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.

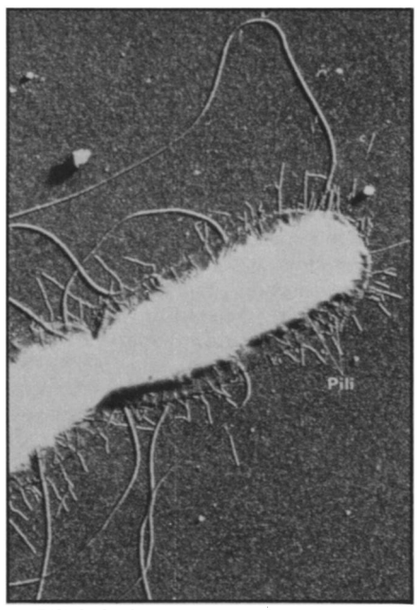
An important question for nuclear-structure physics is whether the quarks interact in groups, preserving the identities of proton and neutron or whether they interact as six individuals. Some theorists, those who propose the so-called bag theories to explain how quarks are held together inside larger 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

public health screening. More testing and development will be necessary before the blood test and vaccine are available clinically, he says.

Another group, Dolores G. Evans and Doyle J. Evans Jr. and colleagues from the Veterans Administration Hospital in Sepulveda, Calif., studied the pili of *Escherichia coli*. This organism normally resides in the large intestine but can sometimes colonize the small intestine and release a toxin that causes a severe diarrhea. *E. coli* can contaminate cheese, milk and other foods, and, particularly in developing nations, where food handling conditions are unsanitary and refrigeration is lacking, such contamination and subsequent diarrhea is a major health problem.

The group found that pili were necessary before *E. coli* could colonize the small intestines of rabbits and that these animals form antibodies which can prevent recolonization. They also found that the traits of colonization and toxin release are directed by separate rings of DNA called plasmids. Knowing this might give the team a handle on a better way to detect virulent strains in food and feces. The team is also working on an experimental vaccine.

Although pili don't figure in the study of dental caries, other surface proteins do. Ronald Gibbons of the Forsyth Dental Infirmary in Boston has found a surface protein in the guilty party, *Streptococcus mutans*, that helps the organism attach to the tooth surface and begin to destroy it. Most persons develop a natural immunity to the streptococci that inhabit the throat. These organisms are able only to colonize mucous membranes, and the physiology of both colonization and natural immunity are now being studied. Gibbons and others have succeeded in immunizing hamsters, rats and some monkeys against dental caries with preparations of surface proteins, and Gibbons sees promise in the development of a human vaccine. □

Food: 'A good moment for stocktaking'

If the weather holds, 1975 could prove to be the bumper-crop year so badly needed to replenish the world's dwindling stocks of food and avert, at least temporarily, an impending famine. "It is a good moment for stocktaking," writes editor Philip H. Abelson in his introduction to a special issue of SCIENCE (May 9) devoted entirely to reassessing the critical period just past and examining alternatives for the future.

What emerges is a stern indictment of the way governments and private planners have faced a challenge that was essentially expected and inevitable—expected because of regular variations in harvest yields, inevitable because of carelessly neglected reserve supplies. Fred H. Sanderson of the Brookings Institution calls the crisis "The Great Food Fumble," and says the whole thing could have been avoided if the United States and other grain-exporting countries "had been more prudent in maintaining grain production and adequate stocks."

This judgment of bureaucratic ineptitude is carried over into analyses of future options. The principal bottlenecks over the short-term to increased agricultural yields will not be the lack of adequate technology, says Pierre R. Crosson, director of the Latin American Program, Resources for the Future, Inc., but rather "those institutions affecting farmers' incentives to innovate." Thomas T. Poleman, professor of international food economics at Cornell University, says that even the seemingly insoluble problem of population control can be overcome more quickly than previously thought if only nations would cooperate more in a full-scale development program for poorer countries. But at present, "somewhere between a quarter and a half of the population is being bypassed by the forward march of development," and these are likely to become a massive burden on the rest of humanity: "The noble peasant is a rich man's delusion."


USDA

Some current shibboleths of nutrition planners are also called for reexamination. Derrick B. Jelliffee and E. F. Patrice Jelliffee of UCLA condemn the decline in breast feeding in many developing countries, due to "forceful and unrealistic advertising of unaffordable formulas by modern motivational techniques." Human milk, they contend, "should be recognized as a national resource in economic, agronomic, and nutritional planning." Substitution of formulas in poor countries can lead to unnecessary infections in infants, due to unsanitary conditions, and since lactating women seem to be less likely to become impregnated, the importance of breast feeding toward population control should not be ignored, say the authors.

Though the short-term problem of feeding the world appears to rest on implementing existing technology and establishing food reserves to protect against inevitable emergencies, the long-term solution of the food crisis is development of new, productive crop hybrids and the spread of modern agricultural technology throughout the developing world. Perhaps the most forceful statement of this issue is made by Michigan State's Sylvan H. Wittwer, who chairs the National Academy of Sciences Board on Agriculture and Renewable Resources. His article is an unabashed plea "for instituting a massive program in agricultural science and technology" complete with a "Manhattan Project on the bioconversion of solar energy." The current lack of commitment to such a project, he says, "is a travesty of the times."

The keys to improving tropical agriculture include new means of pest control, better management of fragile soils, and novel ideas for storing water. A group of staff scientists from the Agricultural Research Service write that losses of crops due to pests could be reduced by 30 to 50 percent, resulting in a 10 to 20 percent increase in the world food supply. P. A. Sanchez and S. W. Boul of North Carolina State University argue that solution of the world food crisis will remain in doubt unless ways are found to better utilize the leached-out soils that cover more than half the tropics. They suggest breeding hardy new crop and pasture strains to make these soils more productive.

Roger Revelle of Harvard and V. Lakshminarayana of the Indian Institute of Technology propose a novel plan to drain aquifers along the Ganges River basin during the dry season so that they will collect more water during the monsoons. They say the annual cost of irrigating crops with this water would be about $40 to $45 per hectare, but the annual return might be as high as $500 per hectare.

The final section of the special issue summarizes the current status of basic biology experiments that promise a new green revolution through tailoring crops to fit specific conditions (SN: 10/5/74, p. 218). Peter S. Carlson of Michigan State University and Joseph C. Polacco of the Connecticut Agricultural Experiment Station report on progress in genetic manipulation and mutant selection of plant cells in tissue culture and regeneration of these cells into entire plants. Israel Zelitch of the Connecticut Agricultural Experiment Station says that tropical plants that use sunlight more efficiently in photosynthesis than most temperate-zone plants do so because of specialized cells that inhibit wasteful photorespiration. Rather than cross-breeding these plants with less efficient varieties as some have suggested, Zelitch concludes the easier approach would be to inhibit photorespiration more directly in those plants. Finally, R. W. F. Hardy and U. D. Havelka of Du Pont report on their own recent work demonstrating that a major limiting factor for