AIDS Research Update

21st CENTURY SCIENCE & TECHNOLOGY

May-June 1988

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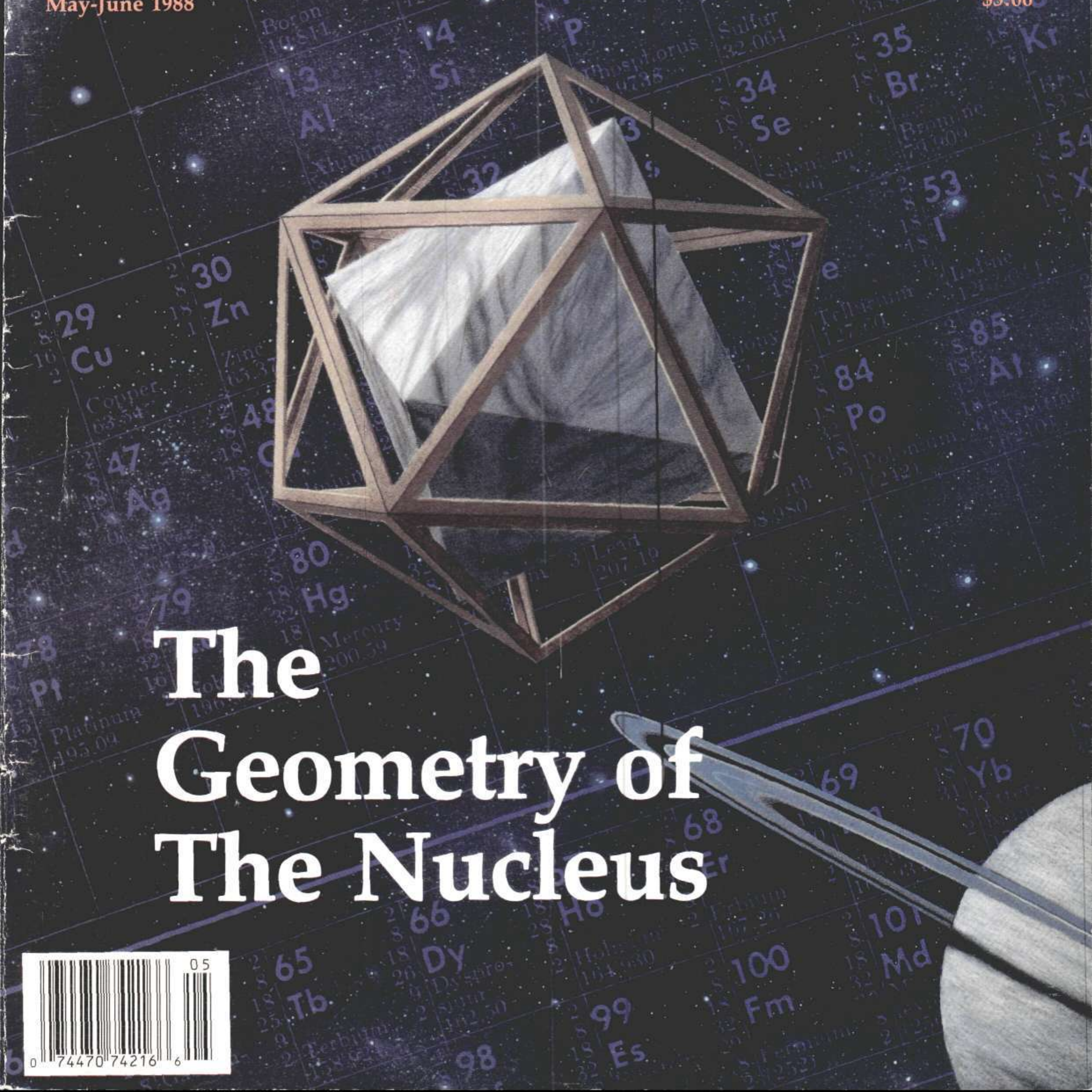

The Geometry of The Nucleus

21st CENTURY SCIENCE & TECHNOLOGY

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Features

News

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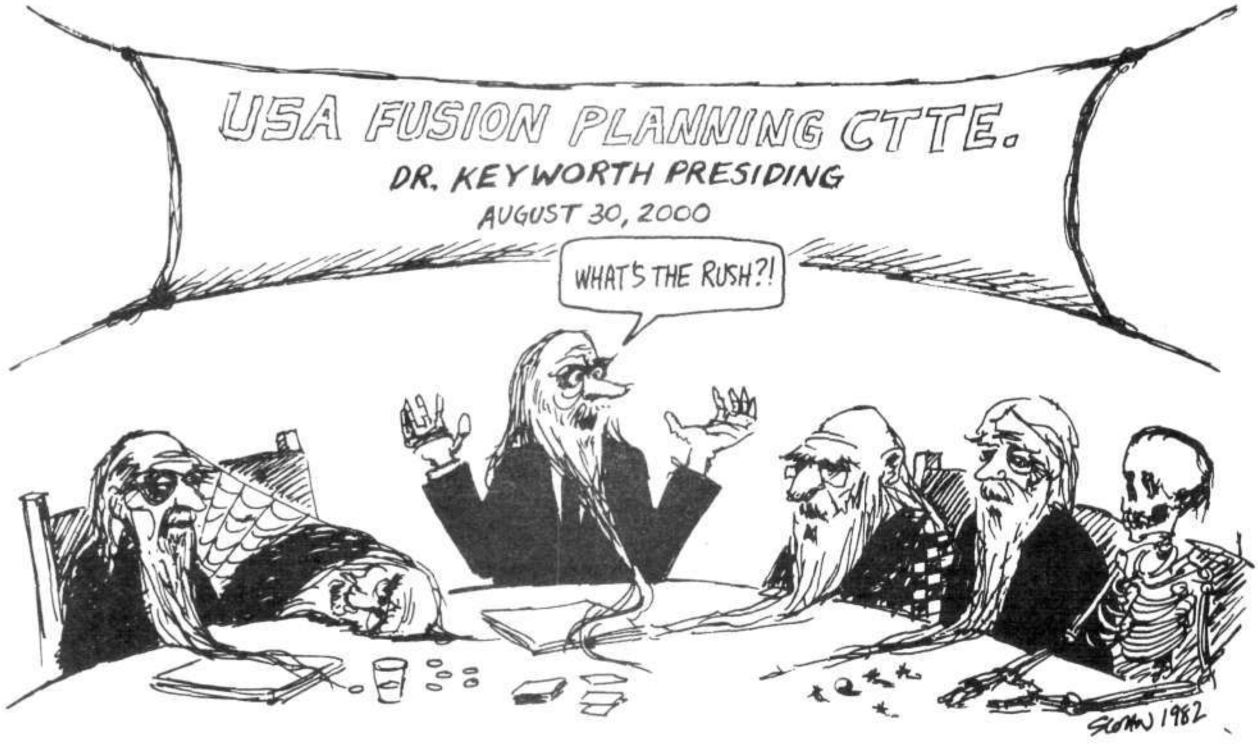
On the cover: Illustration by Christopher Sloan of an octahedron nested inside an icosahedron, as described in the geometric model for the nucleus proposed by Dr. Robert J. Moon.



An American Century?

In the 19th century, the crucial distinction between the United States and the nations of Europe was the versatility and technological competence of the American workforce. Starting with a broad base of literacy, the economy was characterized by its dependence on capital-intensive investment. A whole continent was there to be developed, and human labor and skills were at a premium.

In the 20th century, the nation accomplished the leap from colony to superpower. Although the century began with historians like Frederick Jackson Turner complaining that America had lost its pioneering spirit, under President Kennedy the nation reaffirmed that there could always be a new frontier. He defined a national mission—to land an American on the Moon within a decade—and reasserted the basic values that made this nation great.

We had barely started the program to land on the Moon when the space program was cut back. With the murder of President Kennedy the United States indeed suffered a grievous blow.

This nation was created and dedicated, in the words of Tom Paine, as a "Temple of Liberty and Beacon of Hope" to all the world, including future generations. We were meant to be a nation that could accomplish the impossible—a vision that in the past 25 years has been progressively dimmed.

President Reagan was elected to office eight years ago by a constituency that supported a strong defense and advanced technologies and rejected the environmentalist policies of the Carter period. Unlike Jimmy Carter, President Reagan gave the country hope. He committed us to do great things. He said in 1981 he would see to it that the nuclear industry was back on its feet. He committed the nation to the Strategic Defense Initiative in 1983. He committed us to deploying a space station by the year 1994; and after the Challenger disaster, he committed us to developing the aerospace plane.

Unfortunately, belief in the magic of the marketplace, radical free enterprise, and an economic "recovery" that is a hoax meant that he could not follow through on these commitments. In the main, President Reagan's two terms of office have not provided a favorable climate for science, as this brief summary shows:

Defense and SDI. Because the administration's misguided policies destroyed our ability to do even those things we had done in the past, such as launch large payloads, the Air Force could not launch an important surveillance satellite for a year and a half. The SDI has had to postpone or cancel most of the tests it planned to conduct in space.

Certainly, the SDI has stimulated advances in laser technologies, computers, and areas in electronics associated to the development of advanced sensors. Nonetheless, other areas of high technology have been stifled for lack of funding, the direct result of the administration's irrational policies.

Energy. President Reagan's policies destroyed the U.S. nuclear industry and research and development—something Jimmy Carter tried to do for four years but failed. When Reagan was elected, there were about 100 nuclear power plants under construction or planned. Only a few of those plants have operated since then. The rest were canceled or "mothballed"; the projects were killed by high interest rates and by the Nuclear Regulatory Commission.

The administration also blocked implementation of the Magnetic Fusion Engineering Act of 1980, displaying contempt for Congress. And then, after the President had removed support from efforts to make the U.S. energy independent without fossil fuels, he refused to protect the domestic oil industry from import competition from the Ayatollah Khomeini.

Space. President Reagan allowed opponents of the space program within the Justice Department to tar and feather the administrator of NASA, James Beggs, driving this competent and innocent man from office. The administration then appointed an incompetent man, Dr. William Graham, to head the agency for reasons of political patronage, and Graham made the wrong decisions, resulting in the Challenger disaster. Graham has since been promoted to Presidential Science Advisor.

Medicine and public health. At the same time, President Reagan has presided over implemention of the most reactionary policy in medicine and public health in the history of this country. His administration has lied to the American people about the danger of infection from the virus that induces AIDS, and, "to save money," the administration has neglected to fund the necessary scope of research to find a treatment or to develop a vaccine against it. Now that more than 4 million U.S. citizens are infected, the President seems interested only in selling the National Institutes of Health to "private investors" who would tear it apart, and with it, a good deal of the nation's capability to fight AIDS.

The Fusion Example

What President Reagan and his advisors did to the fusion program is a good example of his bad policy. He took office only months after Congress had passed the Magnetic Fusion Energy Engineering Act of 1980 in a nearly unanimous vote. The law mandated construction and operation of an engineering test reactor fusion power plant by the year 1990 and a commercial prototype reactor by the year 2000. This fusion engineering device would have produced net fusion power, but the Reagan administration refused to fund it.

Reagan's science advisor, Dr. George Keyworth, said privately that he was opposed to implementing the fusion law because going ahead with fusion engineering "would destroy fusion as a science program"! Then he announced publicly that the date for achieving commercial fusion power had to be postponed until 2050 for budgetary reasons. In defiance of a law Congress passed nearly unanimously, Keyworth announced that the world "does not need a new energy source by the end of this century."

By 1983, Reagan's policy was surrendering leadership in the development of fusion energy to Japan, thus fulfilling Keyworth's litany that the United States does not have to be first in the world in science and technology. In 1985, taking Keyworth's advice, Congress began cutting the fusion budget.

At the same time, the White House suppressed a report by a distinguished panel of scientists that concluded that there was "no physical reason" that inertial confinement fusion could not soon be achieved. The House Armed Services Committee had mandated that the Executive branch carry out a review of the civilian inertial confinement fusion program in its 1986 appropriations bill, but when Keyworth received this mandated report in July 1986 he decided not to release it.

This report saw the light of day only after Dr. Stephen O. Dean, president of Fusion Power Associates and a member of the advisory board of *21st Century*, demanded its release under the Freedom of Information Act.

Keyworth's so-called pure science philosophy also delayed initiation of the space station program for three years. NASA Administrator Beggs had called for a space station at his confirmation hearings in 1981. Keyworth's answer was that we did not need men in space, that a space station would be "a mistake" and "a step backward"—and that it would be nothing new anyway, because the Soviets already had one.

Although President Reagan went against his advisors and initiated the space station program in 1984, he has allowed it to be halved in size and postponed in time because of budget constraints. The level of funding for the program, including the 40 percent congressional cut from NASA's request for this year, has stretched out the schedule by at least two years, and downgraded the capability of the original station.

The problem of our commitment to extending the technological frontier cannot be viewed in isolation. As Marsha Freeman documents in this issue in her feature on the Soviet space program, while the United States is lagging behind, the Soviets are resolutely pushing ahead.

What this country needs to get out of the present economic recession is precisely the kind of investment that President Reagan is fearful of making. Not only should the space station be completed according to its original design and schedule, but we can—and must—do much more. Just as we were able to meet President Kennedy's goal successfully and land a man on the Moon in the span of one decade, so we can meet the schedule proposed by the National Commission on Space to get back to the Moon and to establish a U.S. colony on Mars in the next 40 years.

