

# EIR Science & Technology

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## High technology makes health care cheaper!

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*The first in a two-part series by Wolfgang Lillge, M.D., on the "cost effectiveness" of high-quality medical care.*

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The congressional Office of Technology Assessment argues, in recent studies quoted in the accompanying box, that "the increase in the use of new and existing medical technologies" is responsible for the increase in medical costs. The OTA is the voice of the environmentalist, anti-nuclear, anti-defense lobby in Washington. Its "experts" are avowedly Malthusian: Their "objective study" of what they claim to be the runaway cost of medical treatment, is a thinly disguised justification for a policy of euthanasia as a method of population control.

The OTA's argument is hideously simple. High-technology medical treatment has extended life expectancy; this, says the euthanasia lobby, is undesirable. Beneath their fallacious cover-story that high-quality medical care is too costly, lies their hidden assumption: Merely allowing the elderly to stay alive is too costly. We present here the first installment of a two-part report, which is intended to expose this Nazi lie. We will also investigate the enormous promise of modern medicine, even in the abysmal situation confronting physicians and researchers today, in which basic research is hugely underfunded.

Technological progress is the necessary foundation of any healthy economy. Without investment in new technology, not only does an economy stagnate, but it becomes unable to maintain its future survivability as the existing resource base is depleted. It is necessary for a viable economy to increase its potential for future increases in productivity. The same basic economic principle is true for health care. Every efficient new technology introduced into medical diagnostics and treatment will cheapen the overall costs in the long run.

Today it is necessary to invest heavily in providing rising levels of health care for the world's population, if we are not to experience a repeat of the plagues of the Dark Ages, and an accelerating downward spiral of diseases and uncontroll-

able epidemics. AIDs is only one case in point.

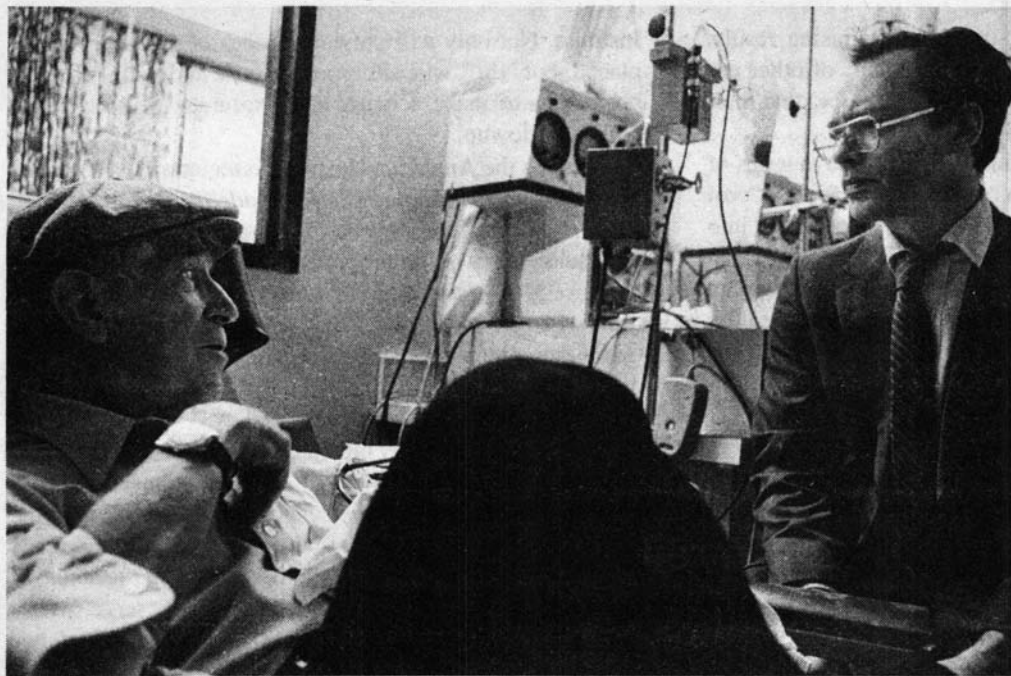
The logical consequence of the ideology of cost reduction in health care is euthanasia. At a certain point, the life of a human being becomes cheap, and individuals will fall under

### OTA demands an end to 'costly' medical research

*The following is an excerpt from the Office of Technology Assessment's 1983 report, "Diagnosis Related Groups and the Medicare Program: Implications for Medical Technology":*

The increase in the cost of hospital care has been a persistent and growing problem for both the Medicare program and the general public for more than 15 years. A substantial portion of the increase in hospital costs has been attributed to an increase in the use of new and existing medical technologies. . . .

