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Ursula Marvin on "The Moon After Apollo": Our new knowledge of lunar history represents "a revolutionary advance in planetary science."

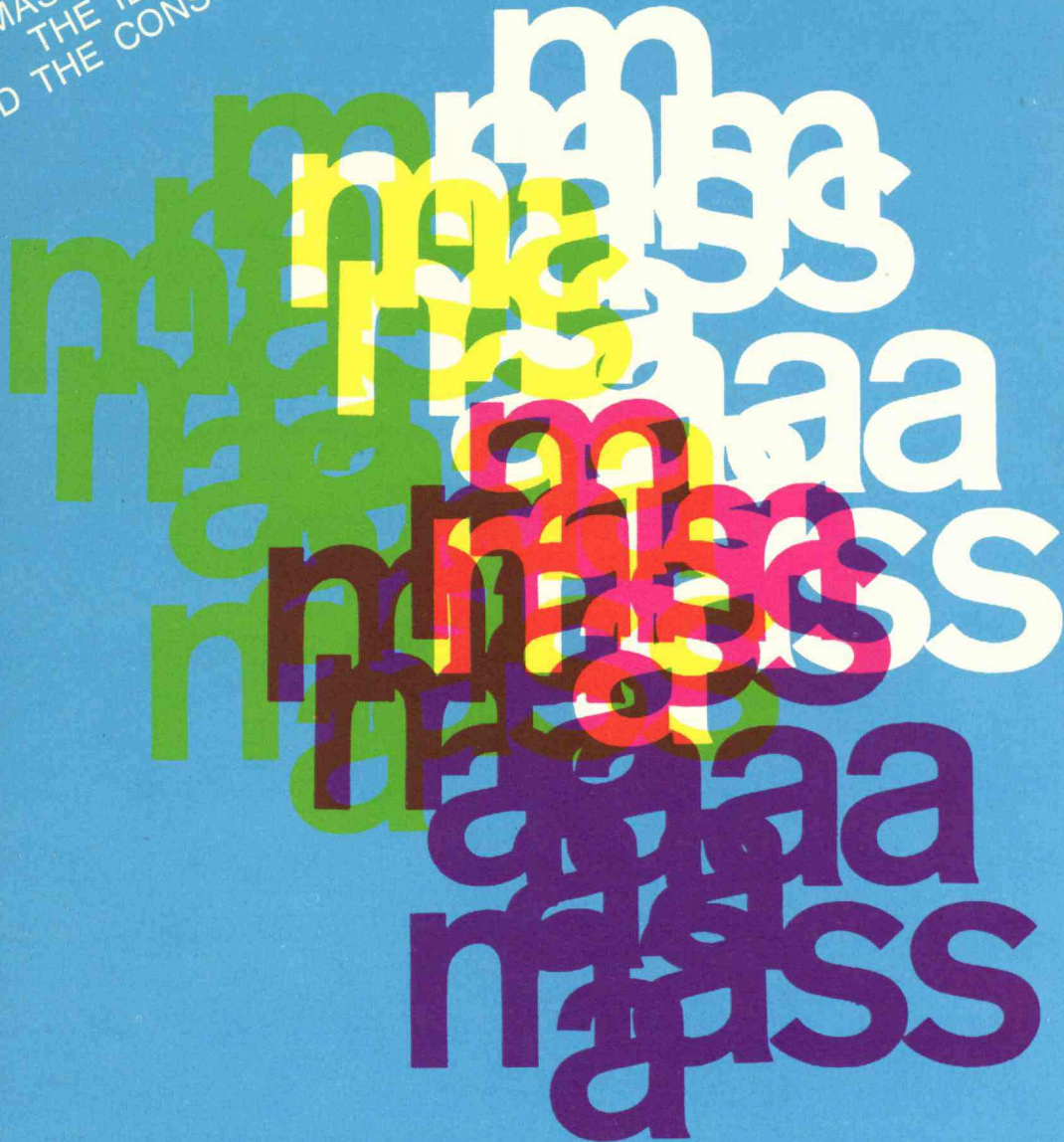
Amar G. Bose on "Sound Recording and Reproduction II": If a distortionless array displayed apparent distortions, what other parameters remain to control?

Stuart E. Madnick on "The Future of the Computer": Computer systems have captured public attention and yielded basic changes in American life. Their future course will depend as much on the way we use information as on the technology we apply to it.

Edited at the
Massachusetts Institute
of Technology

Technology Review

MASS TRANSIT:
THE IDEALS
AND THE CONSTRAINTS



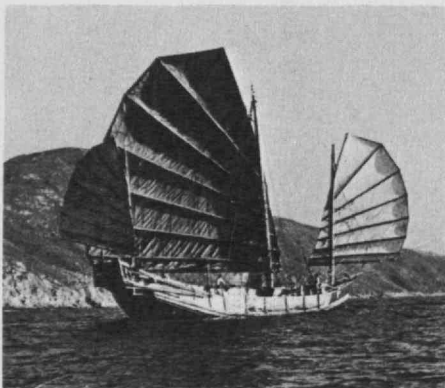
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shopping, and as a special highlight, the fabled island of BALI. Tour dates include outstanding seasonal attractions in Japan, such as the spring cherry blossoms, the beautiful autumn leaves, and some of the greatest annual festivals in the Far East. Total cost is \$1899 from California, \$2005 from Chicago, and \$2172 from New York, with special rates from other cities. Departures in March, April, May, June, July, September, October and November 1973 (\$27 additional for departures in July, September and October).