The 20th century was sometimes known as the American century. The decisions that we, as a nation, make over the next year will determine if the 21st century is to be a Russian century.

The Lightning Rod

My dear friends,

Build a better Mouse Trap, and the World will beat a path to your door.

In New Hampshire, it was decided to build such a Mouse Trap. In design, it was by far the best that had ever been conceived. It featured a self-baiting device offering the mouse, not mere Cheese, but a "Total Pleasure Environment"—analagous in its effects to those sun-and-sand-filled tourist spots featured on winter television commercials. Of course, since no human was required to risk his fingers setting a spring and baiting the Trap, it was also much safer and cheaper than the old-fashioned "cheese-fueled" Mouse Trap.

But despite great initial Enthusiasm *for the trap, certain persons had Objections.*

"We've never done this before," they said. "What if the Total Pleasure Environment turns out to be *dangerous* to other living creatures?"

They announced the formation of a "citizens' action group," which called itself "The Fabulous Furry Freak Brothers and Sisters." They surrounded the Mouse Trap Site and blocked access. They received *environmental service*

awards from the ambitious Governor of a neighboring state. They wrote movie scripts and lobbied Washington. Hollywood benefits were held. *Laws* were passed.

Teams of gerbils were sent in to do Daily Inspections. Hamsters, chipmunks, and Ralph Nader filed *class action suits*. Governmental commissions were created and dispersed. *Emergency evacuation plans* for all Woodland Creatures were drawn up. The now-famous Governor of the neighboring state appointed several Furry Freak Brothers and Sisters to his staff.

It took years longer and cost *much more than planned* to complete the Better Mouse Trap.

When it was finally tested, the Trap was a great success. Many times more powerful than the now obsolete "cheese-fueled" trap, it proved irresistibly attractive to the mice, who lined up in orderly rows for the privilege of being quickly and painlessly disposed of by this Superior Product. No gerbils, chipmunks, or other Woodland Creatures were injured by the Trap.

But now opponents had a *new argument*.

"It is not cost-effective," they complained. "We could have built an old-fashioned trap for much less. Anyway, demand is falling—there are fewer mice."

The proprietors of the Trap, the Public Service Utility Trap Co. of New Hampshire, tried to point out that this might have something to do with the rate at which mice were being efficiently disposed of, in tests of the Better Mouse Trap. In vain.

"It's too dangerous!" the opponents cried. "It's too costly! *We've never done it before!*"

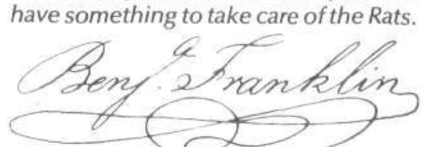
Still, it seemed as if the trap would finally open, provided the utility company were granted a rate increase. Alas, one day there was a terrible accident—two matched pairs of Yuppies wandered into the Mouse Trap by mistake. And before you could say "BMW," the Total Pleasure Environment had subjected them to brain-wave effects evaluated by safety experts as equivalent to those of a year at Club Med.

A tumultuous hue and cry went up. The Governor of the neighboring state, citing one of the numerous laws passed at the behest of the Fabulous Furry Freak Brothers and Sisters, refused to

approve any evacuation plan for Yuppies, thereby stalling the Trap's opening. The rate increase was denied.

Finally, the Public Service Utility Trap Co. of New Hampshire filed for bankruptcy. The next day, four out of five respectable liberal newspapers and all three national television networks declared Governor Rat the frontrunning candidate for President.

Moral: Go ahead and build a better Mouse Trap, but make sure you also have something to take care of the Rats.



NEWS OF
THE FUTURE

50 Years from Now

May 5, 2038, WASHINGTON, D.C.—The National Academy of Sciences hosted a reception here today for its "over 125" division. The event celebrated the opening of a special exhibit, "50 Years of Science," that documents the life and work of the division's working scientists in several fields. Several "over 125s" took part in a simultaneous gathering on the Moon.

100 Years from Now

May 5, 2088, MARS—The park areas of Mars burst into bloom this week with a profusion of spring flowers. This is the first outdoor flower display, made possible by the newly installed artificial atmosphere, held in place electromagnetically over the entire colony. The highlight of the display is a new tulip, "Martian Red," developed especially for the colony.

Editor's Note. Readers are invited to contribute to this column. Please limit entries to 100 words for each item. Contributors whose entries are printed will receive a gift subscription to *21st Century*.

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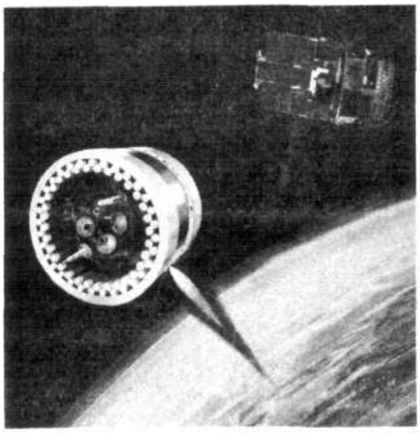
NEWS BRIEFS



U.S. Air Force

Canceled: Artist's concept of the miniature Air Force ASAT vehicle as it closes on the obsolete U.S. Solwind satellite during a successful ASAT test in September 1985.

U.S. SATELLITES ENDANGERED BY CANCELLATION OF ASAT PROGRAM

The cancellation of the U.S. antisatellite (ASAT) program was announced by Secretary of Defense Frank Carlucci in mid-February as a budgetary measure. Congressional opponents of the ASAT program have tried to justify the cuts by saying that the Soviets ASAT program is crude and can only hit U.S. satellites in low-Earth orbit, less than 300 miles up, while U.S. communications, reconnaissance, and early-warning satellites are higher up. However, as documented in this issue (page 44), the Soviets can use the new Energia superbooster to put their ASAT program into high-Earth and geosynchronous orbits, making all U.S. satellites vulnerable—and now without any threat of retaliation.

U.S. STUDENTS RANK VERY POORLY IN SCIENCE

Students in the United States in the fifth, ninth, and twelfth grades perform poorly in science compared to their counterparts around the world, according to the results of an international science survey released Feb. 29 by the National Science Foundation. U.S. fifth graders ranked 8th among 15 countries, ninth graders placed 15th in a field of 16, and seniors placed last out of 14 countries, with an mean score of 37.9 percent. Advanced chemistry students placed 11th and second-year physics students placed 9th among 13 countries.

INFANT AIDS INFECTIONS HIGH IN NEW YORK CITY

One baby in every 61 in New York City is born infected with the AIDS virus, according to recent tests by New York State health officials. The blood of 19,157 infants—every infant born in New York State during a month-long period beginning in late November—was tested for AIDS antibodies. Of 9,047 born in New York City, 148 carried antibodies to the AIDS virus. Statewide results varied from 1 in 43 babies infected in the Bronx, to 1 in 749 infected in upstate New York. A related study of anonymous blood samples found about the same proportion of women infected as babies who tested positive for the antibodies.

State Health Commissioner Dr. David Axelrod called the results of the baby study "alarming," and wrote physicians in the state that "the implications of these findings warrant immediate attention."

NASA

NASA's Space Telescope is a 10-ton unmanned optical telescope that will enable scientists to see seven times farther into space than is now possible.

HIGHER ORBIT FOR HUBBLE SPACE TELESCOPE UNDER CONSIDERATION

Because the Hubble Space Telescope (HST) will now be launched near the 1991 solar maximum, placement in a slightly higher orbit is under discussion, according to NASA officials. The 11-year maximum in solar magnetic activity causes Earth's upper atmosphere to warm and expand slightly, increasing the drag on a satellite in orbit at 320 nautical miles, where the HST was to be put. The increased drag would degrade the telescope's orbit, impairing pointing accuracy and posing the danger of reentry. Occasional reboosting has been part of the plan for HST from the beginning, but with launch at solar maximum—instead of minimum as originally planned—a reboost would be required within one year. Meanwhile, some scientists think the coming maximum may be like the last one—the worst in recorded history. A small increase in orbital distance—such as 10 nautical miles—would make the difference.

"The Shuttle is capable of this, but it does limit our options," said Al Boggess, Associate Director of Sciences for Space Telescope. "You need reserve fuel to station-keep the Shuttle and the HST. My impression, however, is that the present upper limit of 320 nautical miles is a conservative one. We are discussing this with the Johnson Space Flight Center. At 330 miles, when the orbit did begin to degrade, the atmosphere would already be shrinking again," he added.

DIXY LEE RAY ATTACKS GOV. DUKAKIS FOR SABOTAGING SEABROOK

Former Washington state governor Dixy Lee Ray lambasted Massachusetts governor Michael Dukakis for sabotaging the Seabrook nuclear power plant in New Hampshire. Ray, a former chairman of the Atomic Energy Commission, stated: "The Seabrook nuclear power plant has not received a license largely because Dukakis has refused to allow Massachusetts to take part in the emergency planning required by federal regulators. If he had cooperated, the plant would be operating today; it would be reducing our oil imports by 10 million barrels a year; the cost of the plant would be millions of dollars less; and Public Service of New Hampshire would be solvent, if not prosperous." Ray's remarks were made in a letter to the editor of the *Seattle Post-Intelligencer* Feb. 14, commenting on the paper's coverage of the issue.

"A secure supply of electricity is vital to the economy of New England," Ray said. "Its eight nuclear plants avoid the burning of over 50 million barrels of oil every year, and supply New England with one third of its electricity. Nuclear plants have been operating safely there since 1960. Electric power demand in New England is increasing faster than the national average, and without nuclear energy the only real options are more imported oil and Canadian electricity. Both hurt our balance of payments and each has a security of supply risk.

"It is distressing that an elected official—one who is presenting himself as a presidential candidate—would not only drive a company into Chapter 11, but more important, take such a dangerous attitude toward our need for energy and economic security."

Dixy Lee Ray: "It is distressing that an elected official . . . would . . . take such a dangerous attitude toward our need for energy and economic security."

SOVIET UNION INFANT MORTALITY RIVALS THAT OF THIRD WORLD

Infant mortality statistics published by the Soviet government late in 1987 reveal that Soviet infant mortality on average is worse than in some developing nations. The Soviet official mortality rate is 25.6 deaths per 1,000—on a par with Paraguay and Thailand. However, according to Soviet pediatrician Dr. Vyacheslav Tabolin, a member of the Soviet Academy of Medical Sciences, the actual rate is at least 30 per 1,000. One way the statistics are lowered is by recording the deaths of infants 10 and 11 months old under the category of 13-month-olds, thus taking them out of the infant category.

The figures for Muslim republics outside of Russia are even worse. For example, in 1986, the death rates per 1,000 live births in the Uzbek, Tajik, and Turkmen republics were 46.2, 46.8, and 58.2, respectively.

Infant mortality rates in these three republics have worsened since 1970.

NEW JERSEY GOVERNOR REFUSES TO BAN SALE OF IRRADIATED FOOD

New Jersey Governor Thomas Kean vetoed a bill approved by the state legislature Jan. 7 that would have banned the sale of irradiated food in the state. The legislative debate was characterized by an abundance of environmentalist lies and antinuclear fears. However, the governor had said he would not sign the bill if the state health department recommended against it, and apparently the scientists in the health department prevailed.

Among those counseling Governor Kean to veto the bill was Dr. B.P. Sonnenblick, the author of New Jersey's radiation protection law. Sonnenblick told the governor that 30 years of testing on animals had demonstrated no ill effects. Sonnenblick characterized the anti-food-irradiation environmentalist groups as "Luddites, similar to the antiscience mob which burned the house of physicist Priestley" in the 1790s.

Council on Radiation Applications

Low doses of radiation can destroy trichinae in pork, extend the shelf life of strawberries, delay spoilage of shrimp or maturation of mushrooms and broccoli—all without changing the flavor of the food or affecting its nutritional quality.

Let's Tell the Truth About Pesticides

Dr. J. Gordon Edwards

For the past 25 years, irrationality not scientific fact has prevailed on the pesticide issue, and the individual consumer has been the loser. Those spreading fear are not just the environmentalist groups who made their reputation by banning DDT and other life-saving and cost-saving pesticides, but also some overzealous scientific groups with political motives.

The problem is typified in a report by the National Research Council of the National Academy of Sciences that calls for restrictions on the use of agricultural chemicals, allegedly because such chemicals are tumor-causing. Released in May 1987, the report is a "worst case analysis" of the type that was abolished by the White House's Council on Environmental Quality in 1986.

The Council on Environmental Quality had determined that only "reasonably foreseeable" effects that are supported by "credible scientific evidence" should be considered in federal reports, and not "worst case" scenarios that breed endless debate and speculation. Unfortunately, the National Research Council ignored this call for a return to the rule of reason, and instead produced a report based on fantasy rather than fact.

Worst Case Scenario

The Research Council report lists specific pesticides that may be detected in some agricultural products by means of extremely sensitive analytical equipment. If the council had simply studied adverse human reactions associated with the application of agricultural chemicals on crops, its report would have been very reassuring and would not have provided any frightening headlines.

