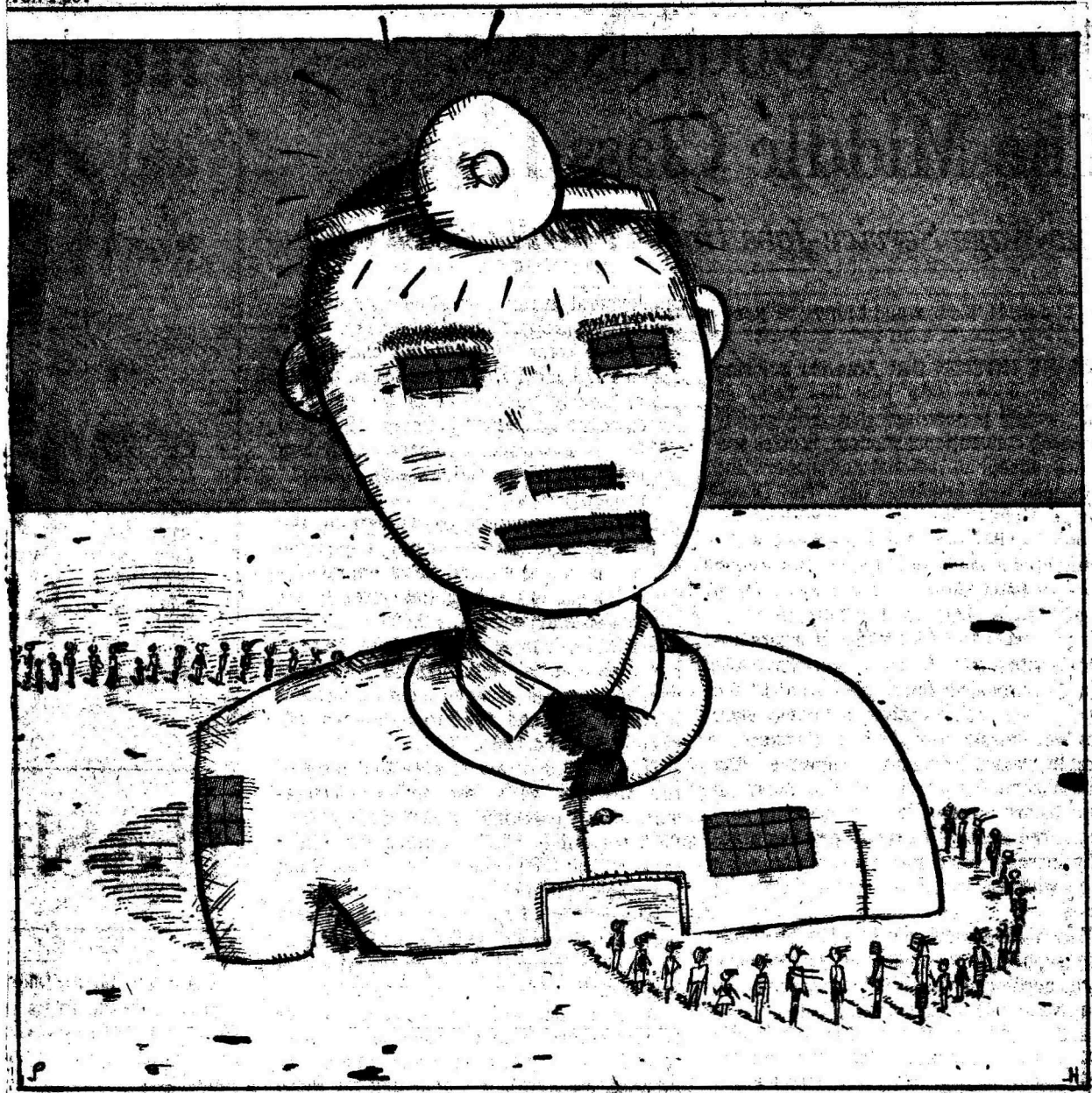

PETER HANNAN FOR THE WASHINGTON POST

Care Executives. "This will be particularly valuable in rural medicine and in cases in which treatment will benefit from periodic checking."

Progress and Problems

Technology and applied research will have advanced substantially by 2010. But the advances will be fraught with legal and moral conundrums. For example, scientists will be able to pinpoint the genetic troublespot for the majority of the 4,000 inherited human diseases using "gene probes"—short stretches of DNA that attach to specific defective genes.

At the moment scientists can analyze the DNA of a fetus only a few weeks old and determine whether it has inherited sickle-cell anemia, thalbryo. Eventually governments will decide that such morally and ethically loaded issues cannot be left to "free-market" negotiations. Too much is at stake to allow human reproduction to be dehumanized, as it has been in the 1980s, by whackos, cranks and publicity-seekers.

Advances in genetics will only be exceeded by new insights into the brain. Computer-assisted devices will enable neuroscientists to display in real time brain activity patterns corresponding to specific mental states. Everything from daydreaming to computational analysis will be correlated with measures of glucose, oxygen and blood flow. Magnetoencephalography—the detection of the magnetic field produced by electrical current within the brain—will make it possible to study patterns of communication among selected neuronal

brain), thereby avoiding the intolerable and sometimes irreversible side effects which can result from taking potent brain-altering drugs by mouth.

Expect that treatments will become more reliable as such illnesses as "schizophrenia" and "multiple sclerosis" become better understood not as monolithic entities but as clusters of illnesses, each of which may require a different treatment. The stimulus for these advances is likely to come not just from neuroscientists but from computer specialists who already are modeling important aspects of brain function. For instance, neuronal groups, not single neurons, are presently becoming the prime candidate for the much sought-after "fundamental unit of brain organization." Such neuronal groups are thought to be only about 50 micrometers wide, too

every smoker gets cancer of the lung, not every person with high blood pressure or elevated cholesterol dies of a heart attack. At present, physicians can only speculate about which patients will suffer those consequences. With the development of additional gene probes it will become possible to translate "susceptibility" and "propensities" into actuarial formulas.