There are two general incentives inherent in any per-case payment system: 1) to reduce the cost to the hospital of each inpatient case stay, and 2) to increase the number of inpatient admissions. Cost per case can be reduced by using fewer technological services, including ancillary services, reducing the number of inpatient days, or both.



*The Office of Technology Assessment of the U.S. Congress maintains that one of the "constraints" which makes cost-cutting difficult, is the fact that physicians have "financial, ethical, and legal reasons to practice high-quality medicine." Here, a doctor visits with a renal dialysis patient in a New York City hospital.*

NSIPS/Carlos de Hoyos

the category of "useless eaters." Especially the elderly are considered to be only a financial burden for the health budget. Movements proposing "death with dignity," "living wills," etc., are the lobby for a euthanasia program which will decide

who shall live and who shall die, according to cost/benefit considerations.

In any instance, where research and high technology in health care have been combined to save the life of patients

This incentive may result in specialization among hospitals for services that require a minimum number of patients to maintain profitability. This specialization may imply lower access to care for some Medicare patients. There are built-in constraints of unknown magnitude on the possibility of adverse effects on access and quality. One constraint is the fact that physicians are the decision makers, and they continue to have financial, ethical, and legal reasons to practice high-quality medicine.

*The following OTA report, "Medicare's Prospective Payment System, Strategies for Evaluating Cost, Quality, and Medical Technology," was released in 1985:*

Twenty years ago, Congress made a major commitment to securing older Americans' access to acute medical care with the creation of Medicare. Subsequent legislation extended the Medicare program to disabled people and to victims of end-state renal disease. Medicare has been an unquestioned success in reducing financial barriers to health care for its beneficiaries, but the program's costs have risen rapidly.

Medicare's payment methods have discouraged doctors, hospital managers, and patients from making cost-effective decisions regarding the use of medical technology. Retrospective cost-based hospital reimbursement was

particularly troublesome and, most would agree, inflationary.

Congress ended cost-based reimbursement for inpatient hospital care for Medicare beneficiaries with the creation of Medicare's prospective payment system (PPS) in 1983. The new hospital payment system has reversed the financial incentives away from the provision of more care for hospitalized patients to the provision of less care.

*Although the OTA claims that it does not issue policy statements, and pretends to an objective standard, the following, issued in September 1984, makes clear its position on reversing the trend toward high-technology medical care ("Health Technology Case Study 27: Nuclear Magnetic Resonance Imaging Technology, a Clinical, Industrial, and Policy Analysis"):*

Although State certificate-of-need (CON) programs were never specifically intended to constrain the diffusion of medical technology, they constitute one of the major policy mechanisms available to health planners for control over technology adoption. CON review of "need" may be based on numerous factors, including clinical use of technology, institutional characteristics, economic and financial effects, and population-based considerations [emphasis added].

(for example cancer patients), the most promising results have been obtained, giving hope to thousands of other patients suffering from presently incurable diseases, that their lives, too, could be saved or at least prolonged.

Human life is sacred and cannot be measured in terms of cost/benefit relations. The main reason we are facing a "cost explosion" in health care is the decreasing investments into medical research and new technologies, in an economy which is contracting. We have to return to a situation where we can afford a modern health care system for everyone, in a healthy economy which can sustain medical diagnostics and treatment.

### **What the future must hold**

What follows is a partial overview of health technologies which must be rapidly introduced. Most of these technologies are "spin-offs" from basic research efforts in biological or medical sciences, by NASA, the national laboratories, or universities. This basic research has to be expanded, too, to provide further breakthroughs in the future.

The use of Computer-Assisted Tomography (the CAT scan) and Nuclear Magnetic Resonance (NMR) devices has been attacked by members of the anti-life lobby, such as the congressional OTA. When a technology is limited in its application, its costs increase, for the same reason that a factory owner must continue to defray his overhead, even when he is forced to cut production. The application of these devices, along with laser applications to be discussed below, can ultimately lead to the virtual elimination of surgical operations. This will shorten hospital stays, and eliminate the need for costly post-operative treatment, as well as reducing the time lost to work. These techniques will become cheaper as, and only as, they are applied on a sufficiently wide basis.

Much surgery serves only a diagnostic function, which can now be replaced. In other cases, the same techniques now applied to diagnosis can be extended to treatment of conditions such as blocked arteries. Lasers are in use already, as a replacement for certain types of eye surgery. The development of technologies such as Nuclear Magnetic Resonance imaging will have the added benefit of reducing the amount of exposure of patients to x-rays.