Instead, the Research Council devised a computer program that calculated the total U.S. acreage of each crop studied and then assumed that every one of those acres would be treated with the maximum legal amount of *all* pesticides approved by the Environmental Protection Agency for use on each crop.

Since every crop is threatened by more than a single species of weed, mold, mite, insect, and nematode, many different herbicides, fungicides, acaricides, insecticides, and nematicides are registered for each. The Research Council computer was padded with the maximum allowable volumes of *each* of these registered pesticides for the crops studied, all at the same time! No crop has ever been treated with such massive amounts of pesticides.

Usually only one pesticide is applied for each kind of serious pest per year, and then only if it appears essential! The California Tomato Growers Association keeps careful records of pesticide applications by its growers. The association reported that *"no pesticides"* were used on more than 70 percent of the tomato acreage in the state, and that no single insecticide was used on more than 40 percent of the total acreage. The National Research Council's calculation of the amounts of pesticides applied per acre of tomatoes was therefore sheerest fantasy!

The Research Council's computer program was also fed unreal figures regarding the amount of pesticides in the food that people consume. The computer program assumed that the maximum allowable levels of *every* pesticide registered for use on each food crop *would* be used, and that large proportions of each would be present in *every* bite of that kind of food eaten during the entire lifetime of each person.

Every actual sampling of pesticide residues in commercial foods belies that ridiculous assumption. In California, thousands of food samples are analyzed each year by the state. In 1986, more than 84 percent of the samples contained *no* detectable pesticides, and less than 1 percent had any illegal residues. ("Illegal" means either that a pesticide unregistered for that crop was present, or that a registered pesticide was present at a level exceeding the allowable tolerance level.)

The Research Council computer program further assumed that every person in the United States ingests all of the 15 kinds of foods studied by the council *every day* throughout his or her entire life. Presumably the council anticipated that every day each person eats tomatoes, potatoes, apples, peaches, grapes, oranges, lettuce, beans, carrots, soybeans, corn, wheat, chicken, beef, and pork.

The computer then multiplied the legal maximum tolerance level of each chemical in each of these foods by the U.S. Department of Agriculture's calculation of the number of milligrams of that food consumed, per kilogram of human body weight. That multiplication yielded a "Theoretical Maximum Residue Contribution" or TMRC.

For each specific chemical, the TMRC figure was then multiplied by a hypothetical "tumor potency factor." The resultant figure was considered as the "risk of excess tumor development" posed by that particular chemical during a citizen's lifetime.

Based on the false assumption that we all eat all 15 foods every day and that all allowable pesticides are used to the maximum on each crop, the Re-

J. Gordon Edwards, professor of entomology at San Jose State University in California, has taught biology and entomology there for 39 years. He is a long-time member of the Sierra Club and the Audubon Society, and is a fellow of the California Academy of Sciences. His Climbers Guide to Glacier National Park *was published by the Sierra Club, and many of his articles on birds have been published by the Audubon Society and other environmental groups.*

search Council cranked out a hypothetical estimate of the "Worst Possible Estimate of Oncogenic Pesticide Residues in Food." That estimate, it asserted, indicates the total combined amounts of pesticides, calculated as the TMRCs of *all* registered pesticides from *all* major foods eaten during the lifetime of *all* U.S. residents. According to that "worst possible case" scenario, the Council concluded that pesticide residues in our food could cause up to 20,000 excess cancer deaths a year.

More realistic calculations, based on actual levels of pesticides in the actual amounts of food eaten by people every day, were not studied by the National Research Council. When those realistic data are considered, they indicate that there are *zero* excess cancer deaths a year attributable to legally applied pesticides on crops. Dr. Arthur Upton, a member of the Research Council study group, has in fact stated, "Pesticides are not presenting the American population with a major health hazard."

The Infamous Delaney Clause

Although the Council report refers to "oncogenic pesticide residues in food," and relies upon the 1954 Delaney Clause of the Food, Drug, and Cosmetic Act as the reason for restricting pesticide use on crops and in our food, there was actually no mention of "oncogenic" hazards in the Delaney Clause. The clause states, *"that no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal."* Notice that the infamous, shoddily written clause referred only to "food additives." Pesticides applied to crops were specifically excluded from its provisions!

The general counsel of the Department of Health, Education and Welfare at the time quickly pointed out that "the Delaney Amendment does not apply to pesticidal chemical residues in raw agricultural commodities or in foods processed from lawful crops."

The Environmental Protection Agency has frequently observed that the Food, Drug, and Cosmetic Act specifically allowed for legal limits of agricultural chemicals and their by-products to be present in food. These legal limits are referred to as "tolerance" levels permitted for each crop/pesticide combination. The legal tolerance is usually at least *100 times less than the amount that experimenters have found to have no effect on animals.*

The most important words in the Delaney Clause are ignored by the antipesticide activists and are usually omitted from media references to the clause. Those words are *"tests which are appropriate."* Tests on animals using dosages hundreds of times greater than they could ever encounter in real life are certainly *not* appropriate. Even worse, the chemicals have frequently been administered in totally unnatural, inappropriate ways, such as saturation, intravenous injection, fetal intubation, gavage, and so on.

The Tumor Fraud

The Delaney clause specifically referred to additives that induce "cancer," which was defined at that time as a malignant growth with the tendency to spread to other parts of the body. "Tumors," on the other hand, were nonmalignant growths that do not spread and that often disappear after the massive chemical insults are terminated. (The Food and Drug Administration had defined carcinogenic substances as "those that cause *cancerous* tumors.")

In 1976, to make it easier to invoke the Delaney Clause as an excuse for banning pesticides, Environmental Protection Agency administrator Russell Train, an attorney, redefined "cancer" and "tumor." Train stated that "for purposes of carcinogenicity testing, tumorogenic substances and carcinogenic substances are synonymous."

Leading scientists objected to this unscientific ploy. For example, Dr. Carroll Weil of the Carnegie Mellon Institute wrote, "The main point of contention [regarding the Environmental Protection Agency's cancer policy] is the unacceptable redefinition of 'tumor' to mean 'cancer.' " Despite scientists' opposition, the EPA deleted the words "carcinogenic" and "tumorigenic" from their rulings and began using the word "oncogenic" to designate substances that caused *either* cancerous or benign tumors in test animals.

The word *oncogenic* was then considered sufficient to justify the banning of pesticides by simply invoking

Continued on page 11

ESTIMATED U.S. FOOD LOSSES WITHOUT PESTICIDE USE

Crop	Percent Loss
Wheat, Great Plain	70
Soybeans, south	50
Corn, corn belt	60
Apples, north	100
Potatoes, northeast	100
Melons, Calif.	45
Lettuce, Calif.	96
Strawberries, Calif.	94
Cole crops, Calif.	95
Tomatoes, Calif.	70
Sorghum, Tex.	50

Source: Dupont Agrichemicals Section, 1979

Crop diseases, insect plagues, and weed pressures even with today's level of crop protection, still claim one-third of the world's potential food harvest. In underdeveloped countries, the losses can be as high as 90 percent.

CHEMICALS INCREASE CROP YIELD

Despite the "organic farming" propaganda, chemically protected crops produce greater, higher quality yields. In one "carrot project" demonstration in Monterey, California, farmers showed in adjoining plots the following yields:

No chemicals, not weeded	1.05 tons per acre
No chemicals, hand weeded	1.47 tons per acre
Treated	21.30 tons per acre

A Venture Capitalist Approach to Development

by Ramtanu Maitra

An Indian venture capitalist from Chicago has managed to cut through India's vast bureaucracy to upgrade the nation's communications system. Working for just 1 rupee a year, Sam Pitroda has shown that India can break out of a situation where it has the third largest pool of scientists and engineers (after the Soviet Union and the USA), yet 70 percent of its population is still trapped in subsistence agriculture. Although the country has had an admirable buildup of indigenous R&D capabilities since independence, this has not had the necessary qualitative impact on economic development.

This is a problem whose solution is at the top of Prime Minister Rajiv Gandhi's agenda for India, and one that has prompted the launching of five "technology missions" over the past 18 months charged with making breakthroughs in *drinking water, oilseed production, eradication of illiteracy, immunization of children, and telecommunications.*

The "mission approach"—targeting a specific area in applied science where real gains can be made with a relatively short, concentrated application of human and financial resources—is clearly intended to break through the inertia built up and carefully maintained by a highly politicized government bureaucracy that has operated for years as a chain of fiefdoms.

Linda de Hoyos

India's technology mission to eradicate illiteracy "with the support of all available information technologies and improved pedagogical inputs" was announced in March 1987. As of the 1981 census, India's literacy rate was only 36 percent, in spite of a constitutional mandate that all children up to the age of 14 must have free, compulsory education. Above, children at Sunni University in Lucknow.

The telecom mission is exemplary. It started in 1984 with government approval of a proposal by the nonresident Indian telecom engineer, Sam Pitroda, to bring Indian telecommunications up to world standards in 10 years, indigenously. At age 42, Pitroda had 19 patents and several multi-million-dollar high-tech businesses in Chicago to his credit, but had nurtured a dream to accomplish something in India.

The Telecom Mission

Pitroda proceeded to put together a new R&D facility, the Center for Development of Telematics (C-DOT), with a first-stage budget of $3 million and a three-year mandate to design a range of electronic switching systems for the country.

It has turned out to be a critical test case, challenging nearly 40 years of government policy and practice in India's telecommunications sector. Government takeover of the Bombay Telephone Company in 1943 brought the visionary scheme of its general manager to set up an Indian industry for the manufacture of telephones and telephone exchange equipment under government control.

Within a few months, political maneuvering from Delhi had pushed the technically qualified individuals out and filled all the chairs with civil servants with no experience in industry. A mid-1960s initiative in telecom R&D was similarly smothered. Meanwhile, the 1956 Industrial Policy Resolution brought all telephone equipment manufacture under government control.

Ever since, the telecom bureaucracy has carefully tended its power and privilege as gatekeepers for foreign concerns that since 1975, at least, have been unloading $80-$100 million worth of foreign-made equipment—which could have been made here—into India every single year.

The result? Today, after more than 30 years, there are a mere 3 million telephones in India to service a population of 750 million. Since 90 percent of those are in the cities, where only 25 percent of the population lives, 300,000 phones are left for some 560 million villagers to share.

There are only 36,000 public telephones, most of which get only local numbers, in the entire country. Moreover, at any given time, 4 out of 10 phones don't work in Delhi; 7 out of 10 in Calcutta. There were other side effects, such as India's failure to develop an electronics industry.

Pitroda was convinced not only that India had to build its telecom network indigenously, but that it was eminently feasible. Moreover, he argued, without extensive rural communication, no real development and modernization of the country could occur. The broad mission he outlined aims to have 30 million lines and 3 million public phones by the year 2000, with at least one reliable public telephone and telex and one data terminal per village by 1995. It will also build up infrastructure for a single national telematics network, and digitize the network.

Panicking the Timeservers

But if Pitroda's brash, can-do spirit seemed to make him an easy target in the snake pit of Delhi's court politics, his success has panicked the timeservers. The fact that the 375 young engineers Pitroda organized at C-DOT actually delivered the new switching systems technology they promised—within the timetable and *under* cost—ought to make it clear that the game is up.

And since Pitroda has just been quietly appointed the prime minister's adviser with ministerial rank, responsible for *all* the rest of the technology missions, the lessons of the telecom mission will not end there. The myth in India that things must be as they are and always have been has been shattered in a way that promises far-reaching effects.

Ramtanu Maitra, a nuclear engineer, is the editor-in-chief of the magazine Fusion Asia.

Viewpoint

Continued from page 9

the Delaney Clause!

In a deliberate and grotesque misinterpretation of the Delaney Clause, the National Research Council report has now used "oncogenic" in that same manner, in order to hasten bans on many kinds of chemicals. Thus, opponents of agriculture have succeeded in preventing the legal establishment of tolerances for new pesticides, by requiring that they fulfill the current misinterpretations of the Delaney Clause. The Research Council now urges that previously registered crop pesticides (which are *not* food additives) be stripped of registration if they do not fulfill the Research Council's distorted interpretation of the Delaney Clause.

What will be the ultimate effects upon the nation's food supply if the will of Congress is subverted by this attempt to "trash" the Delaney Clause? Will the National Research Council's capricious and unsupportable "risk estimates" result in the banning of essential and perfectly safe agricultural chemicals? If so, what harm will that bring to the agricultural industry here and to the "balance of trade" worldwide?

Hopefully, the specter of lowered farm output, more costly produce, and burgeoning world hunger will cause consumers and legislators alike to reject the misleading National Research Council report and demand government actions based on legitimate, realistic estimates of risk, rather than "worst case estimates" with no substantial base of support.

Compact Ignition Torus Put on Austerity Budget by Congress

by David Cherry

Magnetic fusion energy development was all but strangled by Congress in January 1988, when conferees of the House and Senate appropriations committees agreed to authorize only $8 million to initiate construction of the Compact Ignition Tokamak (CIT).

This bare-bones budget for fiscal year 1988 was authorized after the Senate had deleted all funds for the CIT, which is to be built at the Princeton Plasma Physics Laboratory. The Reagan administration had asked for $19 million for the CIT, but even this is only half the amount that would be required to put this next-generation fusion device on a minimally adequate schedule.

The Compact Ignition Tokamak will take the essential next step—plasma ignition—required for the U.S. magnetic fusion program to move toward commercially viable fusion power production.