For several years, companies in the United States, Japan and Britain have been engaged in a race to map the three-billion-unit sequence of chemical bases that make up the DNA comprising the human gene. By the year 2000 this task should be completed at a cost of about $3 billion. But what is to be done with the information? In many cases, illnesses will be predicted for which preventative measures or treatments won't be available. Or suppose a fetus inherits a tendency to high blood pressure. By itself, that may or may not lead to severe health consequences. Should the doctor tell the parents? Few parents would elect to abort a fetus at risk for hypertension; others with a "consumer" orientation ("Why settle for a defective product?") might think otherwise.

Even more ethically ambiguous will be fetal manipulation—now experimental, but probably available in 2000—during the pre-embryonic period, the first two weeks after the human egg is fertilized. Since the egg doesn't attach to the womb during the first six days after fertilization, it could be removed, placed in a culture dish and monitored. Inherited metabolic defects could be detected at the earliest possible moment; and only those eggs free of disorders would be returned to the uterus. Or the pre-embryo can be biopsied at an area, the second polar body, which serves as little more than a reservior for surplus DNA. Analysis could reveal, for example, the presence of an extra chromosome 21 associated with Down's Syndrome.

Such diagnosis could assure at-risk couples that a genetically normal egg would be implanted, greatly reducing the risk of an impaired child without involving abortion. The defective egg is never implanted, never grows to the embryonic stage and, therefore—some would hold—never achieves independent existence and personhood. But even granting this highly arguable point, what will be the limits of parental choice? Forget about "defects." What should the obstetrician say to the couple who, for instance, prefers a boy over a girl?

It's likely that by the year 2000 such agonizing issues will be decided by a Statutory Licensing Authority which will certify institutions and doctors working with pre-implantation eggs. Last year the British government took the first step, propos-

neurochemical and neuroelectrical profiles with normal individuals of a similar age.

Marvels of Medicine

By 2010 it is likely that new drug treatments will be capable of strengthening memory and impeding senility. Many drugs will be delivered in novel forms: inhaled or implanted beneath the skin as "pulsatile" systems which work in concert with the body's own circadian rhythms. At present, medication levels vary widely at different times of the day, thanks to brain-regulated variations in blood constituents. A "pulsatile" system will make it possible to provide the maximum amount of drug at the most propitious moment.

Among the more exciting drugs will be new pain-killers and tranquilizers which do their job without producing euphoria or addiction. (One such tranquilizer, BuSpar, went on the market last year.) These drugs will be harder to synthesize but should be in place by 2010 since neuroscientists have learned more about the brain's pleasure centers and their role in addiction in the past five years than in the previous 30. Moreover, it should be possible to deliver needed neurochemicals and drugs via indwelling canulas (tube-like extensions leading from the scalp to specific areas of the

sults gleaned from animal research that, for ethical reasons, couldn't be carried out in human subjects (since it involves the deliberate destruction of small areas of the brain).

Brain transplants—the insertion of tiny portions of the brains of fetuses into adult brains—will provide treatments if not functional "cures" for persons afflicted with brain diseases marked by deficiencies in specific neurotransmitters. This has already been accomplished in 1987 with patients suffering from Parkinson's Disease, a degenerative nervous system illness marked by a deficiency of the neurotransmitter dopamine.

Finally, don't expect a cure for cancer (a huge chunk of the cancer research budget will be shunted into AIDS research in the early 1990s) or for heart disease, diabetes and hypertension. There are simply too many interrelated contributing variables (diet, heredity, smoking and drinking patterns, exercise and so on). But there will likely be better and more reliable artificial organs, making economic barriers less determinative of who will live and who will die.

All in all, expect that medicine in the year 2010 will bring technological innovations that may out-pace our abilities to devise sensible, fair and ethical uses for them. One thing is certain: More will be required from all of us than simply a "gee whiz."

Terminal Conditions

COMPUTER-ASSISTED devices should be available by 2010 that will enable certain paralyzed patients to walk. They will work by a computer-driven array of electrodes which are implanted in the muscles of the back and legs. On command the computer will generate a motor sequence corresponding to the muscle activity which takes place in normal walking. Information will then be relayed back from the legs at speeds exceeding a million times normal nerve conduction times. This will enable the computer to make instantaneous corrections for variations in terrain. These and other "neural prostheses" for hearing, vision and other functions will depend upon the ability of neuroscientists and computer specialists to connect electronic systems to the brain and nervous system.

Computers, coupled with holograms (laser-assisted imaging devices), and CT and MRI scans will provide 3D images of the human body well before the year 2010. Instead of looking at the brain a slice at a time, as is common now, it will be possible to peer deep into the brain and even peek around more superficial areas in order to see parts that lie deep within. Areas that block the view or are otherwise irrelevant can be removed via computer instructions. Obscure and usually inaccessible areas will stand out with amazing clarity. By means of the computer-laser hookup, surgeons will be able to carry out practice operations. They will introduce innovations at will, take risks, try out novel approaches just to see "how things will turn out"—procedures that would be unthinkable in a live patient.

In the areas of plastic and reconstructive surgery, new computer imaging devices will be particularly useful. At the moment it is difficult for even the most skilled surgeon to know in advance exactly how his or her patients will look after an extensive reconstructive operation. But with the new video equipment, it should be possible