Quarks manifested in the nucleus

A deuteron, the nucleus of an atom of deuterium or heavy hydrogen, is the simplest place to study nuclear physics. Consisting of only two nucleons—one proton and one neutron—it is the smallest structure where the internucleon effects that make nuclear physics appear.

A deuteron, or any other nucleus, shows different aspects in different situations. To the atomic electron that orbits it, it appears as a heavy blob, with a certain charge and mass. The details of its internal structure affect the orbiting electron very little. If the electron is an accelerated probe, it will see some of the deuteron's structure: The neutron and proton differentiate themselves, and much can be learned about their interrelations within the nucleus.

Now it has been found that if the probe electron has high enough energy—though not as high as many people expected—the internal structure of the nucleons appears: Instead of seeing neutron and proton, the probe sees six quarks, three that make up the neutron and three that make up the proton.

The experiment was done at the Stanford Linear Accelerator Center and was reported at last week's American Physical Society meeting in Washington by Benson T. Chertok of American University.

The results seem to contradict widely held theoretical assumptions about the interactions between neutron and proton. They caused some dismay among prominent theorists when Chertok announced them.

Quarks had not been expected to show themselves in nuclear structure at such low energies, 5 billion to 19 billion electron-volts. If six individual quarks were to show up, then the electron ought to hit one, and the other five should share equally the momentum the electron transfers to the quark it hits. It was, says Chertok, "a startling phenomenological prediction that worked very well in the experiment. All underlying features are dominated by the quark degrees of freedom," which is a physicist's way of saying that evidence of quarks dominates across the board.

And what was expected fails to show. Theorists had looked on nucleons in nuclei as consisting of cores surrounded by clouds of virtual mesons that embody the force that holds the nucleus together. Continual exchange of these virtual mesons between nucleons constitutes the bond between them. Theorists like to explain certain important anomalies in the electron-probe data by reference to these meson currents. Since the mesons can be electrically charged, their fluxes amount to electric currents, and the anomalies are supposed to be caused by interactions of the probe electrons with these currents that have to be added to the electron's basic interactions with the charges resident in the proton and neutron per se. Chertok says his experiment sees no evidence for these meson-exchange currents. "Ten years of work shot down," he says.

Chertok and his collaborators are now going after bigger things. Their next step is helium-3 and helium-4 to see if nine and twelve quarks show up respectively. They can go on from there, building up "a kind of Mendeleev table." But they probably will not go as far as Mendeleev did. By the time one checks whether carbon-12 shows itself as 36 quarks, things get extremely tedious. A series of good results for the lighter elements ought to be enough to convince nuclear physicists that the phenomenon works for heavier nuclei as well.

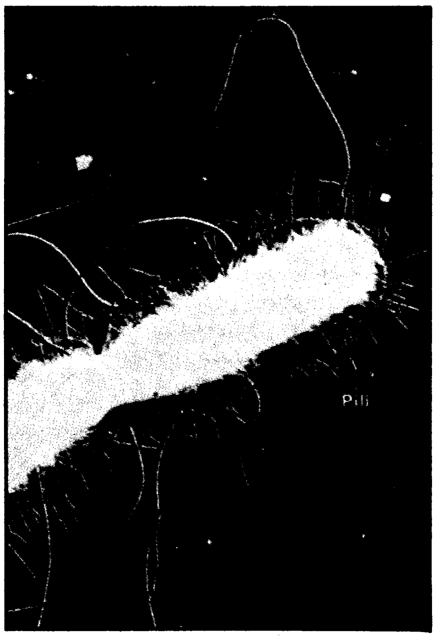
An important question for nuclear-structure physics is whether the quarks interact in groups, preserving the identities of proton and neutron or whether they interact as six individuals. Some theorists, those who propose the so-called bag theories to explain how quarks are held together inside larger objects, would tend to take the second option. Chertok says the present experiment gives "no way of judging." It is, however, an interesting question for future investigation. □

Pili: Unlikely key to besting bacteria

A funny little word, "pili," is more frequently heard these days in microbiology circles. The Latin word for hair, it aptly describes the microscopic structures it names: straight, stubby appendages that emerge from the surfaces of many types of bacteria. Strange as it may seem, these pili are turning out to be key organs in the ability of pathogenic bacteria to colonize a host organism and to cause disease. And studying pili is leading scientists to some promising developments—like vaccines for gonorrhea, dental caries and diarrhea.

This topic was the focus of a symposium last week at the American Society for Microbiology's meeting in New York. Symposium convener Richard A. Finkelstein of the University of Texas Southwestern Medical School in Dallas noted that the classical approaches to epidemic diseases—sanitary measures, antibiotics and vaccines—have all but eradicated many diseases, yet have had little effect on others. New epidemic diseases replace old; smallpox, diphtheria and poliomyelitis are yielding to gonorrhea, dental caries and diarrheal diseases. Consequently scientists are reexamining the basic disease-producing mechanisms in microorganisms, Finkelstein says. A major question is, how does a bacterium know when it has reached the "right place" in the massive labyrinth of tissues and tubules and ducts inside the human body? How does the cholera organism, for example, know to cause diarrhea in the gut and not rhinorrhea in the nose?

An answer emerging to this question is that the invading organism recognizes the host-surface membrane that it must colonize or penetrate in order to cause disease—and that's where the study of pili comes in. These surface proteins seem to help the bacterium find and attach itself to the proper surface membrane. Because they are foreign proteins (antigens), the host can produce antibodies against the pili, and it is by way of this antigen-antibody system that scientists hope to develop vaccines and confer immunity.



Pili help bacteria attach and attack.

Work toward a gonnorrhea vaccine is already well underway. Microbiologist Charles C. Brinton of the University of Pittsburgh has isolated pilic material, both rods of single pili and crystals of aggregated pili, from the surface of *Neisseria gonorrhoeae*, the microculprit. Tests on laboratory animals proved that mammals will form antibodies to the pilic protein and thereby provide some immunity toward subsequent exposures. Brinton has now tested the pilic material on human volunteers (five of his colleagues), and exposed them to *N. gonorrhoeae* by direct injection into the urethra. In the subjects protected by the experimental vaccine, the level of protection was 60-fold higher than in nonprotected subjects, Brinton found.

The pilic material will also clump when mixed with the blood serum of persons, who, through previous exposure, have developed gonorrhea antibodies. This test is easier and quicker than current techniques for detecting gonorrhea, and Brinton is hopeful that it can be used for mass