AEGEAN ADVENTURE

22 DAYS \$1429

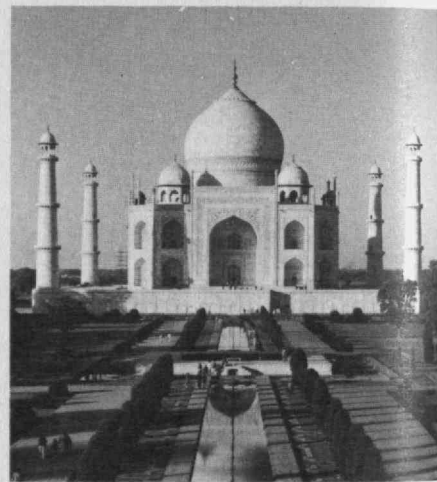
This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean, and Asia Minor—not only the major cities but also the less accessible sites of ancient cities which have figured so prominently in the history of western civilization, complemented by a cruise to the beautiful islands of the Aegean Sea. Rarely has such an exciting collection of names and places been assembled in a single itinerary—the classical city of ATHENS; the Byzantine and Ottoman splendor of ISTANBUL; the site of the oracle at DELPHI; the sanctuary and stadium at OLYMPIA, where the Olympic Games were first begun; the palace of Agamemnon at MYCENAE; the ruins of ancient TROY; the citadel of PERGAMUM; the marble city of EPHEBUS; the ruins of SARDIS in Lydia, where the royal mint of the wealthy Croesus has recently been unearthed; as well as CORINTH, EPIDAUROS, IZMIR (Smyrna) the BOSPORUS and DARDANELLES. The cruise through the beautiful waters of the Aegean will visit such famous islands as CRETE with the Palace of Knossos; RHODES, noted for its great Crusader castles; the windmills of picturesque MYKONOS; the sacred island of DELOS; and the charming islands of PATMOS and SANTORINI. Total cost is \$1429 from New York. Departures in April, May, July, August, September and October 1973.

SOUTH AMERICA

32 DAYS \$1995

From the towering peaks of the Andes to the vast interior reaches of the Amazon jungle, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America: a brilliant collection of pre-Colombian gold and a vast underground cathedral carved out of a centuries-old salt mine in BOGOTA; magnificent 16th century churches and quaint Spanish colonial buildings in QUITO, with a drive past the snow-capped peaks of "Volcano Alley" to visit an Indian market; the great

viceregal city of LIMA, founded by Pizarro, where one can still see Pizarro's mummy and visit the dread Court of the Inquisition; the ancient city of CUZCO, high in the Andes, with an excursion to the fabulous "lost city" of MACHU PICCHU; cosmopolitan BUENOS AIRES, with its wide streets and parks and its colorful waterfront district along the River Plate; the beautiful Argentine LAKE DISTRICT in the lower reaches of the Andes; the spectacular IGUASSU FALLS, on the mighty Parana River; the sun-drenched beaches, unforgettable mountains and magnificent harbor of RIO DE JANEIRO (considered by many the most beautiful city in the world); the ultra-modern new city of BRASILIA; and the fascination of the vast Amazon jungle, a thousand miles up river at MANAUS. Total cost is \$1995 from Miami, \$2080 from New York, with special rates from other cities. Optional pre and post tour visits to Panama and Venezuela are available at no additional air fare. Departures in January, February, April, May, July, September, October and November 1973.



MOGHUL ADVENTURE

29 DAYS \$1825

An unusual opportunity to view the outstanding attractions of India and the splendors of ancient Persia, together with the oneforbidden mountain kingdom of Nepal. Here is truly an exciting adventure: India's ancient monuments in DELHI; the fabled beauty of KASHMIR amid the snow-clad Himalayas; the holy city of BANARAS on the sacred River Ganges; the exotic temples of KHAJURAHO; renowned AGRA, with the Taj Mahal and other celebrated monuments of the Moghul period such as the Agra Fort and the fabulous deserted city of Fatehpur Sikri; the walled "pink city" of JAIPUR, with an elephant ride at the Amber Fort; the unique and beautiful "lake city" of UDAIPUR; and a thrilling flight into the Himalayas at KATHMANDU, capital of NEPAL, where ancient palaces and temples abound in a land still relatively untouched by modern civilization. In PERSIA (Iran), the visit will include the great 5th century B.C. capital of Darius and Xerxes at PERSEPOLIS; the fabled Persian Renaissance city of ISFAHAN, with its palaces, gardens, bazaar and famous tiled mosques; and the modern capital of TEHERAN. Outstanding accommodations include hotels that once were palaces of Maharajas. Total cost is \$1825 from New York. Departures in January, February, August, September, October and November 1973.

THE SOUTH PACIFIC

29 DAYS \$2100

An exceptional and comprehensive tour of AUSTRALIA and NEW ZEALAND, with optional post-tour visits to south seas islands such as FIJI and TAHITI. Starting on the North Island of New Zealand, you will visit the country's major city of AUCKLAND, the breathtaking "Glowworm Grotto" at WAITOMO, and the Maori villages, boiling geysers and trout pools of ROTORUA, then fly to New Zealand's South Island to explore the startling beauty of the snow-capped SOUTHERN ALPS, including a flight in a specially-equipped ski plane to land on the Tasman Glacier, followed by the mountains and lakes of QUEENSTOWN with a visit to a sheep station and a thrilling jet-boat ride through the canyons of the Shotover River. Next, the haunting beauty of the fiords at MILFORD SOUND and TE ANAU, followed by the English charm of CHRISTCHURCH, garden city of the southern hemisphere. Then it's on to Australia, the exciting and vibrant continent where the spirit of the "old west" combines with skyscrapers of the 20th century. You'll see the lovely capital of CANBERRA, seek out the Victorian elegance of MELBOURNE, then fly over the vast desert into the interior and the real OUT-BACK country to ALICE SPRINGS, where the ranches are so widely separated that school classes are conducted by radio, then explore the undersea wonders of the GREAT BARRIER REEF at CAIRNS, followed by a visit to SYDNEY, magnificently set on one of the world's most beautiful harbors, to feel the dynamic forces which are pushing Australia ahead. Limited visits to South Pacific islands such as Fiji and Tahiti can also be included at no additional air fare. Total cost is \$2100 from California. Departures in January, February, April, June, July, September, October and November 1973.