### **Nuclear Magnetic Resonance**

Tremendous progress has been made recently to improve the imaging capabilities of NMR in the clinical setting. NMR is a diagnostic modality that uses magnetic and radio-frequency fields to image body tissue and monitor metabolic processes in the body non-invasively. It uses no ionizing radiation or contrast agents. Because of its high sensitivity and safety, it is becoming increasingly a replacement for some Computer Tomography (CT) procedures, as well as an array of invasive, often risky procedures such as myelography and angiography. "Ten years from now, NMR will have replaced 80% of what a hospital does in diagnosis," says Dr. Jerry Stolzenberg, chairman of radiology at Miami Heart

Institute. Not only will previous modes of diagnosis be replaced, but NMR will offer more precise and useful data for physicians to make a much more accurate decision about clinical followup.

But, as the American Hospital Association (AHA) notes in its *Hospital Technology Series Guideline Report: NMR—Issues for 1985 and Beyond*: "The rate of diffusion of this technology may not be proportional to its clinical superiority because NMR is reaching the health care marketplace at a time when the economic climate is volatile. The hospital that purchases prematurely without carefully weighing the options, risks and benefits associated with NMR could find itself in severe financial difficulties."

In fact, this is a fairly mild description of what, in reality, is a general policy on the part of the Malthusian budget-cutting ideologues to outlaw technologies like NMR from the "marketplace." In the case of NMR, this kind of thinking is particularly absurd, because the benefits of the technology are clearly established, despite the relatively large investments for such a machine. And the full potential of this technology is not yet fully developed.

By eliminating the need for many other examinations, biopsies, and exploratory surgical procedures, NMR could save significant amounts of money and substantially reduce risk and discomfort to the patient. For example, today contrast-enhanced CT and myelograms are used to diagnose tumors in the posterior fossa of the brain or on the spinal column. Abdominal aortic aneurysms often require angiography. Examining the prostate gland to determine the cause of an enlargement usually requires biopsy or exploratory surgery. NMR has already demonstrated its ability to minimize the need for some of these procedures or to displace them entirely, as well as to shorten the hospital stay usually associated with them.

In fact, the American Hospital Association report mentioned above identifies some 40 cost-saving applications, 19 of which are available now and would clearly save money if employed. Based on clinical experience with only 7 of the 19 currently available cost-saving applications, the AHA estimates that NMR should eliminate at least 20% of CT procedures applied to the head, 7.5% of those applied to the body, 28% of major vessel angiography, and 50% of kidney angiography. Furthermore, based on a conservative projection by the AHA, it is assumed that 1.8 million patients annually would need scans:

When followup procedures for these patients are included, the total number of scans becomes 2.9 million annually. A survey conducted by AHA with several leading NMR experts resulted in a model projecting that NMR will replace 34% of CT applications. The greatest area of impact on CT is projected to be for nervous system diseases (94% replacement), circulatory system diseases (75% replacement), and neoplasms (30% replacement).

Yet it is far from certain that NMR will find the general distribution it should have. One of the major obstacles is the

reimbursement policy of the insurance carriers. While more than 70% of the top 30 private insurance carriers now pay for NMR services, there is a very restricted reimbursement system for NMR procedures from Blue Cross/Blue Shield and the Health Care Financing Administration (HCFA). There is a general view among experts that the mounting pressure to contain cost will cause the insurance companies to be even more restrictive with NMR than they were with CT. As a consequence, many firms will shift their investment policy away from NMR, leaving the potential of this technology essentially untapped.

### Frontier applications of NMR

Cooperation with the National Aeronautics and Space Administration (NASA) has brought NMR technology to the verge of yet another breakthrough. Three years ago it was discovered that the computer that processes data from NASA's Landsat satellite could also be used in the NMR imaging process, because of the similarity of the two. This produces a sharper contrast, colored images, and an extension of potential applications. Researchers are confident that the linking of NMR to the Landsat facilities will produce three-dimensional reconstructions of any part of the body, viewed from any angle, or even from inside the body.

The next step which has to be developed is another special capability of NMR, called Nuclear Magnetic Resonance spectroscopy. This is the extension of the imaging of the body by spin resonance patterns detected in the hydrogen atom, to the wide array of atoms found in the organic chemicals of the body. This will allow metabolic processes to be imaged. NMR spectroscopy is a non-invasive technique for measuring biochemical changes in tissue that signal the onset of disease, long before other symptoms appear. If it succeeds, it could eventually replace invasive biopsy, and give us totally new insights into the metabolism of tissue.