Existing tokamaks require a great deal of energy to produce a mere trickle of fusion. Yet they are providing the knowledge necessary to build a new generation of devices capable of *ignition*, self-sustained fusion burning without continuous external heating of the plasma. Although valuable along the experimental road toward commercial fusion, continuous external heating will not get the fusion program to its goal of generating more energy than it consumes.

The Road Not Taken

In 1983-1984, the Princeton Plasma Physics Laboratory proposed a large machine, the TFCX, to achieve ignition while incorporating many engineering features necessary for a commercial reactor. The machine was designed to use superconducting magnets and to produce 250 megawatts of thermal energy for 5 minutes at a time.

Five minutes' "burn time" affords a convincing approximation of steady-state fusion energy generation, since any plasma instabilities usually occur within milliseconds. TFCX would not have been a working reactor, but would have brought the program close to that goal. The Reagan White House and its presidential science advisor, George Keyworth, balked at the $1.5 billion price-tag for taking this step toward achieving a virtually unlimited and cheap source of energy.

A less expensive alternative to the TFCX was to build a smaller machine with a very intense magnetic field to achieve ignition, without otherwise approximating a working reactor. This was an approach championed by fusion scientist Bruno Coppi of the Massachusetts Institute of Technology.

The Compact Ignition Tokamak is Princeton's design for such a machine, although in a more conventional form than that advocated by Coppi. The CIT is projected to cost $350 million, and a Soviet contribution is being sought in exchange for Soviet access to the machine.

The CIT's magnets, which will achieve the enormous field strength of 10 tesla, will be made of resistive copper, not superconductors. Hence it will run only for about 3 seconds before

Fusion: How Close Are We?

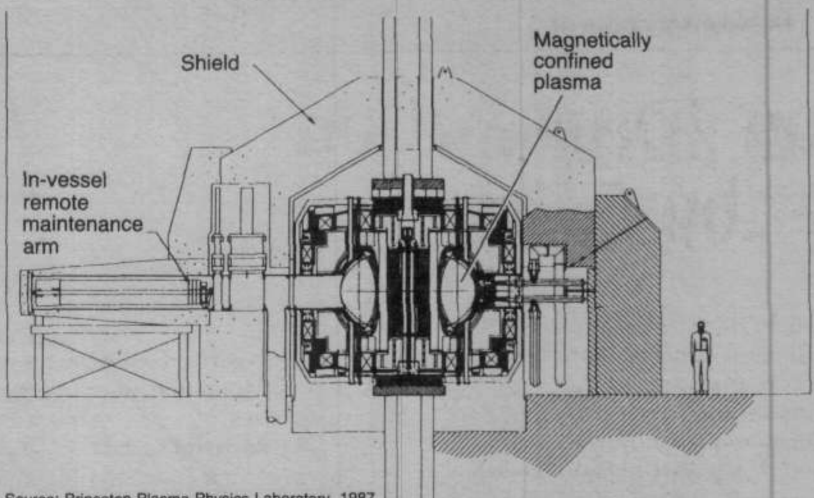
Despite major cutbacks over the last decade in funding, the U.S. fusion program has maintained steady progress in developing the science and technology for harnessing magnetic fusion energy. This has chiefly been carried out on experiments designed and initiated in the mid-1970s, such as the Princeton Tokamak Fusion Test Reactor (TFTR).

Now both the Japanese and Western Europeans have larger experiments that will significantly outdistance the performance of the TFTR. This is occurring at the same time that the TFTR is demonstrating that there are *no major scientific or technical barriers to achieving energy-producing fusion plasmas.*

The fusion program has also been a technology driver for the nation. Even the recent fusion report of the Office of Technology Assessment (an office not known for its friendliness to advanced technologies), noted that the U.S. fusion program had produced most of the scientists and much of the technology that has gone into the Strategic Defense Initiative program. In fact, many spinoffs from fusion research are already laying the basis for entirely new physical processes to harness energy; for example, the generation of so-called antimatter, and new technologies, like the gamma-ray laser and tunable free electron lasers, which will revolutionize every aspect of scientific research.

How much will fusion energy cost? Major engineering studies carried out by the Lawrence Livermore National Laboratory in 1983 demonstrated that existing frontier technologies would lead to advanced fusion reactors that would operate at twice the efficiency of existing types of power plants, generating electricity at half the cost.

—Charles B. Stevens



Source: Princeton Plasma Physics Laboratory, 1987

PRELIMINARY DESIGN OF COMPACT IGNITION TOKAMAK

The donut-shaped chamber for confining the plasma is seen in cross-section (see arrow). The CIT needs an average $50 million per year to be completed by 1995.

requiring shutdown for cooling the magnets. The CIT will be too small to allow for a "blanket" to absorb the neutron emission—a necessary step toward converting a reactor's thermal energy output to electricity.

In fact, instead of scaling up from the radial dimensions of existing fusion machines such as Princeton's Tokamak Fusion Test Reactor or TFTR, the CIT scales down by about a third.

Since the team of scientists and engineers assembled at the Princeton Plasma Physics Lab will exhaust the experimental possibilities of its existing devices by about 1990-1991, the team will go out of existence unless a next-generation device is built quickly.

At a total cost of $350 million, the CIT must receive an average $50 million per year to be built by the beginning of 1995. But this timetable is too slow. Scientific and engineering teams for frontier projects—built up over years and carrying much of their know-how around with them in their heads—are not readily replaceable, and the team at Princeton is ready to build CIT *now*.

How the CIT Works

The deuterium-tritium fusion reaction—around which such machines as the CIT and the TFCX are designed—produces 80 percent of its energy in a spray of neutrons and 20 percent in the form of alpha particles (helium-4 nuclei: two protons, two neutrons). Since neutrons have no charge, the spray of neutrons does not respond to the magnetic field used to confine the plasma. The neutrons fly out in all directions and their energy can be cap-

Continued on page 55

AIDS Study Shows 13 Million Dead or Sick by 2005

Dr. Allen Salzberg is director of medical services at the Veterans Administration Hospital in Miles City, Mont. His computer study on the AIDS epidemic in the United States, summarized in the Dec. 18, 1987 Journal of the American Medical Association, *predicts an economic, social, and medical catastrophe unless the U.S. adopts mandatory testing and other traditional public health measures for AIDS.*

Salzberg, who has a medical degree and a doctorate in plasma physics, was interviewed by Kathleen Klenetsky Jan. 16. The interview does not express the view of the VA or any other government agency.

Question: What have you found so far in your study?

Our numbers at the present time show approximately 64,000 cases at the end of 1987 and about 1.1 million carriers. By the end of 1991, we're estimating from 410,000 to 490,000 cases, with 5 million carriers.

Question: Your initial projections showed that by 2005, 25 million Americans would be sick or dead, and another 40 million would be infected. . . .

The more recent model has made that look a little better, although it's still terrible. Our estimates now for 2005 are between 7 and 13 million dead or sick, and another 18 to 35 million carriers. . . . The most frightening thing we're finding is that AIDS will sneak into the heterosexual population, slowly but very inexorably. AIDS has to move into the heterosexual population, because there are only so many high-risk people. After they're all saturated, who's going to be next? The virus isn't going to go away.

The lower number in these figures assumes improved behavior in the population, which will slow the spread of the disease.

Question: How has the Centers for Disease Control responded to your projections?

They say that although the data are accurate enough at the present time, they don't feel that these numbers [for later years] will be found—which I think is absolutely meaningless. . . .

Question: Your initial study estimated that the epidemic would cost the U.S. $8.2 trillion by 2005.

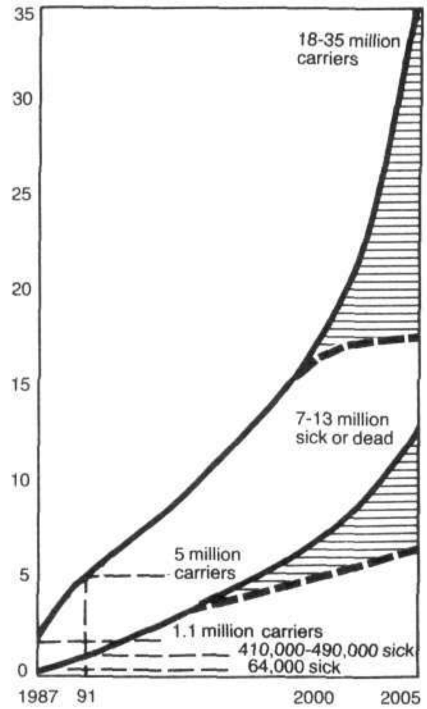
Yes, that figure (in 1987 constant dollars) included losses due to premature death. Because of the time-shift in the model projections, that figure won't occur until 2008. We estimate direct costs of $29 billion cumulatively by the end of 1991. By 1995, costs will have risen to $150 billion. And by 2005, to over $1 trillion. If you included the costs of premature deaths, you could just about triple those numbers.

Question: Does your study assume that AIDS is transmitted only through IV drug use, sexual contact, and blood products?

Yes. And although it might be transmitted in other ways, the rate of transmission would be far lower than the normal rates. There is some worry about transmission by insects. I'm not going to say there's a zero chance of that, because nobody can say that. . . .

Question: Your projections are based on what would happen if the U.S. fails to adopt public health measures, including mandatory testing. How would it help if we did?

The main problem is that we don't really know what's going on in the country, because we don't have the kind of testing program that would allow us to know this. The disease can be stopped. The cost of a testing program would be, in the first yearly cycle, a little over $1 billion. The Army now has got false positives down to 1 in 100,000. And there's a new test coming out, the immunofluorescent antibody test, which will get it down by another factor of 10 to 100.



If we do not institute universal testing, there will be 7 to 13 Americans sick or dead of AIDS by the year 2005, and 18 to 35 million Americans carrying the disease. The lower number presumes improved behavior that will slow the spread of the disease.

Another important reason for testing is that the drugs coming out—AZT and much safer ones—might significantly slow down the progression from infection to disease. If you knew you were infected, you could take advantage of the drugs much more quickly. This would also lower the rate of infection, because the drugs decrease the number of viral particles shed. . . .

Of course, if you just did testing, you'd have to rely on how people's behavior changed. Some studies show that a lot of people would change their behavior. . . . But there will be a minority who will probably not change. Society will have to deal with these people, as they are found to be acting in a manner contrary to human life, in an according manner. You wouldn't allow a person to shoot a gun in a crowded schoolyard. . . .

Question: Are there other reasons we should have universal mandatory testing?

One, you would know what's going on. So if anything does change with the disease, you would know. If things are getting better, you could relax things. If things are getting worse, you'd know what to do. If you did get a mutation, you'd pick it up real fast. Second, you would target education on the people who test positive. Also, you could then have contact tracing, and you'd also be able to inform spouses, if their partners tested positive. If someone with AIDS were behaving irresponsibly, you would have the evidence that they already knew they were infected, and you could do something about it.

***Question:* What do you say to those who claim that testing or contact tracing is a civil rights violation?**

So is death! In fact, the populations at risk whom [civil libertarians] say testing would discriminate against, are, unfortunately, now more black and Hispanic. If you don't stop the spread of AIDS, these groups will be saturated by the mid-1990s. They'll die. I can't see anything worse than that.

. . .Also, you've got to realize we have tested in the past. This is not a new concept in the United States. We tested for syphilis at one time, and in the days before we had penicillin, we darn well did contact tracing. We had no cure. You had to go after the carriers. And we did control the epidemic to a large extent that way. TB was another thing we worked on very hard. We had sanitoriums. . . .

Question: Is there a danger that if the U.S. continues on its present course, people will suddenly realize in a few years how bad things have become, and react the way people did during the Black Death: murdering AIDS carriers, or exiling them where they'll get no treatment?

I'm afraid of that. Either we act rationally now, or we're going to act irrationally later. I don't know about no medical treatment, but I can see things

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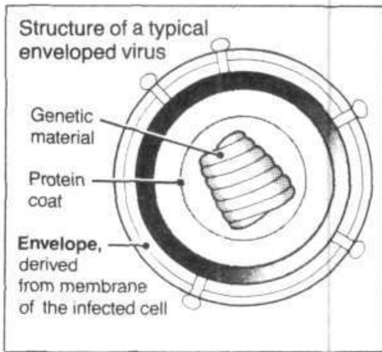
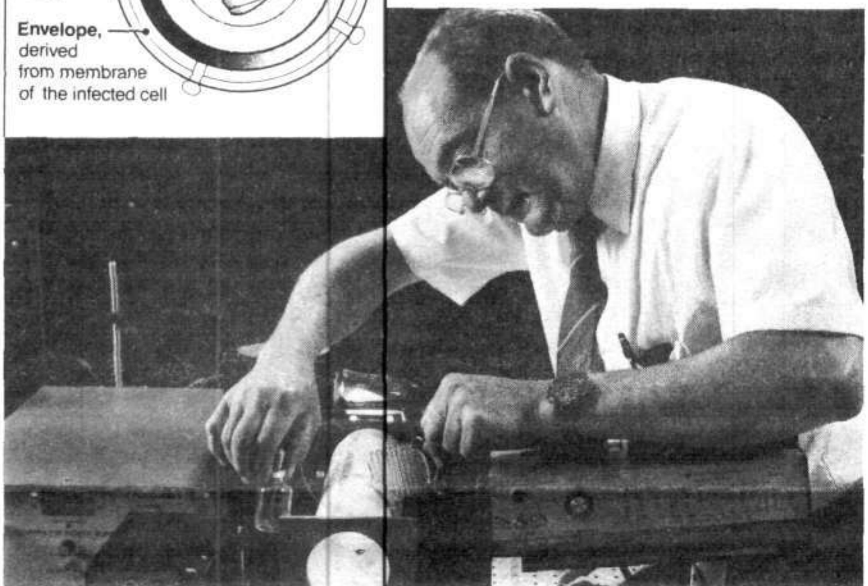


After dye particles have attached themselves to the virus envelope, red light is used to excite the dye to a higher energy state. The light-excited dye results in an altered envelope. Below, Dr. Frank Sogandares-Bernal works on the system used to treat blood with a xenon light source.



