duces magnetic fields. Cohen believes that "magnetocardiograms" are somewhat more accurate for diagnosing heart diseases than the electrocardiograms currently in hospital use. Cohen and colleagues are also attempting to develop a magnetic method to indicate damage from a heart attack. In dogs they have demonstrated an attack produces an "injury" current that cannot be measured with electrodes, but that can be sensed as a steady magnetic field. Now they are trying to extend that technique as a research tool for human heart attacks.

Magnetic fields are caused by contaminants as well as by currents. For example, magnetic dust accumulates in the lungs of certain workers. Cohen has measured magnetic fields indicating high concentrations of magnetic material in foundry workers, welders and asbestos miners. (Magnetite is embedded in asbestos in the mines and magnetic fields may provide a means to monitor asbestos in lungs.)

In the May 4 SCIENCE Cohen, Satoaki F. Arai from Tokyo Denki University and Joseph D. Brain of Harvard University School of Public Health report the lung studies using magnetite (Fe_3O_4) as a "tracer dust." Previous research has employed radioactive tracers to study lung clearance, but was limited by the hazard of long-lived radioactivity. In contrast, the magnetic dust, the scientists say, is harmless inhaled in small amounts.

Twelve male volunteers, including three heavy smokers, breathed in magnetite particles. To determine the lung content of magnetic material, each subject was exposed to a strong external magnetic field for 20 seconds to align the particles in his lungs. Then, in the shielded room, a detector measured the resultant field. The scientists found the clearance curves leveling off after 11 months. Fifty percent of the dust remained in the smokers' lungs; only 10 percent was detected in the lungs of the nonsmokers. Cohen and Brain now plan to do another human study, examining a larger group including moderate smokers.

A new lung phenomenon was discovered with the magnetic technique, Cohen says. After lungs are magnetized, the resultant field gradually fades as the magnetite particles are tumbled randomly by motions associated with breathing. That "relaxation time" is remarkably uniform for an individual, but varies among subjects, Cohen says. The magnetic field drops slowly around the lungs of an arc welder, who has been occupationally exposed to magnetic particles for years. In contrast, a volunteer who has inhaled particles recently shows a rapid drop in magnetic field. Cohen and colleagues find that among the volunteers, relaxation is much more rapid in the lungs of smokers than nonsmokers. The researchers do not yet know in practical terms what the relaxation time represents, but it further indicates that the lungs of people with different exposures handle dust differently. □

Looking for gluons: A sticky business

It's called particle physics. It deals with subatomic particles and how they affect each other. They affect each other mostly by exchanging field quanta. A field quantum is a particle of a special kind. It is really the materialization of a force, a beautiful illustration of the close relation between matter and energy. If there is a force between two bodies, physicists say that is a consequence of a continuing exchange of the appropriate field quanta. Every kind of force that affects particles is supplied by theory (and sometimes by experiment) with one or more quanta of its own.

The latest field quantum to be postulated by theorists is the gluon. Like some others of the ilk the gluon's existence has not yet been proven experimentally, but experimenters talk as if they are on the verge of doing so. Experiments in more than one place are part of the effort; recent results from experiments at the DESY laboratory in Hamburg have contributed one kind of evidence (SN: 4/21/79, p. 262). Now there is another kind from an experiment performed at the Fermi National Accelerator Laboratory. This experiment was reported at the recent Washington meeting of the American Physical Society by James E. Pilcher of the University of Chicago and in three papers in the April 9 PHYSICAL REVIEW LETTERS by Pilcher and 10 others from the University of Chicago, the University of Illinois and Princeton University.

Gluons are particularly important because they are supposed to be the quanta of the force that holds quarks together. Theory requires the existence of quarks as the mathematical and possibly physical basis of the relationships among the subatomic particles, and experiment has shown that quarklike things do exist. One of the things the experiment of Pilcher et al. does is to add an important piece of evidence of quark existence.

The significance of quarks was pointed out by the Roman philosopher Lucretius more than 2,000 years before quarks were theorized, when he warned that the succession of things inside other things had to end. Many physicists would believe this is the end. By theory quarks are structureless. There are supposed to be no divisions or articulations inside them. Structure ends here. Or structure begins here. Most subatomic particles, and all atomic nuclei, are built of quarks. They are thus at the base of all material structures. Gluons are what holds them together.

Not that gluons are easy to find. There is a peculiarity of the color force, as they call the force of which gluons are the quanta. Unlike other known forces the color force gets stronger with increasing distance from the source. Other forces weaken with distance, as many people will remember from Newton's or Coulomb's equations. This means that the farther two quarks get from one another the harder it is to pull them still farther apart. In other words, quarks seem doomed to spend their time forever bound inside the structures they build. If two quark-containing structures meet, they may exchange quarks, or the quarks may interact with each other, but quarks are not supposed to come loose and fly around by themselves. That goes even more strongly for gluons, and in that gluons differ also from other field quanta, which are often found on the loose.

So the experimenters from Chicago, Illinois and Princeton universities decided to study quark-built structures by striking them against each other at energies high enough that they might reasonably expect the quarks within them to interact with each other. The best evidence that quarks exist comes from studies in which beams of electrons found a three-quark structure in protons, results that go back more than a decade. But most other particles will not stand still (relatively) and be targets the way protons will. Pilcher et al. wanted to study the structure of pions. They decided to make the pions the projectiles.

The pions were made by striking protons accelerated in Fermilab's sychrotron against a target. After unwanted particles had been suppressed, the pions, which had energies of 225 billion electron-volts, were struck against atomic nuclei and interacted with protons and neutrons in the nuclei. What was looked for at the other end was pairs of muons with negative and positive electric charge. The muon pairs indicated that a quark in a pion had interacted with a quark in one of the nuclear particles. From the behavior of the muon pairs the physicists could deduce what sort of interaction had happened.

One of the things that came out is that a pion does contain an antiquark. Theory had said there should be a quark and an antiquark in the pion. Theory had said there should be antiquarks to go with quarks on the principle that for every particle there is an equal and opposite antiparticle. Pilcher remarked that this is the first good experimental evidence for antiquarks. The results also indicate that the quark and the antiquark carry less than half (about 0.40) of the momentum, or energy, of the pion. The rest is invested in "something else."

Everyone is ready to believe that "something else" means gluons. The figure for pions parallels that for protons, in which also about half the energy is found in the three quarks. This reinforces the feeling that something is going on across the board, but it is not yet proof positive. A more convincing proof will come if experimenters begin to elucidate the properties of that something else and find that they coincide with those theory has assigned to the gluon. □