lions along the shores of LAKE MANYARA in the Rift Valley; photographing rhino and other big game against the majestic snow-covered background of Mt. Kilimanjaro in the AMBOSELI RESERVE; and the vast and fascinating wilderness of TSAVO NATIONAL PARK, renowned for its elephant and lion and for the unusual desert phenomenon of the Mzima Springs. There is also a stay in NAIROBI, the most fascinating city in East Africa, as well as features such as a visit to a MASAI MANYATTA to see tribal dancing and the tribal way of life. The altitude in East Africa provides an unusually stimulating climate, with bright days and crisp evenings (frequently around a log fire), and the tour follows a realistic pace which ensures a full appreciation of the attractions visited. Total cost is \$1739 from New York. Optional extensions are available to the VICTORIA FALLS, on the mighty Zambezi River between Zambia and Rhodesia, to UGANDA, and to the historic attractions of ETHIOPIA. Departures in January, February, March, May, June, July, August, September, October, November and December 1973 (\$26 additional for departures in June, July and August).



MEDITERRANEAN ODYSSEY

Preliminary Announcement

An unusual blend of countries in the Mediterranean area, visiting TUNISIA, the Dalmatian Coast of YUGOSLAVIA, and MALTA. Starting in TUNIS, the tour explores the coast and interior of Tunisia: the ruins of the famed ancient city of CARTHAGE as well as the ruins of extensive Roman cities such as DOUGGA, SBEITLA, THUBURBO MAJUS and the magnificent amphitheater of EL DJEM, historic Arab towns and cities such as NABEUL, HAMMAMET, SOUSSE and KAIROUAN, the caves of the troglodytes at MATMATA, beautiful beaches at ZARZIS and on the "Isle of the Lotus Eaters" at DJERBA, and desert oases at GABES, TOZEUR and NEFTA. The beautiful Dalmatian Coast of Yugoslavia is represented by SPLIT, with its famous Palace of Diocletian, and the medieval walled city of DUBROVNIK, followed by the island of MALTA, with its treasure house of 17th and 18th century churches and palaces, where the Knights of St. John, driven from the Holy Land and from Rhodes, withstood the epic siege of the Turks and helped to decide the fate of Europe. It is anticipated that the tour will be of three weeks' duration and that it will be inaugurated in the fall of 1973. Further details, including the tour cost, will be announced as soon as possible.

* * *



NORTH AFRICAN ADVENTURE

Preliminary Announcement

A new tour to North Africa and the regions which surround it, visiting GIBRALTAR, MOROCCO and the CANARY ISLANDS. GIBRALTAR, the gateway to North Africa, is the first stop, followed by a crossing of the narrow Strait of Gibraltar to TANGIER, on Morocco's northern coast. From Tangier, the tour proceeds by road to the imperial cities of MEKNES and FES, with an excursion to the Roman ruins of VOLUBILIS, then crosses the Atlas Mountains to the pre-Sahara and ERFUOD, on the edge of the desert. From here, the famed "casbah trail" leads through TINERHIR and OUARZAZATE to MARRAKECH, where an extended stay is provided before continuing to CASABLANCA. The visit to the CANARY ISLANDS, lying off the coast of Africa, will include stops in TENERIFE, the volcanic island of LANZEROTE, and LAS PALMAS. It is anticipated that the tour will be of three weeks' duration and that it will be inaugurated in the fall of 1973. Further details, including the tour cost, will be announced as soon as possible.

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes. Individual brochures on each tour are available, setting forth the detailed itinerary, hotels used, and other relevant information.

* * *

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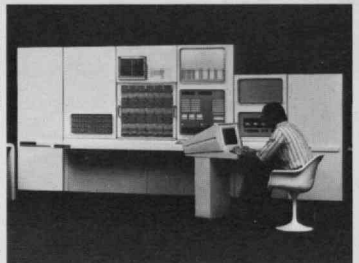
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Articles

The Moon After Apollo 12
Ursula B. Marvin

Twelve men have returned from the surface of the moon with an immense treasure of geological samples and geophysical data. Their findings have brought us much closer to understanding our satellite's unique history

Sound Recording and Reproduction II: Spatial and Temporal Dimensions 24
Amar G. Bose

Distortionless reproduction of sound fails to reproduce the sensation of the concert hall. The difference is partially resolved, and future research could produce dramatic improvements

The Future of Computers 34
Stuart E. Madnick

New technology promises ever-smaller computers of ever-greater power and speed. Their usefulness will depend on the wisdom of their users as much as on the ingenuity of their designers

Para-Transit: Taking the Mass Out of Mass Transit 46
Arthur Saltzman

We have assumed that public transportation must operate on fixed routes and published schedules. But dial-a-ride experiments show that our needs could be better served by systems capitalizing on flexibility

What's New in Transit in Europe 54
Lester A. Hoel

Many foreign cities have opted for major investments in public transport—instead of highways. As a result, their central cores remain compact and livable—and transit innovations have become major urban goals

Departments

Cover
Design by Ralph Coburn

Letters

Washington Report
The Watergate: a timely lesson in the misapplication of science and technology
Victor Cohn