Baylor University Medical Center

Using Electromagnetic Waves To Kill the AIDS Virus

Low-power laser light can destroy viruses in the blood—including possibly the AIDS virus—without harming the blood itself, according to physiologist James L. Matthews of the Baylor Research Foundation at Baylor University Medical Center in Dallas.

Matthews's group is working under a contract with the Strategic Defense Initiative Office to study potential medical applications of lasers, especially lasers newly developed under the SDI program. The medical researchers are particularly interested in the possibilities of the free electron laser, because it is tunable; most lasers are limited to a single frequency.

The method used by the Baylor group is a form of photodynamic therapy, already in use against tumors. First, researchers find a nontoxic dye that is uniquely taken up by the target—in this case, the envelope of the virus. A laser frequency that induces an effect—probably a photochemical effect—in the dyed target is then used to irradiate the virus. The Baylor group successfully tested the technique on herpes, measles, and cytomegalovirus before tackling HIV, the AIDS virus.

"We attained a 100 percent viral kill without seeing any evidence of damage to the normal blood elements," Matthews said. The outcome for HIV will be known very soon, he added.

Why Does It Work?

In simple laser surgery, a thermal (heating) effect is achieved in the target by using sufficient power. Indeed, tumor tissue may be literally burned up without damage to neighboring tissue in some medical applications. But the nonthermal effects that occur at lower powers—as in photodynamic therapy—are not always clearly understood. In order to pass the laser beam through a stream of blood without damaging its components, the Baylor group used a nonthermal power level of only 5 joules/cm^2 and succeeded in killing the viruses. They got the same result with noncoherent (nonlaser) xenon light of the same wavelength.

Earlier studies of viruses with envelopes suggest that the virus loses its ability to infect if its envelope is disrupted, and Matthews's group believes they may be causing minor disruptions of the envelope by a photochemical or physical mechanism yet to be identified.

The Baylor project is only the most advanced of several efforts to deactivate the AIDS virus using portions of the electromagnetic spectrum.

The Promise of Radiowaves

Pathologist John Grauerholz, an associate editor of *21st Century*, addressed the general concept of using nonionizing electromagnetic radiation against the AIDS virus in a paper presented to the Engineering in Medicine and Biology Society in November 1987. Grauerholz drew attention to Soviet and German experimental results over the past 15 years indicating that low-intensity microwaves and other radiowaves can selectively control the expression of genetic material regulating cell processes.

AIDS, Grauerholz noted, results from changes in genetic expression within cells infected by Human Immunodeficiency Virus (HIV), and might therefore be controlled by radiation of specific frequencies.

Grauerholz stated that the experimental results are well ahead of the science necessary to understand them, and therefore the scientific questions must also be tackled in order to guide research toward useful results. How can microwaves affect the processes of cells whose dimensions are thousands of times smaller than the microwave wavelength? How can radiation with an energy that is tremendously lower than that required to break chemical bonds—and even lower than the thermal energy attributed to molecules in living organisms—affect cellular processes?*

The RNA Nucleus As Antenna

In late January 1988, physicist Marvin L. Luther of Illinois State University (at Normal) proposed a highly specific use of microwaves against AIDS to the National Institutes of Health.

Luther plans to pass HIV-infected blood through an intense, solenoidal magnetic field where the field is changing most rapidly, forcing the electron-dense RNA nucleus of the virus to align its symmetry axis parallel to the direction of the blood flow. While held in this position by the magnetic field, the nuclei are to be irradiated by polarized microwaves propagating directly into the oncoming flow of blood.

The RNA nucleus will function as "a properly sized and orientated antenna, which, if it absorbs sufficient energy at its natural resonating frequency, or some multiple thereof, will be so violently agitated as to alter its conformation, most probably by displacing one or more Ca^{2+} [doubly ionized calcium] ions."

Luther suggests circulating the patient's blood outside of the body, in the manner of renal dialysis, in order to treat it. "If the damaged virus is returned immediately to the patient it will stimulate an immune response to the protein coat and viral agents will begin to be destroyed." Once the immunizing agents in the blood are identified, he says, they can be cultured as a vaccine for others.

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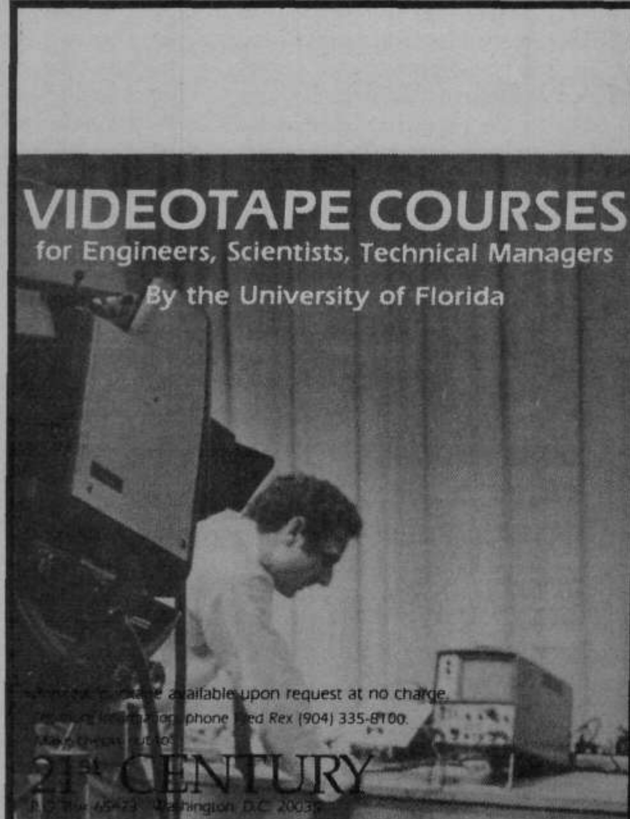
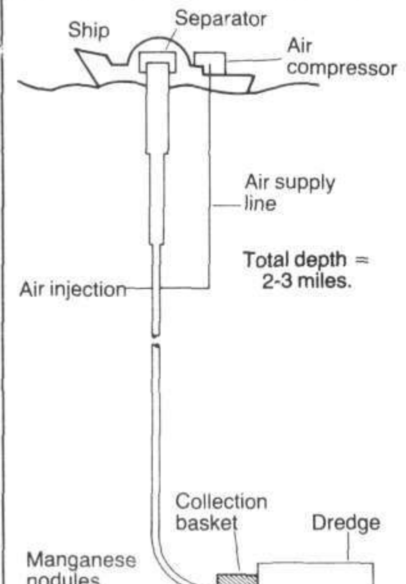
* An edited version of Grauerholz's paper was published in the *Executive Intelligence Review*, Jan. 22, 1988.



'Vacuuming' the Ocean Floor

by Christopher J. Crowley



SCHEMATIC OF COMMERCIAL AIRLIFT SYSTEM

Air bubbled into the pipeline part of the way down induces a constant upward flow of water at the dredge. The manganese nodules are swept up into the collection basket by this water-driven vacuum cleaner.

Miles below the ocean's surface, vast numbers of small, potato-shaped lumps of rock called manganese nodules litter the floor of the ocean. Developing ways to mine these nodules for the valuable minerals they contain is a challenging job, but one promising method has already been put to the test: Tons of these manganese nodules have already been raised from the dark, cold depths using a long pipeline to "vacuum up" the nodules by flowing air and seawater.

Explorers first discovered the manganese nodules only about 100 years ago. They are coal black or dark brown in color, and can be as small as the tip of your finger or as big as a soccer ball. They weigh about twice as much as a volume of water equal to their size.

How are these remarkable nodules formed? They "grow" by collecting the remains of microscopic sea creatures that drift to the ocean floor and decay. Through chemical reactions, the nodules are assembled, bit by tiny bit, around other small rocks or pieces of fish bone. The largest nodules take millions of years to grow.

Changes in the populations of the sea creatures over these years cause the rate of the growth to vary. As a result, when you slice open a nodule, you can see that it is layered like an onion, with thick and thin rings.

The valuable metals contained in the nodules include manganese, cobalt, nickel, and copper. Manganese metal makes up the largest fraction of the weight—about one fifth—which explains how the nodules got their name. Recent explorations of portions of the ocean floor, along with predictions by experts, suggest that many millions of tons of these metals are waiting in these nodules at the bottom of the Atlantic, Pacific, and Indian Oceans.

All these metals have important uses. Manganese, for example, is added during the manufacturing of steel to give the steel extra strength. Cobalt is especially useful in making jet engines and computer parts. Manganese, cobalt, and nickel are known as *strategic metals,* in fact, because of their critical use in aircraft and defense. In 1979, the United States was importing 98 percent of its manganese, 90 percent of its cobalt, and 77 percent of its nickel. Without mining the sea for resources, the reliance on imports will continue (see figure for projections for the year 1990).

The incredible pressures at the ocean depths where manganese nodules are found create special problems in mining the nodules. If you have ever dived to the bottom of a pool just 6 or 10 feet deep, you probably have felt the pressure on your eardrums. *Three miles* below the ocean surface, the pressure would be equivalent to having several thousand people sit on your chest! The weight of all this water can even crush the hulls of the strongest submarines.

Since people cannot survive at these depths without special protection, the mining methods being looked at involve various mechanical devices. Experiments to determine the feasibility of ocean mining, by airlift and hydraulic methods, were begun as early as 1976 by a multinational consortium of German, Japanese, Canadian, and American scientists. The initial test, which

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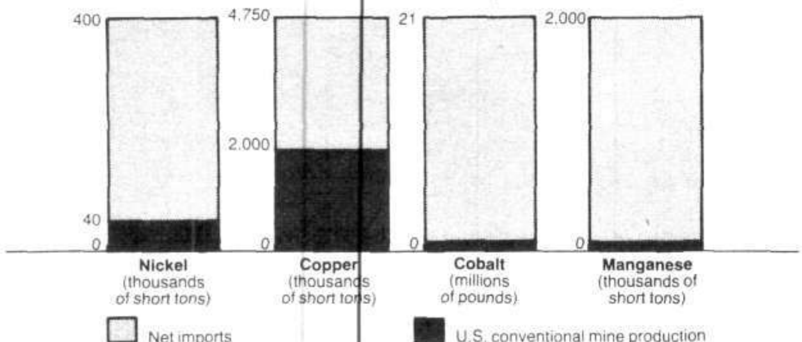
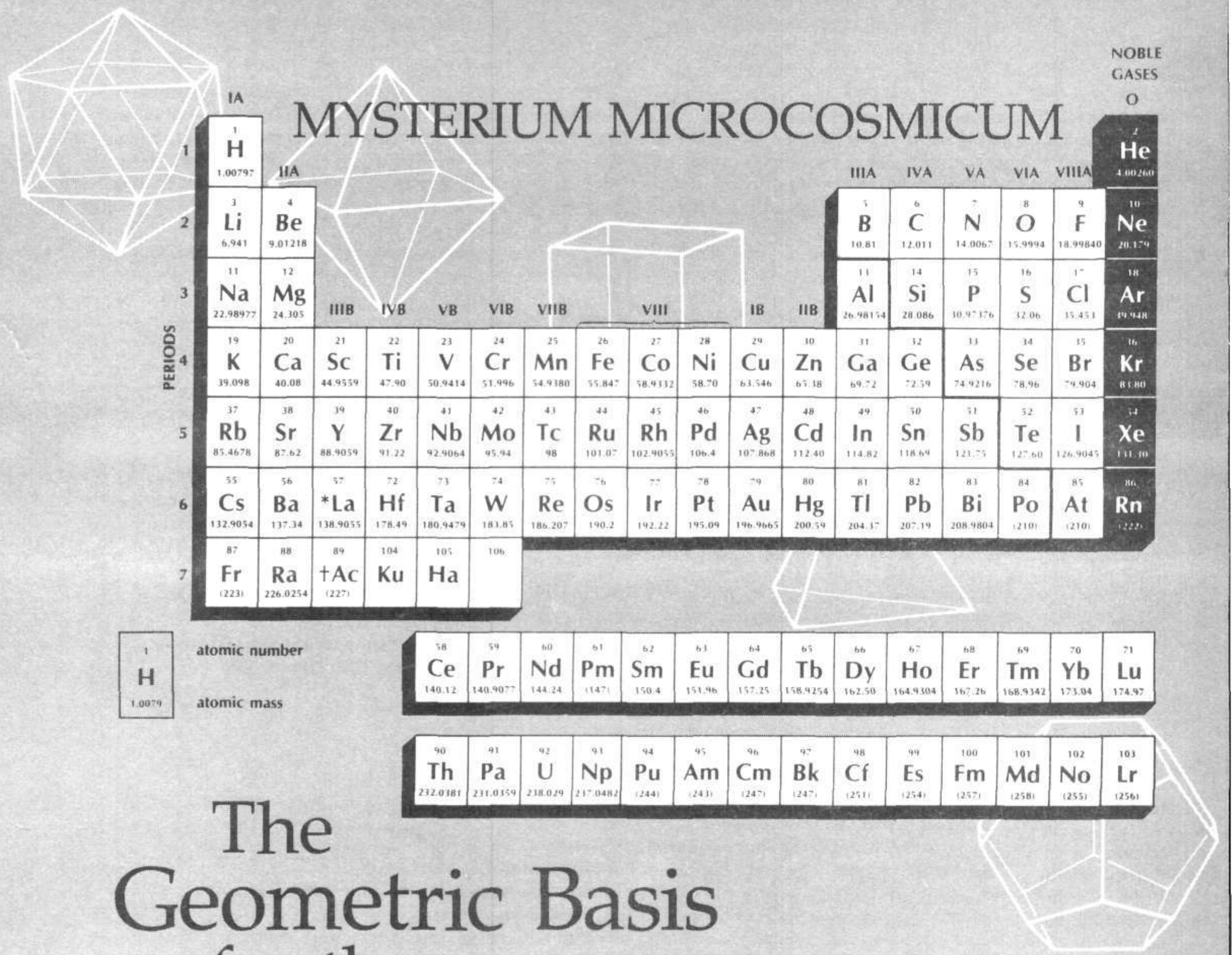
HOW THE U.S. WILL MEET DEMAND FOR 4 METALS: IMPORTS VS. DOMESTIC MINING (Forecast for 1990)



Source: National Commission on Materials Policy Interim Report, April 1972.

