SCIENCE NEWS OF THE WEEK

Views Into the Living Brain

The visible man and the visible woman, a concept once limited to educational toys, is now an immediate goal of biomedical research. The internal structure of an individual can be observed from outside the body by the technique of X-ray transmission tomography (CT scans, SN: 3/13/76, p. 171). Now an approach using radioactive chemicals is baring the body's biochemical workings, creating possibilities for mapping brain activity, analyzing disease and following drug actions.

So exciting is the possibility of analyzing biochemistry in specific locations, noninvasively in living persons, that the National Institutes of Health has earmarked about $10 million for work on the method. In the past two years interest has exploded, says Michel M. Ter-Pogossian of Washington University in St. Louis. But, because the procedure requires the expense of a cyclotron and the cooperation of an extensive team of different specialists, only about six medical centers in the United States and a few in Europe are working on the technique.

The strategy is to label biologically important molecules with a radioactive atom that emits high-energy electromagnetic radiation. The labeled molecule is administered to a person, and external detectors record the location of the label over time. The technique, called Positron Emission Tomography (PETT), differs in two ways from routine uses of radioactive chemicals in medical diagnosis. The radioactive atoms used — carbon-11, nitrogen-13, oxygen-15 and fluorine-18 — all decay with emission of positrons. Annihilation radiation of positrons is particularly well suited for external detection, and the short lifetimes of the radioactive atoms (half-lives of 2 to 110 minutes) provide only a minimal dose of radiation to a subject. The other innovation is the use of detectors that sweep their focus across specific points on a plane through the body. A computer then reconstructs the "slices" on a screen, showing the distribution of a biochemical tracer in the same way that CT scans show the absorption of X-rays.

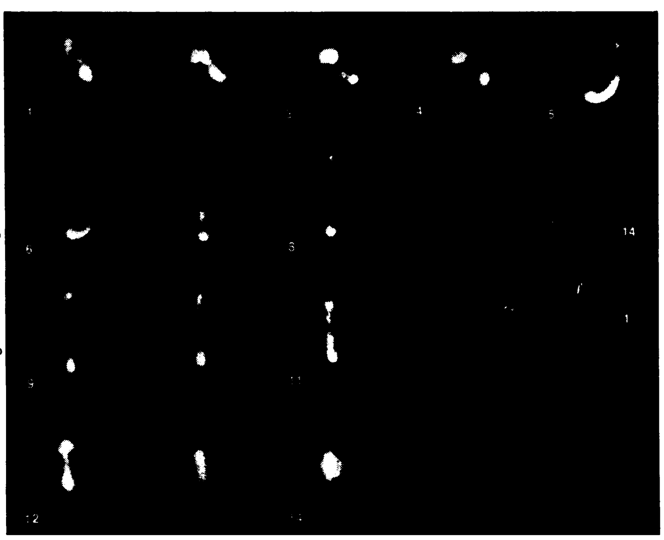
The short lifetime of the radioactive labels dictates precisely orchestrated teamwork among the physicists, chemists, mathematicians, biologists and physicians involved in each project. The radioactive atom must be generated in a cyclotron and immediately used to label the chemical to be followed. In the past, there was skepticism about whether important molecules could be synthesized so rapidly, but imaginative chemists have now labeled more than 100 biological compounds including drugs, proteins, amino acids, fatty acids, alcohols and sugars. As an example of ingenious chemistry, Ter-Pogossian described synthesis using carbon-11 (half-life of 20 minutes). The standard procedure for incorporating a long-lived radioactive carbon into glucose had been to expose a green plant to radioactive carbon dioxide for several days. But working with carbon-11, chemists discovered they could obtain a radioactively labeled glucose in less than an hour if they starved Swiss chard leaves in the dark, then exposed them to labeled carbon dioxide and intense light for just 20 minutes.

The brain and the heart have been the focus of the first PETT research. Animal researchers have been able to identify specific areas participating in a brain activity, such as vision, by slicing sections of an animal's brain (SN: 11/11/78, p. 324). Similar information, although at a lower resolution, is now available from living human brains. At the meeting in St. Louis of the Society for Neuroscience, Martin Reivich of the University of Pennsylvania and collaborators at Brookhaven National Laboratory described recent experiments. Visual stimulation of the left half of the visual field caused the glucose analog, ^{18}F-fluorodeoxyglucose, to concentrate in the area known to process visual information on the right side of the brain. Rapid stroking of the right hands of other subjects gave a dramatic increase in glucose analog uptake in the brain's sensory and motor areas that correspond to the hand. During a listening task in which the subject heard a story through just one ear, the researchers were surprised to observe the greatest activity on the right side of the brain, regardless of which ear was used. Reivich proposes that they were observing an area of higher processing. They now plan to do experiments investigating brain activity in response to pure tones, rather than stories.