Gas Well Enrichment
A new confrontation of energy and conservation has ended by serving the interests of both
Peter Gwynne

Plants in the City
Remarks on the remarkable survival of plants and trees in an urban environment
Ruth S. Foster

Trend of Affairs
Perspectives, 65
Solid State, 68
Energy, 69
Land and sea, 70
Body and mind, 71
Education, 71

Books
The Nuclear Power Rebellion: Citizen vs. Atomic Industrial Establishment and *The Atomic Establishment*, reviewed by Henry W. Kendall

Eater's Digest: The Consumers' Factbook of Food Additives, reviewed by Emily L. Wick

Science and Technology as an Instrument of Soviet Policy, reviewed by Robert P. Mikulak

Whistle Blowing, reviewed by Joel Primack

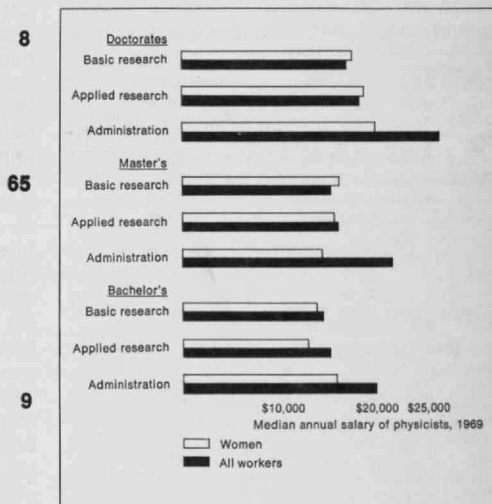
"A Constant Among Some Variables," a poem by David McCord

Puzzle Corner
How four dogs meet in a field, and other problems
Allan J. Gottlieb

Institute Informant

The First Line

The Women Wronged
Only a few hours were needed for the *Review* to stand corrected on a sensitive—and important—point on which no editor would have chosen to be in error. A chart on page 56 of *Technology Review* for June proposed to show that women physicists working in government laboratories are paid less, almost without exception, than the average of all physicists of equivalent qualifications in government laboratories. The chart, with the legend corrected (the designations were originally reversed), is reproduced below.



Volume 75

This issue completes Volume 75 of *Technology Review*. An index is in preparation and will upon completion be sent without cost to all subscribing libraries; others requiring the index may write to place their names on the list to receive it.

As we complete the volume, we announce with regret that Janet Kreiling, Associate Editor of the *Review*, has resigned to take an important assignment in educational television. She has brought wisdom, perception, and a woman's touch to the magazine since September 1969; and readers who are unaware of the implications of that statement will soon enough discover as the *Review* appears in the future without benefit of Miss Kreiling's special talents.—J.M.

The "Fusfeld Functions"

Concerning the dialogue on the use of mathematical symbols in *Technology Review* (see "The First Line," February, p. 3), I find that I am of a mind with Michael Faraday. In a letter to the theoretician James Clerk-Maxwell, Faraday, the experimentalist, made the following request (*The New Yorker*, March 10, 1973, p. 56):

"When a mathematician engaged in investigating physical actions and results has arrived at his conclusions, may they not be expressed in common language as fully, clearly, and definitely as in mathematical formulae? If so, would it not be a great boon to such as I to express them so?—translating them out of their hieroglyphics, that we might also work upon them by experiment. I think it must be so, because I have always found that you could convey to me a perfectly clear idea of your conclusions, which, though they may give me no full understanding of the steps of your process, give me the results . . . and so clear in character that I can think and work from them."

Ralph Segman
Cambridge, Mass.

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An Unstressed Reader

The Editor's concern that many readers may not be willing to cope with the intellectual exercises presented by the mathematical functions in Alan R. Fusfeld's article ("The Technological Progress Function," February, pp. 29-38) is unfounded from my point of view. Mathematical/intellectual exercises have always been a part, though optional to the reader, of *Technology Review*—to wit, "Puzzle Corner" by Allan Gottlieb. More importantly, the level at which Mr. Fusfeld presented the mathematical material and the ample written explanations supporting those expressions leave the reader relatively unstressed.

As long as equations are described in literal form and well supported by graphics, the future inclusion of similar articles will greatly enhance the value of *Technology Review* to me.

G. M. Kipnis
New York, N.Y.

Productivity and Progress

Two further comments about technological progress functions, stimulated by Alan Fusfeld's fine article ("The Technological Progress Function," February, pp. 29-38):

First, Fusfeld states that "the two versions (i.e., technological progress as a function of time and the Fusfeld cumulative experience forecast) agree if and only if the rate of production is a constant fraction of total production to date. And that is experiential growth." This is not quite correct. One can easily convince one's self that the two are, in general, equivalent when b (the "experience" constant) is equal to 1; and, in any case only differ as the inverse power of b . This is important because it implies that the reason that so little difference is apparent in Fusfeld's curves and those of the conventional time series forecasts is that, by and large, the same functional relationships exist in each formulation. This in no way diminishes the importance of Fusfeld's contribution. He has certainly provided us with greater insight into the process of technological progress and this is important. The fact that a learning curve formulation correlates the data provides a rational for action that this simple time series can not.