This forecast for the year 1990 shows the United States continuing to import the majority of its nickel, copper, cobalt, and manganese to meet the projected demand. In fact, imports of these metals have been growing since about 1955.



MYSTERIUM MICROCOSMICUM

PERIODS	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIIA	NOBLE GASES O
1	1 H 1.00797																	2 He 4.00260
2	3 Li 6.941	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.99840	10 Ne 20.179
3	11 Na 22.98977	12 Mg 24.305											13 Al 26.98154	14 Si 28.086	15 P 30.97376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
4	19 K 39.098	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.90	23 V 50.9414	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.70	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc 98	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.4	47 Ag 107.868	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.30
6	55 Cs 132.9054	56 Ba 137.34	57 *La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.9665	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.9804	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.0254	89 †Ac (227)	104 Ku	105 Ha	106												

58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (147)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.97
90 Th 232.0381	91 Pa 231.0359	92 U 238.029	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (255)	103 Lr (256)

1 H 1.0079 — atomic number; atomic mass

The Geometric Basis for the Periodicity of the Elements

by Laurence Hecht

Although an elaborately refined set of rules exists to explain many phenomena observed at the atomic level, there is no satisfactory model of the atomic nucleus, the central core of the atom around which a precise number of negatively charged electrons is presumed to orbit. Any attempt to produce a coherent theory of orbiting electrons, without knowledge of the structure around which these orbits are constructed, would seem to be doomed to failure. Nonetheless, a highly elaborated algebraic theory of the atom, designed to account for a mass of data gathered from spectral analysis and other operations, does exist in the form of the quantum mechanical model. Most of this theory presumes no more about the atomic nucleus than that it contains a certain number of positively charged particles agglomerated in a central mass.

It would seem past time to arrive at a more developed theory of the atomic nucleus, and from there to rework the cumbersome and very problematical portrait of the atom that the quantum mechanical model has bequeathed us. University of Chicago physicist Dr. Robert J. Moon has proposed a geometrical model of the nucleus to do just that.[1]

Moon has produced a synthetic geometric construction of the periodic table of the elements in such a way as to account geometrically, in a first approximation, for the existence of the 92 naturally occurring elements and many of their physical properties. I have added to Moon's hypothesis a construction that provides a nonmagical cause for the Magic Number theory (the theory that attempts to account for changes in the nuclear properties of the elements), and I have reexamined in a new light some of the original data used to establish the periodicity of the elements. It is hoped that a further working out of this approach will offer a causal explanation for the electron shells and orbitals and so provide a more solid grounding, as it were, for a new quantum mechanics.

Professor Moon's Hypothesis

The existing dogma of nuclear physics requires us to believe that protons, being all of positive charge, will repel each other up to a certain very close distance corresponding to the approximate size of the nucleus. At that point, the theory goes, a binding force takes hold, and forces the little particles to stick together, until they get too close, at which point they repel again. Thus is the holding together of the protons in the nucleus accounted for.

Disdaining such arbitrary notions of "forces," and preferring to view the cause of such phenomena as resulting from a certain characteristic of physical space-time, Moon and the author demanded a different view. Considerations of "least action" suggested to Moon a symmetric arrangement of the charges on a sphere, while the number of such charges (protons), and the existence of shells and orbitals beyond the nucleus (electrons) suggested a nested arrangement of such spheres. Our belief that the universe must be organized according to one set of laws, applying as well to the very large and the very small, suggested that the harmonic proportions which the astronomer Johannes Kepler found in the ordering of the solar system would also be evident in the microcosmic realm, so we looked for this also in the arrangement of the nucleus.

We were led immediately to the five regular or Platonic solids—the tetrahedron, cube, octahedron, icosahedron, and dodecahedron (Figure 1). Moon developed a nested model, using the Platonic solids to define the atomic nucleus in much the same way that Kepler determined the orbits of the planets of the solar system. In Moon's "Keplerian atom," the 92 protons of the naturally occurring elements are determined by the vertices of two identical pairs of nested solids. Before elaborating the construction of this model, let us review the properties of the Platonic solids.

The five Platonic solids define a type of limit of what can be perfectly constructed in three-dimensional space. These solids are the only ones that can be formed with faces that are equal, regular plane figures (the equilateral triangle, square, and pentagon) and equal solid angles. A derivative set of solids, the semiregular or Archimedean solids, can be formed using two or three regular plane figures for faces in each figure. Both species of solids can be circumscribed by a sphere, the *circumsphere*, such that all the vertices of the figure are just touched by the sphere. The Platonic solids are unique in that each has just one sphere, the *insphere*, that will sit inside, just tangent to the interior of each one of the faces (Figure 2). The Archimedean solids must have either two or three distinct inspheres.

A third species of sphere, the *midsphere*, is formed by a radius connecting the center of the solid with the midpoint of each of its edges, and is associated with both the Platonic and Archimedean solids (Figure 3). The surface of the midsphere pokes both inside and outside the faces of the figure. Two of the Archimedean solids, the cuboctahedron and the icosidodecahedron, actually are formed by the midspheres of the Platonic solids.

The surfaces of the Platonic solids and related regular solids represent unique divisions of the surface of a sphere according to a least-action principle.[2]

How the Model Works

In Moon's "Keplerian atom," the 92 protons of the naturally occurring elements are determined by two identical sets of nested solids each containing 46 vertices. Moon's proposed arrangement is as follows:

Two pairs of regular Platonic solids, the cube-octahedron pair and the icosahedron-dodecahedron pair, may be called duals: one will fit inside the other such that its vertices fit centrally on the faces of the other, each fitting perfectly inside a sphere whose surface is thus perfectly and symmetrically divided by the vertices (Figure 4). The tetrahedron is dual unto itself and therefore plays a different role.

The four dual solids may be arranged in a nested sequence—cube, octahedron, icosahedron, dodecahedron—such that the sum of the vertices is 46 (Figure 5):

Cube	= 8
Octahedron	= 6
Icosahedron	= 12
Dodecahedron	= 20
Total	= 46

The nesting of the cube-octahedron and icosahedron-dodecahedron is clear from a study of the duality relationship. However, to fit the first pair of duals into the next pair appears at first to be a problem: The 6 vertices of the octahedron do not fit obviously into the 20 faces of the icosahedron, nor could the fourfold axial symmetry of the former be simply inserted into the fivefold axial symmetry of the latter. Yet, the octahedron may still be placed within the icosahedron in a manner that is fitting and beautiful. Six vertices of the octahedron may be placed near to six vertices of the icosahedron, such that the distance from the nearby vertex of the icosahedron to the edge opposite it is divided in the divine proportion [$\phi = (\sqrt{5} + 1)/2 =$ approximately 1.618] (Figure 6).[3]

The axis of the cube-octahedron pair is thus skew to the axis of the icosahedron-dodecahedron dual, and a special relationship exists at this point of singularity in the model.

Examining the edges of the figures so nested, and designating the length of the smallest inner figure, the cube, as unity (1), we find:

Edge of cube	1.00
Edge of octahedron	2.12
Edge of icosahedron	1.89
Edge of dodecahedron	1.618

Then taking the radius of the sphere circumscribing the

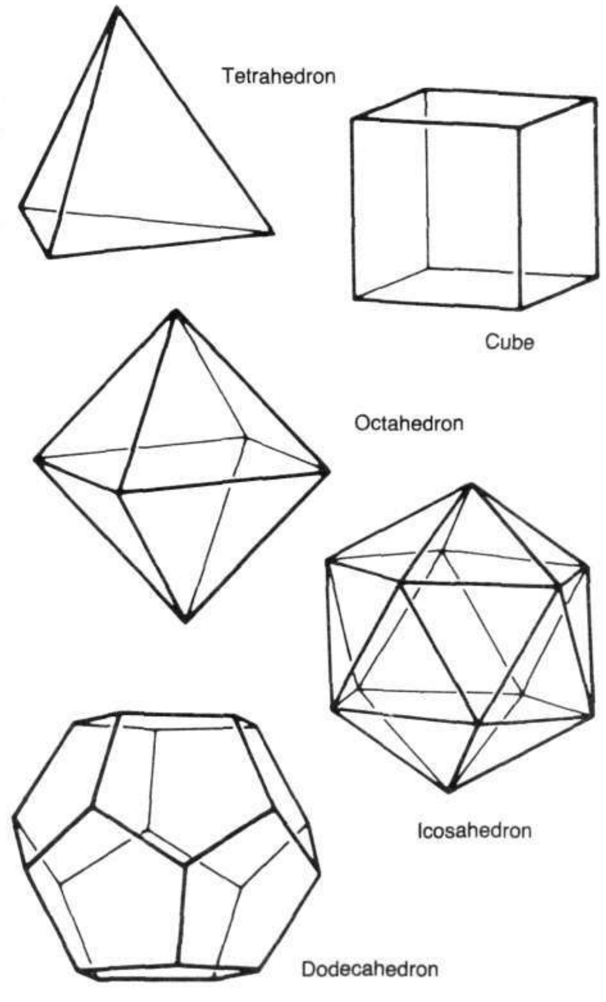


Figure 1
THE FIVE PLATONIC SOLIDS

The five regular or Platonic solids represent a limit of constructibility in three-dimensional space. Euler's formula correlates the relationship of vertices (V), faces (F), and edges (E) for each solid as $V + F = E - 2$.

Polyhedron Name	Vertices	Faces	Edges
Tetrahedron	4	4	6
Cube	8	6	12
Octahedron	6	8	12
Icosahedron	12	20	30
Dodecahedron	20	12	30

cube to be unity, the radii of circumscribing spheres stand in proportion:

Cube	1.00
Octahedron	1.733
Icosahedron	2.187
Dodecahedron	2.618

Note that the ratio of edges between the inner and the outer figures is in the divine proportion. Also, the ratio of radii between inner and outer spheres is the square of the divine proportion (approximately 2.618).

Building the Nucleus

If we now take the vertices of the solids so arranged to be the singularities in space where the protons are found, a remarkable structure to the nucleus appears. First we see a sort of periodicity in the nucleus, formed by the completion of each of the "shells," as we might call the circumspheres of the cube, octahedron, icosahedron, and dodecahedron.

Let us first look at which unique elements correspond to the completed "shells":

Oxygen (8)	= completed cube
Silicon (14)	= completed octahedron
Iron (26)	= completed icosahedron
Palladium (46)	= completed dodecahedron
. . .	. . .
Uranium (92)	= completed twin nested figures

Thus, highly stable oxygen, which makes up 62.55 percent of the total number of atoms in the Earth's crust, and silicon, which makes up 21.22 percent, are represented by the first two completed figures. Together these two elements account for 84 percent of all the atoms in the Earth's crust. Although the curve of the relative abundance of the elements declines exponentially with increasing atomic number, iron, the completed icosahedron, is three orders of magnitude higher than the elements near it on the atomic number scale and makes up 1.20 percent of the atoms in the Earth's crust, and 5 percent by weight. Iron is also a most unique element in that it represents the minimum of the mass packing fraction and the endpoint of the natural fusion process.

A look at the graph of atomic volumes (Figure 7) is also very thought-provoking in this regard. The periodicity exhibited in the atomic volumes (atomic weight divided by the density of each element) was being examined by the German scientist Lothar Meyer in l869 at the time he and Russian scientist Dmitri Mendeleyev simultaneously developed the concept of periodicity. It was later discovered that other physical properties—compressibility, coefficient of expansion, and reciprocal melting point—obey the same periodicity (Figure 8).