While NMR spectroscopy has been used in laboratories for a long time to analyze pure chemical samples and, increasingly, also biological specimens, today this technology promises to be applicable also for *in vivo* tissue analysis. The benefits would be enormous, if we were able to conduct live studies of the chemistry of human tissue—without surgery, pain, or risk.

While NMR imaging uses only the magnetic resonance effect of the hydrogen proton, all atoms with an odd number of protons in their nucleus (atoms with a "spin" like carbon, fluorine, sodium, or phosphorus) could be used to generate resonance signals. In contrast to the hydrogen proton signal, these will be much weaker and more difficult to detect, so that great efforts have to be made to build more efficient superconducting magnets with high field strengths and extremely high levels of uniformity to reach adequate resolution of the signals. One spinoff to be expected from the U.S. Strategic Defense Initiative, is the development of such magnets at a reduced cost.

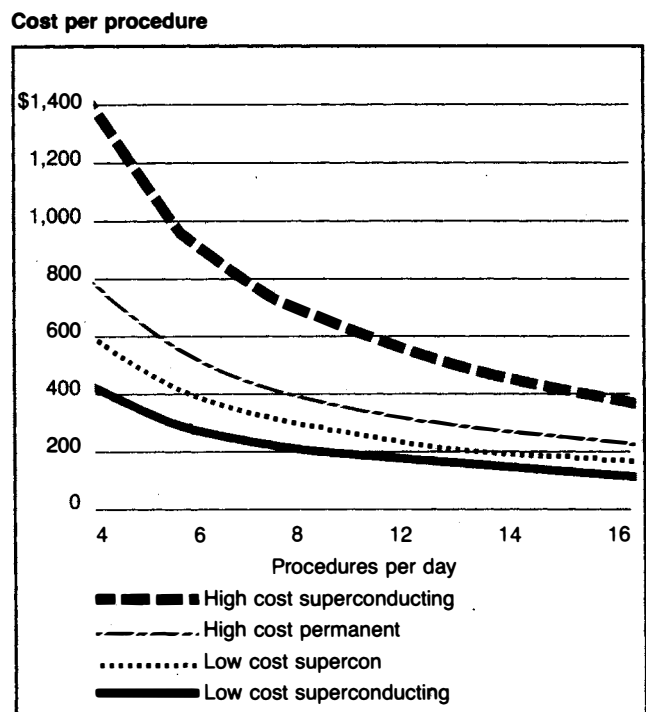
Phosphorus is probably the best-researched atom for NMR

spectroscopy so far, because it plays such a key role in metabolic processes in any tissue. It is possible to generate clearly distinguished signals of different phosphorus compounds in human tissues, like phosphocreatine, adenosine triphosphate (ATP), and inorganic phosphate, which will allow us to visualize important steps in, for instance, energy turnover in cells. In this way we could gain detailed insights into the functional and metabolic status of the brain, the heart, and other organs or peripheral muscle tissue in various physiological and pathological states. Such changes could be detected early, before they transform the tissue into a diseased state.

An NMR unit today costs from \$600,000 to \$2.5 million, depending mainly on the type of magnet used (superconducting, restive, permanent, high field strength for spectroscopy, low field strength for proton imaging only, etc.). Even if this seems to be a large initial investment, the overall cost reduction, through elimination of other procedures, reduction in hospital stays, etc., makes NMR a profitable venture, even over the relatively short term. Also, the costs for a single procedure can be brought down to \$200 or less, given an adequate utilization of the machine (Figure 1).

There can be no doubt that technologies with such a great potential must be massively disseminated, and the medical technology firms must be encouraged to develop them fur-

FIGURE 1  
Nuclear Magnetic Resonance (NMR) Costs per procedure  
(by ranges and magnet types)



ther, especially NMR spectroscopy, which has tremendous implications for basic biophysical research.

### **The CAT scanner**

Computer-Assisted Tomography is an x-ray machine linked to a computer. The computer processes the information from multiple x-ray beams focused on the patient from different angles, and produces a cross-sectional picture at any site along the length of the body. In this way, sequential "slices" of brain, liver, spine, and other tissue can be visualized in detail. For several diagnostic objectives, the CT scanner is still superior to NMR, while NMR effectively has replaced the CT technique in all aspects of brain imaging. One CT scan currently costs twice as much as other medical diagnostics, but replaces two to three such diagnostic studies, and provides the physician with much more direct and valuable evidence.