Secondly, it is interesting to note that Mansfield and others have shown that productivity has the same type of "experience" curve relationship to cumulative research and development expenditures within an industry. This observation has interesting implications for research and development policy. One can easily show that the key variable for policy is the relationship of the "experience" exponent (b) to the exponent which expresses the growth of research and development expenditures with time. Generally, if both are positive, that is research and development expenditures are increasing as a function of time and productivity is improving as a function of research expenditures, then productivity will increase over time. However, if research and development expenditures increase at a low rate (say as the square root of time) and productivity is less than

fully responsive to the increasing stock of research and development (as it is non-durable goods where $b=0.1$) then one can actually find one's self with a declining rate of productivity increase. This is precisely what has been happening over the past few years in the U.S. To the extent that we fail to increase our rate of expenditures on research and development or continue to fail to understand how better to utilize the results of research and development to increase productivity, particularly in sectors of increasing importance—non-durable goods and services—we can expect to see little progress in productivity and therefore inflation and thus international competitiveness.

Richard N. Foster
Cambridge, Mass.

The writer is Director of the Technology Management Group of Abt Associates, Inc.—Ed.

Mr. Fusfeld comments:

Mr. Foster's comments are particularly insightful. Their focus involves the functional forms of three relationships:

□ Technology as a function of cumulative production (the technological progress function), $T = h(i)$.

□ Technology as a function of time (the technology time trend), $T = f(t)$.

□ Cumulative production as a function of time, $i = g(t)$.

When any two of the three relationships are assumed fixed in form, it is possible to derive specific characteristics of the third. Dr. Foster and I differ in our selection of which functions are assumed to be fixed in form.

Cellular Regeneration

Though Dr. Robert O. Becker's hypothesis regarding the role of piezoelectrically-generated currents in remodeling stressed osseous tissue is intriguing ("Electromagnetic Forces and Life Processes," December, pp. 32-38), his model of externally applied electric fields in causing cellular dedifferentiation of the red blood and hence regeneration appears untenable to me.

His model system describes the dedifferentiation of the red blood cells into an imitative cell. This cell is then to differentiate despite the combined presence of the external field into an entirely different mature species such as cartilage or bone. I would be interested in knowing how Dr. Becker proposes an enucleate cell such as the mature red blood cell could possibly reacquire its lost genetic material and then "dedifferentiate."

Stephen E. Straus, M.D.
Richmond Heights, Mo.

Dr. Becker responds:

I fear Dr. Straus missed the point mentioned in the legend for the illustration on page 36: ". . . in all vertebrates other than mammals . . ." I'm sure that he is aware that only the mammals have enucleate red cells; all other vertebrates have erythrocytes with nuclei that are fully competent, genetically speaking. Of course, no one can effect any such D.N.A.-determined transformations on the mammalian red cell.

It might not be amiss to comment that the mechanism described is a very useful one for organism survival: if the red cells in the blood clot at any injury site had the capacity to dedifferentiate and then redifferentiate with the cell type required, healing would be considerably expedited. We apparently have "traded off" this ability for increased oxygen transfer capabilities.

Hard Work, Small Reward

The lag in the supply of new engineers (see "Engineering: Prosperity Returns?" in "Trend of Affairs" for March/April, p. 73) is not due to waiting "for the message of manpower needs" to filter to students and their parents.

First, part of the manpower needs for new graduates is obviously to fill the jobs of older engineers whose yearly salary increases have compounded them out of a job. It would be comforting to say they were all "overspecialized" or "technically obsolete," but it is simply not true.

Secondly, it is a bit fanciful to link the words "prosperity" and "engineering" in the same sentence. The good vacations, the fine cars and houses in the nicer part of town are left to other professions. Raises, geographical location, and continuity of employment are usually at the whim of some larger institution.

My point is that young people can see these things for themselves, and if they can't, engineers will tell them (most people know at least one engineer). The message is simple: it's a tough, demanding course of study for very limited reward.

Milton I. Lillie
Stamford, Conn.

Can Marketing Aggregate the Environment Market?

Terry Rothermel's description of "The Profit Side of Pollution Control" (*January*, pp. 49-56) is a capable and usefully skeptical analysis, one which should be helpful to those contemplating investment in the pollution control industry. It is worth noting, moreover, that the tone of the article, to the degree that it is representative, confirms Natural Resources Counselor Earl Butz' contention that we have passed "the crest . . . of the environmental binge we're on." While we should doubtless be pleased that "we have markedly departed from the simplistic positions of environmental prophets," (p. 49) it is perhaps not out of place to remark that "the proper blend of technology and marketing" (p. 56) is closer to the narrow letter than the broad spirit of Earth Day.

For there can be little doubt that the environmental concerns of the last several years have included the feeling that the despoliation of our natural surroundings is more than *merely* a blemish to be excised by the most efficient technical means. As Langdon Winner noted recently, we feel the need to do more than set the standards of acceptability: "The point of the matter seems to be that the standards themselves must be open to question. . . . Our beliefs concerning the inherent beneficence of economic and (Letters continued on p. 80)

Watergate Bug Infects Technology

Washington Report
Victor Cohn

It is the time of the Watergate, and the spirit of the Water-bug in Larry O'Brien's telephone has infested all aspects of American life, including science and technology.

For at least the past 28 years, since Hiroshima, thoughtful citizens have warned of two dangers: the subversion of government by science and technology and the subversion of science and technology by government. The events of recent months, the revelations of the Watergate and all that has gone with it, tell us that both are happening—sufficiently, at least, to give us future warning; and possibly even more seriously, to imperil us now.

For all these revelations are shot through with the nastiest applications of some of our proudest sciences and cleverest technologies. The surveillance at the Watergate, the bugging and attempted bugging interrupted by arrests on the night of June 17, 1972—this was not just old-fashioned gumshoe surveillance but electronic surveillance. Another electronic device, the walkie-talkie, had been intended to prevent the arrests, and would have done so but for an unpredictable fluke.