Most textbooks discuss the maxima of these properties occurring at atomic numbers 3, 11, 19, and so on, the so-called Group 1a, or alkalies. Moon's construction drew my attention, however, to the minima. The minima occurring in the range of 4-8, 13-14, 26, and 46 suggest that a minimal space-filling and maximal structural stability occur at the completion of each Platonic solid within the nucleus. We shall see later how a second periodicity of the neutron structure can be derived from the same geometric picture to account for the maxima observed, thus defining both the maxima and minima of these periodic properties from within the nucleus.

Fission of the Nucleus

Moon's model beautifully accounts for the process of fission. Filling out with protons the outermost figure, the dodecahedron, brings us to palladium, atomic number 46, an element that has an unusually symmetric character. First, a look at the table of electron configurations (Table 1) shows palladium to be the only element in which an outer electron shell, previously occupied, is completely abandoned by the extra-nuclear electrons. Second, palladium is a singularity in the fission process, falling at a minimum on the table of distribution of fission products. Palladium also marks the boundary point for the sort of fission that occurs with very high energy (for example, protons of billion-electron-volt energies), when nuclei are split up into two parts of similar size. Silver, atomic number 47, is the lightest of the elements that may split this way.

To go beyond palladium in our model, a twin structure joins at one of the faces of the dodecahedron (Figure 9) and begins to fill up its vertex positions with protons, beginning on the outermost figure. (Silver, atomic number 47, is the first.) Six positions are unavailable to it—the five vertex positions on the binding face of the second figure and the one at the face center where a vertex of the inscribed icosahedron pokes through.

Thus on the second nested dodecahedron figure, 15 out of 20 of the dodecahedral vertices are available, and 11 out of 12 of the icosahedral vertices. We now fill 11 of the available dodecahedral vertices, thus creating 47-silver and continuing through 57-lanthanum. At this point, one face of the dodecahedron remains open to allow filling of the inner figures. The cube and octahedron fill next, producing the 14 elements of the lanthanide, or rare earth series (58-cerium to 71-lutetium). Placing the proton charges on the inner solids causes a corresponding inward pulling of the electron orbitals. Thus, the otherwise unaccounted for filling of the previously unfilled 4-*f* orbitals (see Table 1), and the mystery of the period of 14 for the rare earths are explained.

The figure is complete at radon, atomic number 86, the last of the noble gases. To allow the last six protons to find their places, the twin dodecahedra must open up, using one of the edges of the binding face as a "hinge" (Figure 10).

The element 87-francium, the most unstable of the first 101 elements of the periodic system, tries to find its place on the thus-opened figure, but unsuccessfully so. Less than one ounce of this ephemeral substance can be found at any one time in the totality of the Earth's crust. Then 88-radium, 89-actinium, and 90-thorium find their places on the remaining vertices. Two more transformations are then necessary before we reach the last of the 92 naturally occurring elements.

To allow for 91-protactinium, the hinge is broken, and the figure held together at only one point (Figure 11).

The construction of 92-uranium requires that the last proton be placed at the point of joining, and the one solid slightly displaced to penetrate the other, in order to avoid two protons occupying the same position. This obviously unstable structure is ready to break apart at a slight provocation. And so we have the fission of the uranium atom, as hypothesized by Dr. Robert J. Moon, one of the scientists who first made fission happen in a wartime laboratory on the University of Chicago football field.

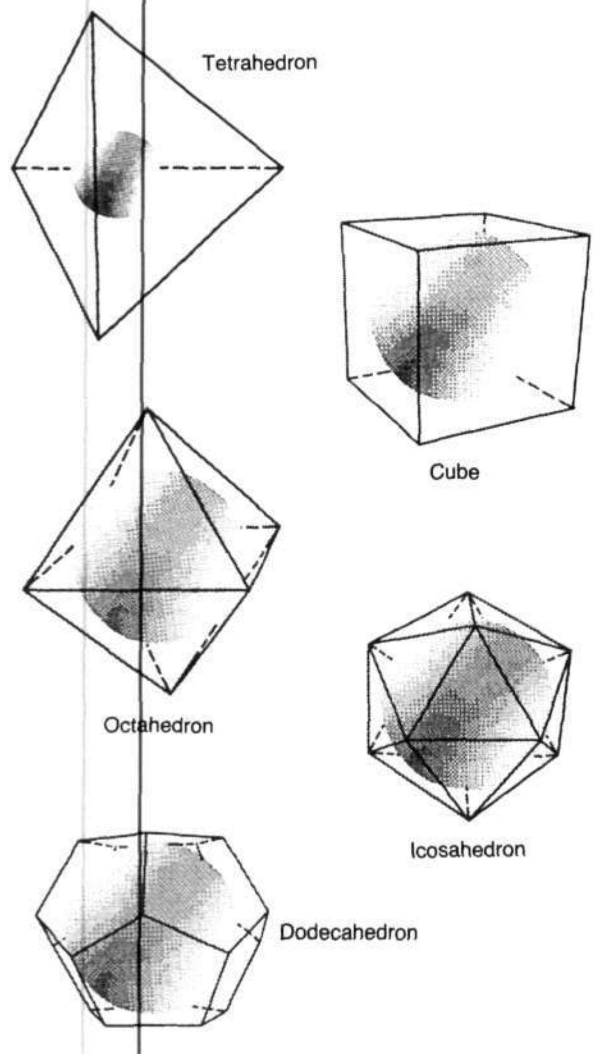


Figure 2
INSCRIBING THE PLATONIC SOLIDS
Both the Platonic and Archimedean solids may be circumscribed by a single sphere (the circumsphere), but the five Platonic solids are unique in having only one sphere that may be inscribed within them (the insphere), as shown.

How Free Is Free Space?

Before proceeding, let us pause to consider the implications of this model. The sympathetic reader is perhaps intrigued with the model, but probably wondering whether we actually intend him to believe that protons find their way into these pretty little shapes and if so, how and why they do it.

The answer to the first part of the question is, yes. As to the second part, the reader would best find the answer by

Table 1
THE ELECTRON ORBITS OF THE ELEMENTS
(Atomic numbers 1–54)

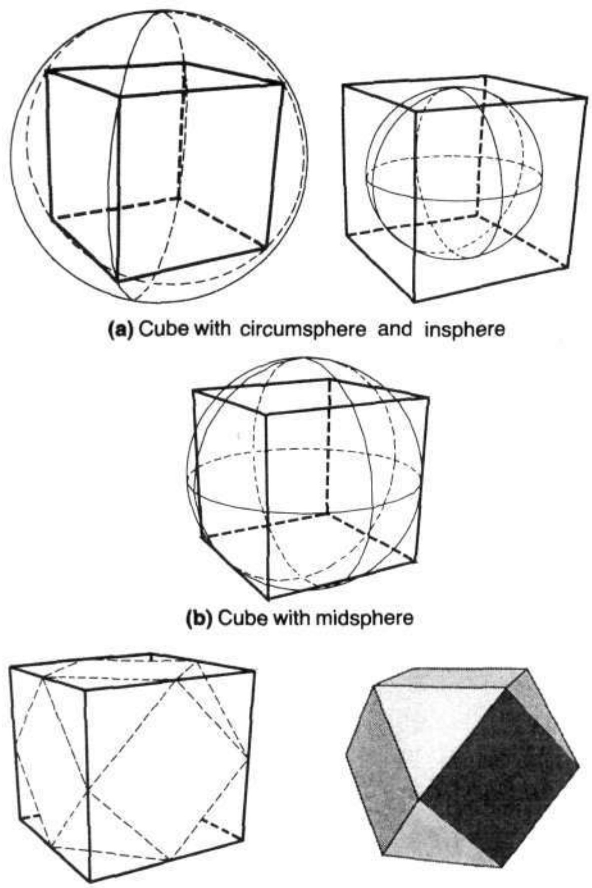
Atomic No.	Element	K	L	M	N	O
		1	2	3	4	5
		s	s p	s p d	s p d f	s p d f
1	H	1				
2	He	2				
3	Li	2	1			
4	Be	2	2			
5	B	2	2 1			
6	C	2	2 2			
7	N	2	2 3			
8	O	2	2 4			
9	F	2	2 5			
10	Ne	2	2 6			
11	Na	2	2 6	1		
12	Mg	2	2 6	2		
13	Al	2	2 6	2 1		
14	Si	2	2 6	2 2		
15	P	2	2 6	2 3		
16	S	2	2 6	2 4		
17	Cl	2	2 6	2 5		
18	Ar	2	2 6	2 6		
19	K	2	2 6	2 6 ..	1	
20	Ca	2	2 6	2 6 ..	2	
21	Sc	2	2 6	2 6 1	2	
22	Ti	2	2 6	2 6 2	2	
23	V	2	2 6	2 6 3	2	
24	Cr	2	2 6	2 6 5*	1	
25	Mn	2	2 6	2 6 5	2	
26	Fe	2	2 6	2 6 6	2	
27	Co	2	2 6	2 6 7	2	
28	Ni	2	2 6	2 6 8	2	
29	Cu	2	2 6	2 6 10*	1	
30	Zn	2	2 6	2 6 10	2	
31	Ga	2	2 6	2 6 10	2 1	
32	Ge	2	2 6	2 6 10	2 2	
33	As	2	2 6	2 6 10	2 3	
34	Se	2	2 6	2 6 10	2 4	
35	Br	2	2 6	2 6 10	2 5	
36	Kr	2	2 6	2 6 10	2 6	
37	Rb	2	2 6	2 6 10	2 6 ..	1
38	Sr	2	2 6	2 6 10	2 6 ..	2
39	Y	2	2 6	2 6 10	2 6 1	2
40	Zr	2	2 6	2 6 10	2 6 2 ..	2
41	Nb	2	2 6	2 6 10	2 6 4*..	1
42	Mo	2	2 6	2 6 10	2 6 5 ..	1
43	Tc	2	2 6	2 6 10	2 6 6 ..	1
44	Ru	2	2 6	2 6 10	2 6 7 ..	1
45	Rh	2	2 6	2 6 10	2 6 8*..	1
46	Pd	2	2 6	2 6 10	2 6 10*..	0
47	Ag	2	2 6	2 6 10	2 6 10 ..	1
48	Cd	2	2 6	2 6 10	2 6 10 ..	1
49	In	2	2 6	2 6 10	2 6 10 ..	2 1
50	Sn	2	2 6	2 6 10	2 6 10 ..	2 2
51	Sb	2	2 6	2 6 10	2 6 10 ..	2 3
52	Te	2	2 6	2 6 10	2 6 10 ..	2 4
53	I	2	2 6	2 6 10	2 6 10 ..	2 5
54	Xe	2	2 6	2 6 10	2 6 10 ..	2 6

* Note irregularity.

Source: Adapted from Laurence S. Foster's compilation in the *Handbook of Chemistry and Physics* (Boca Raton, Fla.: CRC Press, 1980), p. B-1.

asking himself a question: How otherwise would he expect to find elementary particles arranged? The reader probably does not have an answer, but might, if pressed, retort: "Any one of a million possible ways, but why yours?" The reader who answers this way has made some assumptions about the nature of space-time and matter, probably without even realizing it. He has assumed that "things," like protons, are pretty much free to move about in "empty space," except insofar as certain universal "forces," like "charge," "gravitation," and the like might prevent them from doing so. These are assumptions that have no place in thinking about such matters as these.

Take one example, which is relevant to the thinking that went into the development of this nuclear model:



(a) Cube with circumsphere and insphere

(b) Cube with midsphere

(c) 12 points of cube forming the cuboctahedron

Figure 3
FORMING THE CUBOCTAHEDRON FROM THE CUBE
The cube is shown (a) with the circumsphere, which is internally tangent to the 8 vertices, and insphere, which is tangent to the interior of the 6 faces. The midsphere (b) is tangent to the midpoints of the 12 edges. When these 12 points are connected (c), the figure formed is the Archimedean solid known as the cuboctahedron. The midsphere of the cube is the circumsphere of the cuboctahedron.

There is a certain maximum-minimum relationship in electrical conductivity. There is the impedance of free space of 376 ohms, a value used for the tuning of antennae, for instance. There is also the "natural resistance" of 25,813 ohms, demonstrated by Nobel prize winner Klaus von Klitzing in his experiments with very thin semiconductor surfaces (see *Fusion*, May-June 1986, pp. 28-31). The ratio of the two is 1: 68.5, and when the pairing of electrons is allowed for, it is seen to be twice this, or 1:137. The same ratio also appears in the fine structure constant and in the ratio of the velocity of an electron in the lowest orbit to the velocity of light. Von Klitzing also found a quantization in his results. The resistance reached plateaus and appeared as a step function downward from the maximum, suggesting a discrete relationship between the number of electrons and impedance.

The most important thing to observe is that there is a continuity of relationship between the impedance of "free space" (the vacuum) and the resistance found in a thin semiconductor sheet. The point is elaborated in the accompanying article on the subject written by Moon (page 26). We are led to question how "free" is free space. Indeed, the very idea of empty space, filled by particulate matter, must come into question. We look instead to identify the appropriate geometry or curvature of space-time. A proper solution would lead immediately to a solution of the puzzle of superconductivity, and a great many more problems facing science today.