The anti-technology lobby launched probably its largest effort to implement "cost/benefit" restrictions, when the issue of introducing this revolutionary technology into the American health system arose in the early 1970s. A multitude of extremely biased studies of cost-effectiveness and cost/benefit analysis (CEA/CBA) were performed, and all proved incapable of determining the real impact of CT scanning, resulting in delays for delivery of this technology and increasing the costs of its development.

An OTA report on CT scanning issued in April 1981 had to admit the problem of economic feasibility studies of diagnostic procedures: "Judging by the quantity of published research, one would surmise that the state of the art of economic evaluation of diagnostic procedures—CT scanning in particular—is well advanced. In fact, the opposite is true. The studies of the cost-effectiveness or economic benefit of CT scanning reveal major conceptual and methodological weaknesses that not only mitigate these particular studies' value, but also cast doubt on the overall feasibility of conducting economic evaluations of diagnostic procedures."

This qualification has not, however, deterred the OTA from its effort to organize a popular and congressional backlash against high technology. A far better way to save the taxpayers' money would be to shut down the Office of Technology Assessment.

### **The laser flow cytometer**

Another area of advanced medical technology of potentially enormous benefit, is laser diagnostics. These techniques allow such speed in diagnosis, that treatment can begin at the outset of a disease.

The laser flow cytometer, which was developed in the 1960s by Lawrence Livermore and Los Alamos National Laboratories, is only now becoming available for medical application. It will revolutionize all microbial diagnostics. The machine suspends cells or individual molecules in liquid; they then pass through a flow chamber at rates of up to 20,000 cells per second. The cells are illuminated by lasers of differ-

ent frequencies, and the absorption or scattering of the laser light, or the fluorescence of molecules excited by the lasers, is measured.

Together with another technology now under development, an instrument called the angular scanning Circular Intensity Differential Scattering (CIDS) spectrometer, the flow cytometer potentially can identify bacteria and viruses in a couple of minutes, which now take hours or even even days and weeks to discover. CIDS measures the scattering of left- and right-polarized laser light by bacteria and viruses.

The huge economic potential of this technology can now only be roughly estimated, given the huge costs incurred in clinical microbiology laboratories in the United States—approximately \$30 million per week—for isolating and identifying microorganisms. This technology can not only cut costs in direct laboratory expenses because of its high efficiency, but can enable the physician to start treatment of patients with infectious diseases much earlier and more effectively, thus cutting costs in medical treatment and hospital stay.

The laser flow cytometer can be used to detect and isolate cancerous and precancerous cells, in a much faster, less complicated and more sensitive way than with traditional methods. Potentially the most important area of application for the flow cytometer/CIDS technology is the fight against AIDS. First experiments are now being undertaken by scientists at Los Alamos National Laboratories to identify the AIDS virus (HTLV-III/LAV) directly, by means of CIDS. If successful, this would be an important breakthrough on the way to a comprehensive screening program for AIDS in the entire population.

### **Mass spectrometer microbial identification**

In collaboration with NASA, another technique for identification of bacteria has been developed at the University of California at Los Angeles, using a new procedure for producing samples for a mass spectrometer. The technique generates an aerosol of the organisms and feeds it into the spectrometer. Each species of organism produces a characteristic set of peaks in the mass spectrum, and might thereby be identified.

### **The x-ray laser**

The medical/biological application of the x-ray laser is another area justifying a major research effort. It will become a diagnostic tool which opens our eyes to the internal structure of living cells, in a way which has not been otherwise possible. The x-ray laser, now in its final phase of development, could be used as a highly efficient microscope, comparable to the electron microscope. Its unique advantage is that with it we can image living specimens. No longer will tissue need to be stained, frozen, or cut, processes which distort the image and obviously can only be done outside the body. With ultra-short flashes of a coherent x-ray source, it will be possible soon to identify structures in the cell, like the membrane, the mitochondria, the Golgi apparatus, etc., in

real time, and possibly even in the form of a three-dimensional hologram.

The implications of such a scientific revolution for medicine are still beyond imagination today; it might lead to a total revision of our view of certain microscopic processes. The defeat of cancer and the aging process are only two areas which come within reach when the x-ray laser comes online.

### **Coronary angiography without risk**

On the basis of currently available high-flux monochromatic x-rays produced by a synchrotron accelerator, a special diagnostic procedure has developed as a medical diagnostic procedure, enabling doctors to "see" inside a patient's arteries around the heart. By using the synchrotron x-rays and image enhancement techniques, a procedure known as coronary angiography can be replaced, avoiding the risk associated with it when a bolus injection of a dye is injected into the coronary arteries, via a catheter which is pushed forward through an arm artery to the heart, followed by a series of shots with traditional x-rays. The technique, using coherent x-rays, requires only a small injection into an arm vein, eliminating the main risk of coronary angiography and opening the way for a broader screening of patients who are at risk of coronary disease by family history or other factors.