A radio-equipped E. Howard Hunt was stationed in Room 419 of the Howard Johnson Motel on that night to watch the Watergate apartment and office complex and warn of any police. When an \$80-a-week security guard spotted some adhesive tape over a door-lock, removed it, returned later, found more tape, and alerted the police, the nearest squad car in the vicinity of Virginia and New Hampshire Avenues NW just happened to be an unmarked car manned by three plainclothes police.

They thus escaped Hunt's attention and radio-equipped electronic agent James McCord went unwarned; otherwise we would probably be ignorant still of not only this event but also the whole White House and White House-directed spying and sabotage apparatus that it represented.

U.S. political parties have often tried to plant operatives in the enemy camp to report inside plans, but none had ever been inside a campaign manager's telephone before, so far as we know. The difference, considering only technology, is like the difference between the long-bow and atomic bomb, to repeat a Hiroshima-era analogy. Consider now the imminent if not current advent of eavesdropping by the super-sensitive long-distance parabolic listening device aimed like a rifle, or eavesdropping by bouncing a laser beam off a window to pick up conversations by their vibrations, and the difference becomes the difference between the A-bomb and H-bomb.

Add the fact of a White House security

apparatus a la James Bond, dispatching its own agents, co-opting the aid of the F.B.I. and C.I.A., and you indeed bear out the warnings about 1984's Big Brother invading our lives. All in all, noted *Time* magazine, agents like G. Gordon Liddy and Hunt "set out with zest, technological skill and a mind-boggling indifference to the Bill of Rights."

Stretching the Boundaries

All this, we learned, started in 1969, shortly after President Richard M. Nixon took office, when what was later dubbed a White House "plumbers' squad" was first mobilized to seek out leaks of facts to the press and make some wiretaps on over-inquisitive newsmen and National Security Council officials suspected of being over-candid. What was that super-secret information that the administration in the spring of 1969 was so zealously guarding, causing it to give birth to this new presidential black squad that was later to be assigned to help re-elect the President?

It was in part the revelation in the *New York Times* of the fact that U.S. aircraft—again the multi-million-dollar products of our technology—had been pounding Cambodia with the acquiescence of Prince Norodom Sihanouk. In other words, our leaders were once again extending the boundaries of a war never declared by the Congress, and once again (in the spirit of Lyndon Johnson) using super-secrecy stamps to keep us from knowing or debating it.

Enter a Daniel Ellsberg with the conviction that the public should see at least some of the Pentagon's papers. He too employed a new technological tool indispensable to his peculiar kind of revelation: xerography. He did not "steal" the papers, so it might be maintained, he only copied them—and the legal difference still has not been resolved thanks to his mistrial caused by the government's further use of secret wiretaps, as well as highly sophisticated burglary on Mr. Ellsberg.

Enter a medical science to be subverted. A key to understanding Ellsberg—and thereby convicting him and blocking future pilferers, so it was decided—was to be a "psychiatric profile" such as those the C.I.A. regularly makes of foreign leaders. The C.I.A. ordered its director of medical services and chief of psychiatry to produce such a profile, and they did so, despite—so they have testified—their reservations; for this was to be the first C.I.A. psychiatric profile of a U.S. citizen.

To get input for the profile—or so it was hoped; it is still not clear at this writing whether or not this next caper produced fruitful results—the C.I.A. in the summer of 1971 provided the White House's secret squad with disguises, electronic gear, and cameras to help them burgle Ellsberg's psychiatrist's inner sanctum. In grand jury testimony, Hunt later referred to this as the "bag job on the psychiatrist's office," a tragicomic phrase worthy of only a Hunt or Art Buchwald.

Only a few weeks after we learned about this operation, we learned that Sen. Thomas Eagleton's medical record,



from the Newsletter of Computer People for Peace

"A future bag-job artist equipped with who-knows-what electronic tools."

telling of his 1960, 1964 and 1966 shock therapy, had been burgled too. There have been some suggestions that this job was originally pulled by the F.B.I. as part of the late J. Edgar Hoover's running file on American political officials. In any case, these records had finally reached the White House safe of John Ehrlichman, from whence they found their way into the 1972 headlines that sank Eagleton and damaged McGovern.

Let Congress Act

The everyday applications of this vast rat's nest of technological villainy are only too obvious. Health insurance companies, just to take one example, are already putting medical information on all their policy-holders into computer memory banks and exchanging such information through a central repository. How long before all our medical histories will be computerized, with access to anyone with the right code, no matter what "safeguards" are supposedly established? Safeguards might or might not keep the information on my bleeding bonkus from an ordinary prospective employer. They would surely be less effective against a future bag-job artist equipped with who-knows-what electronic tools, or maybe just payoff money and the Watergate-like indifference to the Bill of Rights that we know already pervades far too much of government and society.

One could go on to cite disclosures that collections of political and personal information on thousands of citizens have already been gathered by Army domestic intelligence agents, Congressional internal security committees and—increasingly—state and city police departments.

The last group, many of them newly furnished federal Law Enforcement Assistance Administration funds for computers in which to store this data, could potentially interface it with the F.B.I.'s National Crime Information Center. Persons close to this field think it would take a strict act of Congress, one not yet even being debated, to keep this from ultimately happening.

If this did happen, or if it has, we might not even know it. Ellsberg testified that government secrecy has already become so pervasive that there are now some 20 classifications "above top secret" (he himself, he said, possessed 12), though none is authorized by law and all have been set by mere executive regulation. This all amounts, Ellsberg claimed, to "a government of espionage cells" where there could "even be clearances the President doesn't know about" in a system that makes it "your duty to lie" when asked about such information.