Medical investigations using PETT should allow physicians greater insight into diseases, even those that cannot be mimicked adequately in animal models. D. Comar of the Hospital of Orsay in France has used the technique to pinpoint where the damage is in the brain of a stroke victim and to follow changes during recovery. The researchers in St. Louis have similarly examined the sites and extent of heart damage in patients in the cardiac care unit. "PETT allows you to look at the infarct directly. You can follow therapy and recovery," Ter-Pogossian says.

In other medical research, David Kuhl of the University of California at Los Angeles has been examining epileptics. Between their seizures he finds decreased metabolism by the cells, as well as decreased blood flow, at specific brain sites. However, during seizures the metabolic activity in those areas increases to double the activity of the other side of the brain. In a preliminary experiment, Reivich and colleagues have seen depressed metabolism in one brain area of a schizophrenic.

Following the fate of drugs is also an important application of the PETT technique. A drug may be metabolized differently throughout the body, yet previously it could only be traced in the blood. Now researchers can directly measure the specific activity of a drug within an organ. For example, Comar is looking at labeled chlorpromazine in brains of schizophrenic patients. The potential of the procedure for both basic and medical research, Reivich says, is only limited by ingenuity. □



Ter-Pogossian, Washington Univ.

Fourteen computer-reconstructed slices through a living human brain show the course of a blood vessel. A whiff of carbon-11-labeled air introduces the positron-emitting tracer into the blood and external detectors reveal its distribution.

Magnetic moments for hyperons and quarks

Magnetism has taught physicists a lot. That is especially true in the study of the structure of atomic and subatomic systems. In an article in the Nov. 13 PHYSICAL REVIEW LETTERS a group of physicists from the University of Michigan, Rutgers — The State University and the University of Wisconsin (L. Schachinger and 14 others) list some of the major advances made with the aid of magnetism in the last 70 years or so. They do this as a preface to the report of their own achievement, a very precise measurement of the magnetic moment of the particle called the lambda hyperon, and to set the atmosphere for a discussion of the things that can be deduced from that measurement about the structure of neutrons, protons and related particles and about the nature of the quarks, the elemental objects that are supposed to build up those structures.

Magnetism is useful to the student of subatomic physics because it is a long-range effect by which macroscopic equipment can manipulate the behavior of subatomic structures, and because the magnetic properties of subatomic objects are connected to important characteristics of their structure. For example, spin. An object that has both electric charge and spin will be a kind of little magnet and will display a magnetic moment, a tendency to influence and be influenced by external magnetic fields.

A measurement of the magnetic moment can tell whether an object has internal structure, because a structured object tends to have more magnetic moment (an "anomalous part" as it's called) than it would have if it were unstructured or pointlike. A structured object is not elemental; a pointlike object may be.

Measurements of the magnetic moment of the neutron and the proton give evidence that these are structured objects. Theory has elaborated a structure for them based on the so-called quarks. The quarks are derived from a mathematical principle called unitary symmetry that builds orderly groupings of particles and explains their properties and behavior by making various combinations of a few generating elements. These generating elements have come to be called quarks.

Here at last we reach the neutral lambda hyperon and its significance. The lambda is a member of a group that includes the neutron and proton, the group called the baryon octet. Although quark theorists now talk of six varieties of quark, in the early days of the theory there were only three, and the baryon octet under consideration here needs only those three, called up, down and strange. The neutron and proton may be made with up and down quarks only, but the other members of the octet require the strange quark. The lambda has the useful property that inside it the spins, and therefore the magnetic moments, of the up and down quarks cancel each other. So, if you can measure the magnetic moment of the lambda accurately, you have measured the magnetic moment of the strange quark.

To do this the experimenters went to the Fermi National Accelerator Laboratory, one of the two places in the world where they could get beams of protons with 300 billion electron-volts' energy. The lambda particles produced when these very high energy protons strike a target tend to have their spins, and thus their magnetic moments, polarized and last long enough (before their eventual radioactive decay) to permit precise recording of the precession of their magnetic moments as they move through a magnetic field. From this precession the size of the moment can be calculated. The number comes out -0.6318 ± 0.0047 of a nuclear magneton.