### **Other laser applications in medicine**

The use of lasers has been widespread in several branches of medicine for many years, mainly as surgical tools. Use now includes sealing hemorrhaging blood vessels in such diverse organs as the eye, the stomach, the colon, etc.; cutting in areas where high precision is wanted, as in the ear; and excising tumors. Generally, such lasers generate heat in the tissues on which they are used. As laser systems are perfected and become cheaper, they will be applied to more areas of medicine.

A new type of laser, known as excimer or excited dimer laser, can be used for treatment of coronary artery disease. This laser produces extremely short, intense bursts of ultraviolet light, which shatter the molecules of the atherosclerotic plaques blocking the flow of blood in the arteries around the heart, without heating effects of the blood vessel, which would only increase the tendency of the blood to clot. The laser is incorporated in a 1.5-millimeter-diameter catheter, containing three bendable glass fibers: One carries the laser energy, another shines a light on the catheter tip, and the third provides a view of the area in front of the catheter. The initial laser used in current experiments was developed by NASA at the Jet Propulsion Laboratory, for remote atmospheric sensing.

The estimated costs of the perfected laser-fiber optic device is \$100,000. With it, a patient could have his coronary arteries cleaned out in a few minutes and might not even have to stay overnight in the hospital. When one considers that 170,000 patients underwent coronary bypass surgery in 1982, at an average cost per person of \$20,000, providing 50 of

these devices would represent savings in health care costs of at least \$3 billion per year! More important, many patients who could not tolerate surgery because of the severity of their disease, could be treated by this method and restored to productive activity.

A new method for precise localization and definite treatment of lung cancer in an early stage is now in an experimental phase, using laser light of two different frequencies (photodynamic therapy). To improve the visualization of tumor tissue in the lung, which in the early stage is difficult to differentiate from healthy tissue, the patient is injected with a special dye, chemically related to the heme portion of hemoglobin (photofrin II or HpD), which selectively localizes in tumor cells.

When the bronchi are then illuminated with a blue laser fitted into the fiber optics of a bronchoscope, the HpD-laden cells fluoresce in the red region of the spectrum, so that they stand out clearly against the background tissue. First reports indicate that the HpD technology can find the tumor in 60-70% of the cases where the patient's sputum shows malignant cells, but no cancer tissue can be seen on normal bronchoscopy. Once the tumor is located in the sights of the instrument, the doctor can switch to another laser frequency, produced by a red ruby laser, and focus the laser light on the tumor. This frequency is differentially absorbed by the HpD-containing tumor cells, many orders of magnitude more than by the normal surrounding tissue. The red light does not kill the tumor by heating it, but actually causes the HpD dye to photo-excite, causing irreparable damage to cell membranes, mitochondria, etc., which slowly kills the tumor.

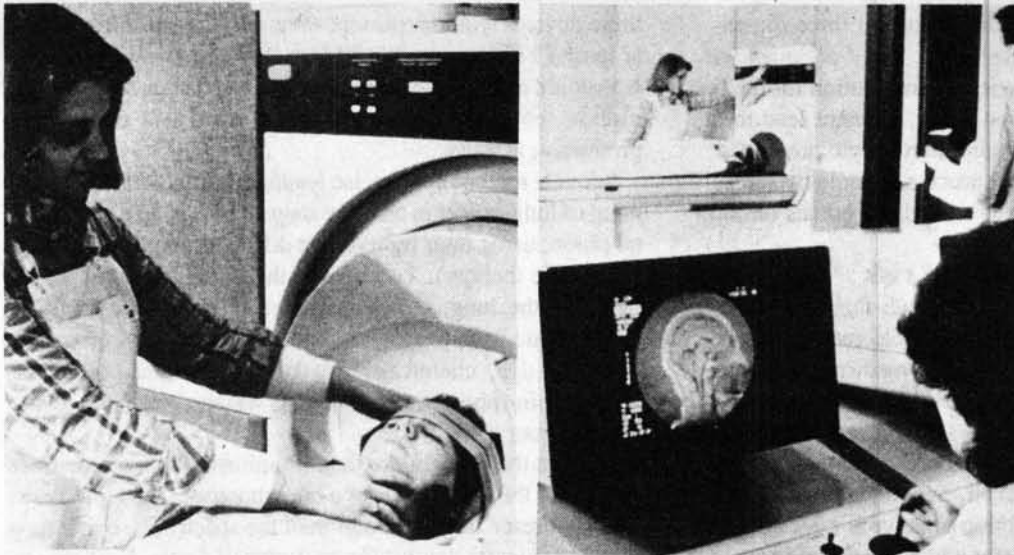
The same method has also proven effective in cases of end-stage lung cancer, where tumor masses obstruct the lumen of the main bronchi, leading to a collapse of the distal part of the lung. Treatment with the HpD technique results, in a high percentage of cases, in the total reopening of such obstructed bronchi—a significant palliative improvement in the condition of non-operable lung cancer patients.