On Daniel Ellsberg's say-so, this is not hard enough evidence. But at the least, the many-headed Watergate monster—once all its faces become clearer—should trigger an investigation not just of political espionage and dirty tricks, but of the whole, larger complex of federal secrecy and invasion of Americans' privacy.

This at the least. At the most we had better all ponder the accelerating trend toward impersonal and technologically-equipped government that growing world populations and speeded-up science seem to make inevitable.

Is there any antidote? There is none that is simple. Yet we might try one by one to create what humanistic psychologist Carl Rogers, asking the same question, recently called "a new value system" in which society's "new and powerful person"—small in number, perhaps, yet the change agent—could be each man or woman who shuns Watergate morality and is willing to think through and live by a better set of convictions.

Formerly Science Editor of the Washington Post, Victor Cohn now concentrates on major science-oriented reporting assignments for that newspaper.

Nuclear Relief for Natural Gas?

Peter Gwynne

In mid-May, at the time that engineers of the National Aeronautics and Space Administration were desperately trying to redesign the faltering Skylab mission, an event occurred that perhaps two years ago would have warranted just as much publicity as the precarious space endeavor. Three nuclear bombs, 30 kilotons of power each, were exploded simultaneously beneath the Rocky Mountains in northwest Colorado as part of an ongoing effort to determine the feasibility of using nuclear power to release the

natural gas more than a mile beneath the surface. If analysis of the test, which was codenamed Rio Blanco after the county under which it took place, shows the concept to be favorable, then the event will undoubtedly have a far earlier impact on the man in the street than Skylab.

Both supporters and critics of the nuclear mining business agree that economic acquisition of natural gas by this method will eventually require the explosion of many hundreds of underground nuclear devices; and because the nuclear lobby is promoting the concept as a short-term solution to the energy crisis such explosions are likely to come sooner rather than later.

Rio Blanco was the third of a series of blasts undertaken as part of Project Plowshare, the Atomic Energy Commission's effort to develop peaceful uses for nuclear energy. The two previous tests—Gasbuggy, in December, 1967, and Rulison, in September, 1969—were designed to study the basic technology for nuclear mining, and were set off in areas with relatively little natural gas. Rio Blanco, by contrast, involved an area in which the gas wells are present in profusion; it should therefore give an accurate estimate of the feasibility of the concept for production purposes—although neither the A.E.C. nor the CER Geonuclear Corporation that actually sponsored the test believes that gas from it will yield anything like the \$7 million that it cost.

Nuclear Escalation

From this point, the project will undergo a nuclear escalation. Next year or the year after, for example, engineers will fire five nuclear devices sequentially in the same borehole, to produce a much larger cavern than Rio Blanco. And eventually, according to a study by the Lawrence Livermore Laboratory, if any significant proportion of the 3 trillion cubic feet of natural gas locked beneath the Rockies is to be tapped, the nuclear industry will have to set off a mind-boggling 370 nuclear explosions annually until the end of the century—a rate, in other words, of one underground blast a day.

This prospect was understandably more than environmentalists could stomach, and in the year or so before the Rio Blanco test took place a strong protest movement against it was mounted in such centers as Denver and Boulder. To be sure, the critics indulged in little of the environmental doomsaying and legal posturing that had preceded previous underground nuclear explosions, such as Rulison and the A.E.C.'s massive blast beneath the Aleutian island of Amchitka in November, 1971. In the main, the opponents of Rio Blanco set their sights on the possible long-term effects of the tests and its successors, aiming as much to lay the groundwork for convincing protests against the future escalator by blasts as to halt Rio Blanco itself.

In fact this approach was the only sensible course for the environmental lobby. Before the Amchitka experiment the lobby had all but promised destruction of the islands ringing the Pacific, as a result of earthquakes and tidal waves

that would be caused by the blast; when nothing happened in the wake of the explosion it was clear that the A.E.C.'s critics had cried wolf once too often.

Furthermore, both the A.E.C. and CER Geonuclear had obviously learned from the Amchitka blast the value of good public relations. Before the Rio Blanco test they kept residents in the test area in touch with their plans through newsletters and lectures, and even invited them out to see the Las Vegas test site. The publicity worked to perfection; even though many of them had to leave their homes briefly on the morning of the blast, the locals were 100 per cent behind the Rio Blanco project.

The opposition to the test hammered away at two targets: the future hazards caused by Rio Blanco and tests to follow it, and the possible damage to other energy resources.

Water Contamination

One major point was made by geologist David M. Evans of the Colorado School of Mines, who argued that long-lived radioactive by-products of the underground tests might contaminate water from underground aquifers and eventually end up in drinking water taken from the Colorado River and its tributaries. The A.E.C. admitted that contaminated water would be present in the cavity formed by the blast, but noted that it would be covered by steam, which is a barrier to impurities. "We don't see any way for the radioactive substances to get up to the surface and into the water table", declared Dr. Edward Fleming of the A.E.C. Evans remained unconvinced. "If thousands of wells are detonated", he noted, "how can anyone say that water seepage will never occur?"

Other long-range doubts about the outcome of the test appeared less convincing. Thus, the AEC noted that housewives cooking with gas from a nuclear-blasted well would be exposed to less radiation than they would receive on a cross-continental flight, and geological experts tended to dismiss the possibility that a string of underground explosions could trigger major earthquakes.

For the politicians, perhaps the most compelling argument against Rio Blanco was concern that the test might damage the oil shales that lie directly above the blast site, some 1000 feet beneath the surface. Although currently impracticable as an energy source on both economic and environmental grounds, the shales are likely to become more attractive as the energy squeeze continues. Thus any possibility that they might be contaminated with radioactivity or destroyed by "spalling"—the effect of reflection of the shock wave produced by the triple blast from the surface—warranted serious consideration in energy circles. No damage of this sort seemed to occur in the test.

