battery is being charged.

The battery is charged by connecting one polyacetylene strip to the negative terminal of another battery, the other strip to the positive terminal. The strip attached to the negative terminal of the outside battery acts as the sink, accepting electrons; the strip attached to the positive terminal of the outside battery acts as the source, donating electrons. To keep the net charge of this system neutral during charging, explains MacDiarmid, the  $Bu_4N^+$  ions "snuggle up" to the now negatively charged polyacetylene electrode — the electron acceptor, or cathode. Likewise, the  $ClO_4^-$  ions move to the positively charged electrode — the electron donor, or anode.

When discharging, this process is reversed: The electrode strip that had accepted electrons now loses them, and the electrode strip that had donated electrons

now accepts them. This time the electrodes are connected not to an outside battery, but rather to a motor, to make use of the electric energy. As the electrodes gradually become neutral during the discharge, the ions are released and combine with each other in solution.

Such an organic storage process fits the bill for electric car batteries because it has a high energy density, or quantity of electricity stored per unit weight—a property that will dictate an electric car's possible driving range. The organic battery also has a high power density, or rate of electrical discharge, which is important for automobile acceleration and uphill speed.

In addition to their potential utility for electric cars, organic batteries have other possible applications. They could provide cheap storage for systems that depend on a sporadic source of energy, such as the sun and wind. The batteries also could be charged during off-peak power hours to provide relatively cheap power during later, more expensive peak-power times.

Says MacDiarmid, whose work has been accepted for publication in the *JOURNAL OF THE ELECTROCHEMICAL SOCIETY AND CHEMICAL COMMUNICATIONS*, "These organic batteries open up a complete new vista in battery technology concepts." □

## More TMI questions

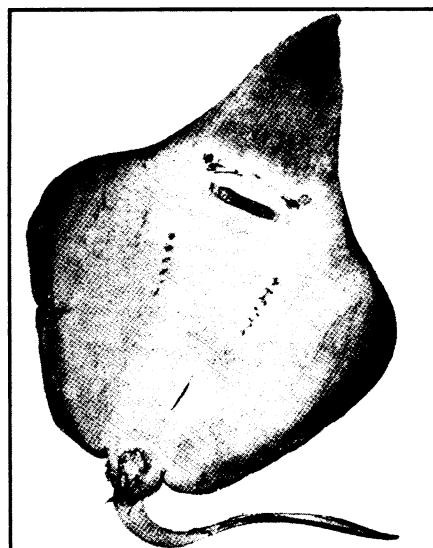
Metropolitan Edison employees failed to provide important information to state and federal officials on the drama unfolding March 28, 1979, at the Three Mile Island nuclear power plant, says a congressional investigation. Not yet established is whether the "communication failure" might have resulted from a willful withholding of facts to mislead those officials as to the seriousness of the accident.

According to the 250-page congressional study released this week, "State and federal officials, judging from information they released during the first two days of the accident, were largely unaware until March 30 of significant information available to and understood by TMI supervisors. As a result, during the most dangerous hours of the accident, state and federal officials were unable to make an accurate assessment of the necessity to undertake emergency measures for which they were responsible." Among such measures was a precautionary evacuation of nearby residents, which a Nuclear Regulatory Commission review group later concluded was warranted as early as 9 a.m. on the day the accident occurred. An evacuation call was made by Pennsylvania's governor, but not until two days later.

As a result of its panels' findings, the House Committee on Interior and Insular Affairs is investigating whether Met Ed violated federal accident-reporting regulations and whether NRC has sufficient authority to require reporting of data like that believed lacking on March 28. □

## New stingray from deeper waters

*A stingray recently found on a South African beach may be the first known deep-water stingray. Both a new family and new suborder have been created for the fish, named Hexatrygon bickelli and described by P. C. Heemstra and M. M. Smith in the ICHTHYOLOGICAL BULLETIN OF THE J. L. B. SMITH INSTITUTE OF ICHTHYOLOGY. Among the stingray's distinctive features, suggesting adaptation to deep water, are six pairs of gill openings, instead of five; small eyes; closable external flaps on its spiracles (first gill slits); thin black skin on its back, and a snout filled with an acellular jelly and richly supplied with electroreceptors for finding food in the bottom ooze. The small brain of Hexatrygon fills only 3 percent of its head; in shallow-water stingrays the brain fills 80 percent. These features and the chemistry of its liver oil are thought to be adaptive for survival in the deep.*



Nature

## Pollution rules must stay, new study says

Rumors of a proposed relaxation in regulatory requirements, such as those for controlling pollution, have surfaced periodically from the otherwise tight-lipped Reagan administration—almost as if those rumors were being floated to test the political winds. But a study released last week warns that now is hardly the time to consider slackening air-pollution controls. "If the pessimists are correct," it says, air pollution accounts for three to 10 percent of the total U.S. death rate.

"As the country prepares to burn coal more extensively, we have very little margin for safety," says Richard Wilson, a Harvard professor and one of four scholars who authored the 392-page study: "Health Effects Of Fossil Fuel Burning." According to that report, existing evidence already suggests that 53,000 deaths per year can be attributed to pollution emitted by fossil fuels in the continental United States.

Information correlating fossil-fuel emissions with adverse health effects is voluminous. But it is also "imprecise and inadequate, and to a considerable extent will always remain so," the study finds. For instance, all U.S. retrospective studies relating death rates to air-pollution concentrations show a higher death rate in those geographical regions where the pollution level is highest, the report says. But it is important to know whether this is due to air-pollution alone or to a combination of variables. And three factors helping most to obscure that answer are cigarette smoking habits, occupational differences and migration between communities.

To statistically verify whether deaths attributable to air pollution represent at least two percent of all deaths annually, a prospective study (collection and analysis of current data) of 100,000 persons ex-

posed to polluted air together with a like number exposed only to clean air would be necessary. Since that is unlikely ever to occur, federal policymakers and regulators must be content to work with what is available—voluminous imprecise and inadequate data.

Arguing on purely economic grounds, the study's authors claim that the health risks posed by fossil-fuel pollutants "are worth reducing." However, they are not worth as much as investing to reduce the risk caused by cigarette smoking, "even though the latter is voluntary," they say, and add that at least one "classic paper... suggests that the public accepts risks voluntarily 100 times as dangerous as the involuntary risks."

Assuming the 50,000-deaths-per-year estimate is close to accurate, the authors go through complex calculations to show why it would be worth perhaps \$50 billion per year to reduce the attributable pollution "if we can reduce it completely." However, that, too, being unlikely, the authors suggest a solution more likely to appeal to President Ronald Reagan's advisors: Let the marketplace determine who pollutes and how much. Pollution emissions would be measured "in some acceptable way" and the polluter would be billed at a set rate per unit mass emitted. For instance, a proposed charge of 10¢ to \$6 per pound was suggested for sulfur emissions.

For now, authors Richard Wilson, David Wilson, Steven Colome and John Spengler suggest that industry begin implementing solutions "which are simple and moderately cheap, and which work independent of the source of the hazard." They include: siting powerplants downwind of major urban areas and using fuels other than coal. □