### **The lithotripter**

Last year, the Food and Drug Administration (FDA) approved a device called lithotripter, which focuses shock waves on kidney stones and crumbles them into sand-like particles that can be passed in the urine. The patient is positioned in a large stainless steel tube filled with water, and the shock waves, generated by a spark between two electrode tips situated in a concave metal reflector, are focused on the stone. Since water and body tissue have the same acoustical properties, they are unaffected by the shock waves, whereas the more brittle stone crumbles.

The machine, developed by Dornier System of West Germany, could save approximately \$2,000 per patient treated, as compared to surgery. It is estimated that the procedure would be effective in 80-90% of the 100,000 kidney stone operations that are done each year in the United States. A rough calculation shows that 100 such machines, properly





*Nuclear Magnetic Resonance is a diagnostic method that uses magnetic and radio-frequency fields to form images of body tissue and to monitor metabolic processes in the body, without surgery or other risky invasive techniques. In the photo shown here, physicians are able to "see" inside a patient's brain.*

National Institute of Health

located, costing a total of \$170 million, could save \$2,000 per case on 80,000 cases in one year, and thus essentially pay for themselves in their first year of operation.

A very recent report from Germany indicates that the same shock-wave principle has also proven effective to break up painful gallstones, eliminating the need for gall bladder surgery. Depending on the location of the stones in the gall bladder or the bile duct, the success rate was up to 80%, in the limited number of patients treated with this procedure so far.

### **The artificial heart**

Over the long run, the use of a fully implantable artificial heart will be a superior solution to the treatment of end-stage heart disease than transplantation, because it does not rely upon the death of another person and avoids the problem of graft rejection. Whereas modern transplantation surgery has saved many lives and made important contributions to the understanding of basic immunology, the use of organs from cadavers will never be free of disputes over what constitutes brain death, and appropriate criteria for the termination of treatment.

The experience of the last round of artificial heart implants has established that the basic technology to make the device a lasting replacement for an irreversibly damaged heart is available. The Jarvik-7 heart used in the six implants of 1984-85 even proved capable of reacting to the patient's activity by increasing the flow of blood. The portable power unit for the artificial heart, the Heines driver system, has proved to be very efficient, while enabling the patient to have a good deal of mobility.

The next step in research and development must be a fully implantable artificial heart which is small enough to fit into the chest cavity of any potential recipient, including a driving unit which could be nuclear powered.

All the major development work for an artificial heart goes back to basic engineering, material, and hydrodynamic research conducted by NASA in the context of the manned Moon mission in the 1960s and other projects. The significance of this work cannot be overestimated and underlines, once again, the urgent necessity to resume broad-based basic research efforts, in order to develop more such practical applications for the future.

One of the major complications of the present artificial heart program is not so much an engineering problem, but reflects the failure of biology to comprehend the biophysics of heart action and blood flow. There is still a major problem of blood clotting, with consequent strokes. This is an immunological complication caused by interreaction of the blood with the plastic surfaces of the device. Too little is known today to fully account for these complications which nearly proved fatal for several of the artificial heart recipients.

The major stumbling blocks are a pervasive misconception about the flow patterns required in the artificial heart chambers, and a misconception about the nature of surfaces, and their interaction with blood platelets. The immunogenic properties of almost any kind of plastic have been the major problem in any organ replacement, and it is not really known, why under certain conditions blood coagulation occurs. This lack of knowledge reflects the lack of fundamental research in biology and biophysics since, effectively, the late 1960s, when the United States almost totally eliminated this branch of research.

### **NASA spinoffs for medical use**

Basic research by NASA initiated during the period of the Apollo Project in the 1960s, and other more recent programs, resulted in the development of many technologies which proved to be highly useful in medicine. Here are a few of the many examples which grew out of that program, mak-

ing health care more efficient and cheaper.