Overall, however, the most effective weapon against extension of Rio Blanco seems to be a general feeling that the A.E.C. is involved in the gas mining business for want of anything better to do with its nuclear devices. Having been turned down on such spectacular projects as nuclear canal building, the agency is virtually putting all its Plow-

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share eggs in the mining basket, and paying little heed to the non-nuclear alternatives. A good alternative does in fact appear to be on the horizon, in the form of a technology known as high pressure hydraulic fracturing. This is basically a more powerful version of the conventional hydraulic fracturing, designed to wrest gas from tightly bound formations such as those beneath the Rockies.

For the moment, it appears that the A.E.C. and the nuclear industry has won the first round of the battle. But the environmentalists have handled themselves more responsibly than in the past, and have laid firm foundations for future counter-attacks in what will inevitably become a long-drawn-out war. In the end, the result will probably depend on the public's feeling of how much nuclear pounding it can take. Rio Blanco offered relatively little threat to the local populace. But the industry and the A.E.C. will plainly have to check their homework thoroughly and perform a five-star public relations job to convince the public that hundreds of blasts occurring beneath them each year will represent a solid benefit with an utter minimum of danger.

Formerly Managing Editor of Technology Review, Peter Gwynne is now Associate Editor of Newsweek.

Plants and the Urban Ecosystem

Ruth S. Foster

Technology has altered the natural environment nowhere as completely as in the city. The urban ecosystem is a man-made series of relationships totally different from the farming-grazing-hunting areas originally inhabited harmoniously by man and plant.

The basic relationships upon which plants and animals depend have been changed. The city is a virtual desert of concrete, wind, and steel.

Yet plants—and even birds—can serve man predictably in this urban environment if their needs and sensitivities are understood.

Plants, especially trees, affect and ameliorate the climate. Condensation and air currents created by trees in summer can turn the hottest street into a city oasis. They can serve as windbreaks, and they use the pollutant CO₂. More trees would improve the air quality in cities where that is needed most.

More than any other single thing, trees—or their lack—make a city inviting—or de-

humanizing. Flowers add cheer, while shrubs and refinements of the landscaper add to the sophistication. But nothing takes the place of trees—the leafy canopy that brings the cityscape into human scale.

To bring living plants and animals successfully into this harsh new environment, we must understand the complex changes which are wrought by urban development.

Natural water circulation patterns are drastically altered, because surface drainage is made efficient and underground aquifers are not recharged. Water tables which nourished trees in time of drought are generally absent. The city habitat is essentially similar to the desert in terms of water runoff and drought between rains.

Urban climates are changed by industry and buildings. Particulate and chemical smog change the temperature and heat retention properties of the atmosphere and alter precipitation patterns. The expected "zone-of-hardiness" changes. The modified rainfall ultimately affects the water cycle of the entire area.

Wind buffets both plant and man on most urban plazas and long avenues. Indeed, the desiccating effect of wind is the severest test city plants must endure, especially evergreen. Hot afternoon sun pockets vie with dank northern corners as inhospitable city microenvironments.

Plant material adapts to a harsh environment or dies. Genetically suitable plants are necessary for urban environments. But a wider choice of greenery is possible if protective microenvironments such as courtyards and low walls are consciously created by planners and architects who understand the outdoor stresses that affect growth and survival.

Water—Too Much and Too Little

More plants die for lack of water in the city than for any other reason. The more surrounding stone and concrete, the more need for supplemental water. Young trees are especially vulnerable. A newly planted tree needs about 1" of rainfall per week, or a supplemental watering of 10 gallons. A two-ft.-square opening in the sidewalk hardly provides enough water to sustain a tree in good health. A better solution is an irrigation system that uses rain water instead of allowing it to run into already overloaded sewers. Even certain clean waste water such as washing water and some industrial wastes could be safely dispersed underground towards tree roots. New thoughts about water reuse are needed.

Often tree plantings are mounded when they should be concave to hold water. Grass rather than concrete highway center strips would help tree health. Roots of trees must breathe. Trees drown in constant puddles, or choke from compression. How many majestic trees can you count today that have been blacktopped right up to the trunks—a sentence of death by desiccation? A ring of stone (or brick set in sand) around such a tree would save it.

City soil is often clay, fill, or rubble. Usual planting procedures place a tree in



"More than any other single thing, trees—or their lack—make a city inviting—or dehumanizing."

a 3' deep hole with loam—enough to survive, but not to sustain optimal growth and long life. If such a hole is dug in clay soil the result is likely to be a non-draining tree pit, requiring either drainage or a plant variety that tolerates wet feet. Proper tree pits should be incorporated into building and street plans and filled deeply with good soil.

Reflected sunlight from masonry walls and walks intensifies to desert-like heat. Especially when it is coupled with the wind tunnels that city streets often provide, the drying effect is serious. In addition, sun scorch is a common winter injury. These problems can be avoided by providing artificial shade and utilizing—in the case of sun scorch—the lower angles of the winter sun in northern latitudes.

Soil that has been compacted by machines will not allow for proper root penetration. Physiologically a tree is supported by the air and water near the roots. Trucks driving over the roots of established trees will kill them. Compacted soil supports nothing.

Trees respond to sound and pressure waves, though the question of how this occurs is but a clutter of unscientific opinions. Constant vibration damages plant material, whether it be blasting, drilling, rumbling trucks, or swinging children.

Insects and Diseases

Because the city ecosystem is technologically created, the natural insect balance is non-existent. New landscaping in areas previously devoid of vegetation suffers from what pests are brought in with the new plants or soil, and there is

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