Taking that number and assumptions from the theory, the experimenters calculate moments for the other two quarks in question here: 1.8875 for the up and -0.9438 for the down. They can then predict the moments of other baryons in the octet. Assuming that quarks are elemental and therefore pointlike particles, the results can be used to calculate their masses. The up and the down have the same mass, 0.331 billion electron-volts; the strange is 0.510 billion electron-volts. These values, the experimenters say, compare well with those derived by comparing the ratios and differences of the masses of particles made out of quarks, and so go to strengthen the feeling that quarks are pointlike, elemental particles. □

Carter space policy: The NASA view

Even before President Jimmy Carter's new U.S. civil space policy was announced about a month ago, some administration officials were likening its weight to that of President John F. Kennedy's declared national commitment of a manned lunar landing. The Carter policy was greeted with less-than-unanimous approval, however, and was accused in various pro-space quarters of being weak, overly conservative and short on specific commitments, either programmatic or financial.

Since — and perhaps because of — that initial reception, key officials of the National Aeronautics and Space Administration have expressed views on the matter. Whether from true conviction or administration solidarity (agency heads are presidential appointees), the official NASA view is a relatively optimistic one, or at least supportive.

According to NASA administrator Robert A. Frosch, the new policy, together with remarks made by the President shortly before and after its release, constitutes "a positive source of policy direction" for the space agency, "and indeed for all those with an interest in the future of our country's efforts in space."

Costs are a key thread in the Carter policy, weaving their way through most of its eight general areas of emphasis. These are: space applications (resources studies, weather monitoring, etc., with increased involvement of the private sector); science and exploration (with "short-term flexibility to impose fiscal constraints when conditions warrant"); use of the space shuttle "to reduce the cost of operating in space"; improved technology transfer, "thereby increasing the return on the $100 billion investment in space to the benefit of the American people"; assured American leadership in space; relevance to developing countries; cooperative (and thus cost-shared) international programs; and continued work on space as a legal regime.

These objectives were detailed in a White House "fact sheet" issued on the same day (Oct. 11) as the new policy. "To meet the objectives specified above," says the statement, "an adequate Federal budget commitment will be made." In fact, says Frosch, "Federal budget commitments will be not simply adequate, as has been reported, but adequate to [the objectives] specified in the statement." The fact sheet, however, leaves room for the redefinition of "adequate" in light of future developments. The sentence immediately preceding the budget reference says: "As the resources and manpower requirements for shuttle development phase down, we will have the flexibility to give greater attention to new space applications and exploration, continue programs at present levels or contract them."

In Frosch's view, however, the outlined emphases "are all straightforward directives and provide the basis for an exciting and productive space program in the years ahead."

The particular area of space exploration by interplanetary probes was addressed recently by A. Thomas Young, director of the planetary division in NASA's Office of Space Sciences (and who was named last week to become deputy director of the NASA Ames Research Center on Feb. 1). Speaking to the annual meeting of the American Astronomical Society's Division for Planetary Sciences in Pasadena, he outlined NASA's current planetary planning priorities. There is "not much in the bank for the future," he said — the only mission now being funded other than those already in space is Galileo, an orbiter and atmosphere probe of Jupiter.

The Carter space policy, however, Young said, is "positive," although "it is clearly not a blank check." Next on the NASA priorities list is a Venus orbiter equipped with an imaging radar system to map the planet's entire cloud-covered surface at high resolution. After that are a comet mission (possibly a flyby of comet Halley that would then rendezvous with comet Tempel II), a Mars sample-retrieval mission (or an advanced orbiter for global geochemical studies), a Saturn orbiter and atmosphere probe, and a possible asteroid rendezvous. "I think we will get approval for [these] programs ... ," Young said, "though maybe not as rapidly as we might want." An exception may be the costly Mars-sampling flight, which Young feels may well not take place "if the world forever stays as it is today." (Also troubled are studies of the Apollo lunar samples, whose fiscal 1979 funding was cut by more than 80 percent from the previous year with instructions to NASA and the National Science Foundation to reevaluate the program.) "Gloom is contagious," Young warned the DPS audience, "but success is contagious too." □