● **Programmable Implantable Medication System (PIMS)** has been approved by the Food and Drug Administration for human trials with morphine for cancer patients and insulin for diabetics. PIMS is a device which releases medication automatically as needed by the body. The technology was developed for the Viking spacecraft (the Mars mission), which required miniaturized fluid control, used for metering nutrients into soil samples.

● **Automatic Implantable Defibrillator (AID)** has been authorized by the FDA for commercial sales. Heart attack victims often can be saved by electric shock defibrillation, but many who die from a fibrillation episode are far away from a proper treatment facility. The AID can sense the onset of fibrillation and deliver a balanced electric pulse to restore the heart to a normal rhythm.

A second-generation device, known as the Implantable Automatic Cardioverter-Defibrillator, detects and corrects a broader spectrum of arrhythmias, including ventricular tachycardia as well as ventricular fibrillation. It also has an audio speaker that can be externally activated to determine the status of the device, and it has an internal counter to record the number of countershocks delivered. This information, important for the attending physician, can be telemetered to an external receiver.

● **The multi-module AutoMicrobic System (AMS)** originated in a NASA-sponsored study aimed at development of a fully automated microbial detection and identification system for the space program. In this system, specimens are exposed to microbe nutrients for the nine most common pathogens. During a 4-to-13-hour incubating cycle, an electro-optical scanner studies each specimen once an hour. Changes in cell growth on each culture are monitored by computer. When growth reaches a predetermined level, it indicates the presence of pathogens. On push-button command, the information is displayed in video or reported on a print-out.

AMS enables the microbiology lab to furnish guidelines for antimicrobial therapy the day after specimen collection; this amounts to a time saving of 50-80% over standard laboratory methods, and it can handle up to 240 specimens at a time. Savings in laboratory costs and reduced hospital stays of patients due to faster analysis could be estimated accordingly.

● **Temperature measurement aid:** NASA's Ames Research Center has designed a simple but medically important device—one which holds temperature probes, called thermistors, to a person's skin. The device improves the accuracy of skin-surface temperature measurements, valuable data in health evaluation.

● **Blood pressure checker:** A simple device that is now widely located in public places, is a direct spinoff from NASA technology developed to monitor astronauts in space. NASA's Johnson Space Center, in collaboration with a contractor, developed an electronic sound processor that automatically analyzes blood flow sounds to get both systolic and diastolic

measurements of blood pressure.

● **Programmable pacemaker:** A private contractor introduced in 1979 an advanced cardiac pacing system which allows a physician to reprogram a patient's implanted pacer without surgery. The system has a two-way communications capability and incorporates a number of technologies based on those employed by NASA to send coded instructions or queries to unmanned satellites and to receive information from satellites.

● **Cordless instruments for surgery:** Such instruments, for example those needed for bone surgery, have obvious advantages: They require no connecting lines or hoses, which have to be sterilized and can burst or tangle. The cordless, battery-powered precision instrument gives the surgeon optimal freedom and versatility in the operating room. Such instruments evolved from a private company's participation in the Apollo lunar landing program.

● **Slow Scan telemedicine:** This technology, which originated in the U.S. space program, permits transmission of still video images inexpensively over telephone lines, or over radio, microwave, and satellite channels. In addition to CT scans, the technique allows transmission of x-rays, nuclear scans, ultrasonic imagery, thermograms, electrocardiograms, or live views of patients. Such transmissions enable extension of physicians' and specialists' services to remote communities, through paramedics or nurse practitioners at Slow Scan-equipped clinics.

● **Prosthesis for urinary control:** This device, developed for the Marshall Space Flight Center in Alabama, is helpful for people who have lost muscular control of the urinary canal through disease or injury. Implanted so that it surrounds the urethra, the sphincter is deflated and inflated at will by the wearer, to start and stop the urination. The principle can be adapted to other organs, such as the colon, ureter, or ileum.

● **Automated cancer diagnosis:** In a work done for the Johnson Space Center in Houston, Texas, five new algorithms have been established as a complete statistical procedure for quantifying cell abnormalities from digitized images. The procedure could be the basis for automated detection and diagnosis of cancer. When atypical bronchial cells from the sputum of cigarette smokers were analyzed, for example, the levels of carcinogenesis assigned by the algorithms agreed with those assigned by visual classification. This method could prove essential for mass screening for lung cancer.

Future applications developed by NASA in collaboration with other institutions include:

- Memory or wandering aid for the elderly, stroke victims, and Alzheimer patients;
- Hydrocephalus (water on the brain) shunt for relieving intracranial pressure;
- Intracranial pressure-monitoring device for victims of head injury;
- Handicapped driver-assist device.