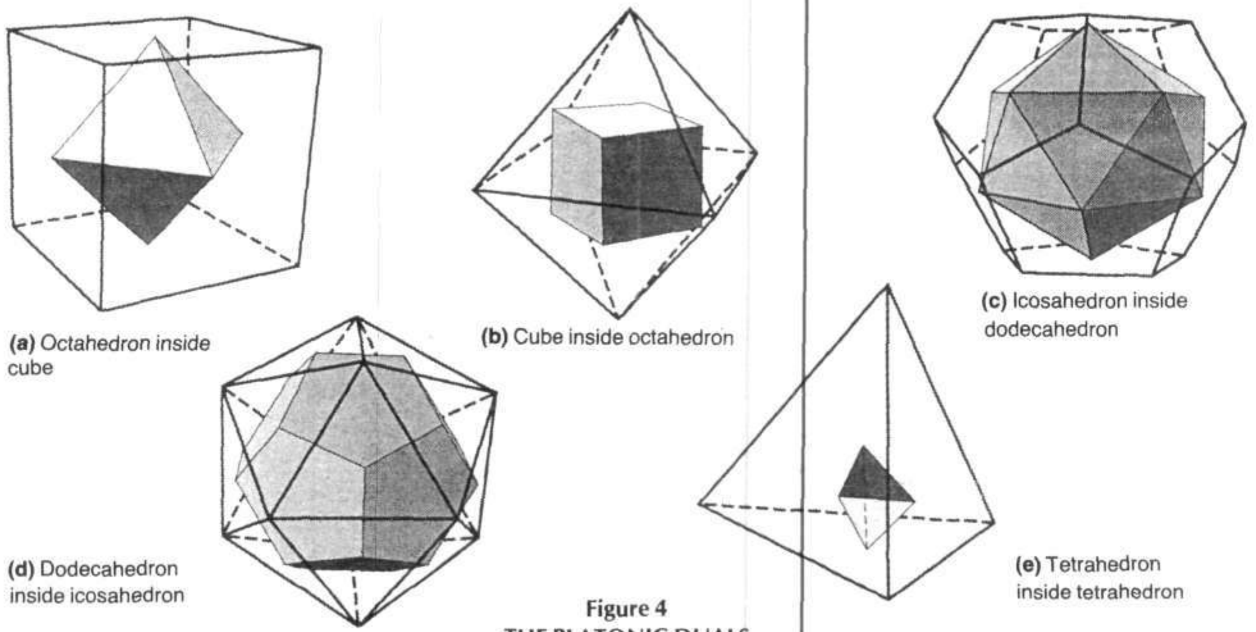
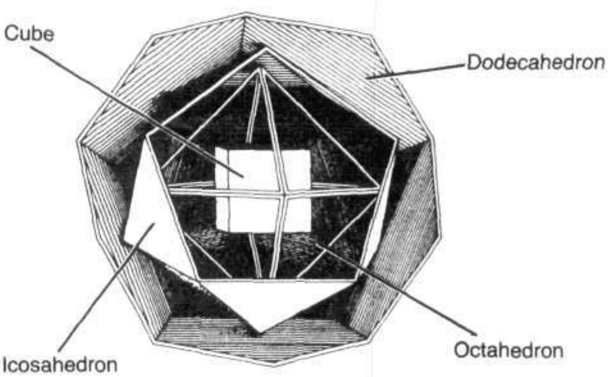
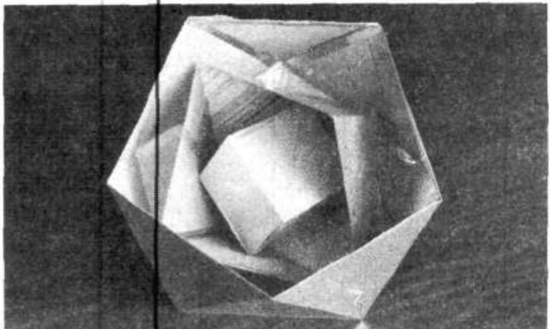


Figure 4
THE PLATONIC DUALS
The cube and octahedron are dual, meaning that they fit one inside the other (a, b). Similarly, the icosahedron and dodecahedron are dual (c, d). The tetrahedron is dual to itself (e).





This working model of the four nested solids was made for Moon by George Hamann out of used offset printing plates. For information on obtaining copies, see page 5.

Figure 5
The sequence of four solids whose 46 vertices form half of the "Keplerian atom."

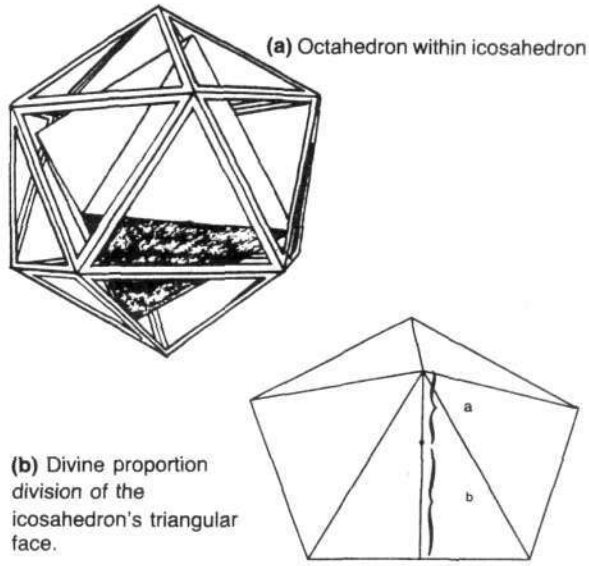
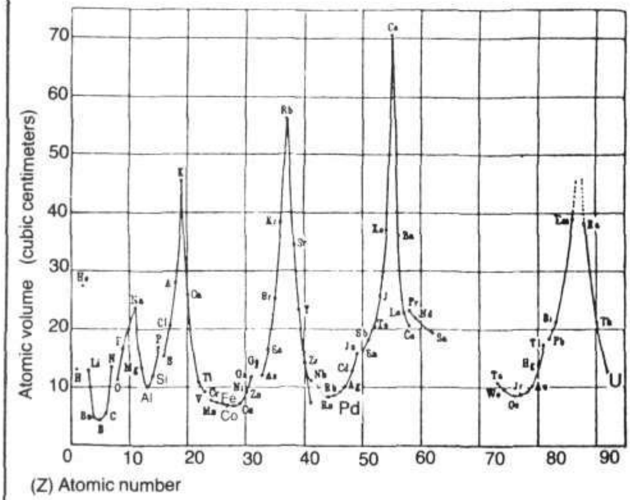


Figure 6
THE OCTAHEDRON INSIDE THE ICOSAHEDRON
The octahedron fits within the icosahedron (a) such that 6 of the 20 faces of the icosahedron receive vertices of the octahedron. The vertices strike the triangular face of the icosahedron (b) so as to divide the altitude line in the divine proportion. Thus, a/b = b/(a + b).



Source: Arnold Sommerfeld, *Atomic Structure and Spectral Lines*, p. 144.

Figure 7
PERIODICITY OF ATOMIC VOLUME
The periodicity of the atomic volumes (the ratio of atomic weight/density) of the elements guided the 19th-century German scientist Lothar Meyer in developing the periodic table. The maxima at atomic numbers 3, 11, 19, 37, 55, and 87 identify the Group 1a elements that begin each period. Notice how minima occur at or near the atomic numbers 8, 14, 26, 46, which mark the completed proton shells.

Implications for the Periodic Table

We have hinted in some ways—for example, in the case of the rare earths—how such an arrangement of the nucleus might be reflected in the arrangement of extra-nuclear electrons. It remains the case, however, that the *periodicity of physical and chemical properties*, as demonstrated in the crowning achievement of 19th and early 20th century chemistry, the periodic table of the elements, is not the same as the *periodicity of the proton shells.* The latter, we have shown, follow the sequence 8, 14, 26, 46, as determined by the Platonic solids. The former are governed by the great periods of 18 and 32, and the small periods of 8, once called the octets.

Years after the establishment of the periodic table, its truth was verified by the data of spectroscopy, which established that the extra-nuclear electrons are found in shells (labeled *K, L, M, N,* and so on), each containing one or more subshells, designated *s, p, d,* and *f* from the appearance of their spectral lines. The "occupancy level" of each shell and subshell is well established and can be seen in the electron configurations in Table 1. The ordering of successive subshells, as follows,

$$
\begin{aligned}
&2 &&= 2\\
&2, 6 &&= 8\\
&2, 6 &&= 8\\
&10, 2, 6 &&= 18\\
&10, 2, 6 &&= 18\\
&14, 10, 2, 6 &&= 32
\end{aligned}
$$

corresponds to the ordering of the number of elements that can be seen in the periods (rows) in the table of the elements—the small and great periods.

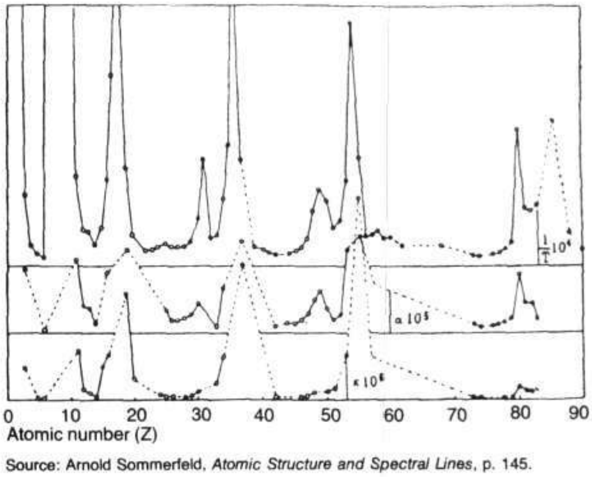
What causes this number series is one of the great mysteries. Rydberg, one of the early contributors to the development of quantum theory, was fond of presenting it in a manner which the great German physicist of the time, Arnold Sommerfeld, characterized as "the cabalistic form":

$$
\begin{aligned}
2 \times 1^2 &= 2\\
2 \times 2^2 &= 8\\
2 \times 3^2 &= 18\\
2 \times 4^2 &= 32.
\end{aligned}
$$

'Magic Numbers'

The modern theory of the atom is also premised on another mystery series, this one more aptly named "Magic Numbers" by its discoverer, physicist Maria Goeppert-Mayer. Careful observation of the nuclear properties of the elements showed certain patterns that seemed to abruptly change at certain key elements. Goeppert-Mayer noticed that whether we were looking at the atomic number (*Z*), which tells us the number of protons in the nucleus, or the number of neutrons (*N*), or the sum of the two, which is known as the mass number (*A*), there were certain so-called Magic Numbers that identified abrupt changes in nuclear properties. These numbers are:

2, 8, 20, 28, 50, 82, 126.



Source: Arnold Sommerfeld, *Atomic Structure and Spectral Lines*, p. 145.

Figure 8
OTHER PERIODIC PROPERTIES OF THE ELEMENTS
Many other physical properties of the elements, including compressibility (bottom line), coefficient of expansion (middle), and reciprocal melting point (top), obey the same periodicity as atomic volume.

An element containing such a Magic Number either as its atomic number (for example, 2 for helium, or 82 for lead), or its neutron number (also 2 for helium, or 8 for oxygen, or 126 for lead or bismuth), or its mass number (for example, 20 for neon, or 28 for silicon) is likely to manifest an abrupt change in nuclear properties from its nearby neighbors in the periodic table. This is not a hard-and-fast rule, but a tendency.

But what can be the cause for this strange series of numbers? Can it be that the same Creator who built into the structure of the atom the simple and harmonious arrangement of the 92 protons, which we have shown here, would leave to chance the configuration of the rest of his creation?

A Hypothesis on Neutron Configuration

I could not believe this, and so I struggled with the problem, until I had a solution. I had already noticed one peculiar thing about the Magic Numbers—the first-order differences of part of the sequence corresponds to the numbers of the edges of the Platonic solids. Thus, $8 - 2 = 6$, the edges of the tetrahedron; $20 - 8 = 12$, the number of edges for the cube and octahedron; and, skipping 28, $50 - 20 = 30$, the number of edges in the icosahedron and dodecahedron.

It was necessary, also, that the neutrons have a lawful place in the structure of the nucleus, for otherwise, why should some isotopes exist in abundance and others not? However, lacking charge, the neutrons would not have to have the same degree of symmetry as the protons. It was while considering the question why iron and palladium, two key singularities in the proton structure of the nucleus, did not appear as Magic Numbers that the idea for a lawful placement of the neutrons within the hypothesized structure of the proton shells came to me.

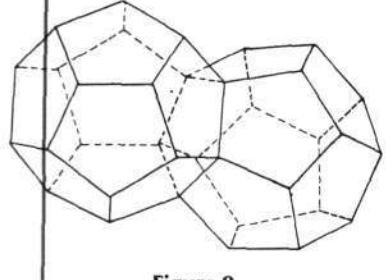


Figure 9
THE TWIN DODECAHEDRA
To go beyond palladium (atomic number 46), which is represented by the completed dodecahedron, an identical dodecahedron joins the first dodecahedron at a face. When fully joined in this way, the two figures represent the nucleus of radon (atomic number 86).

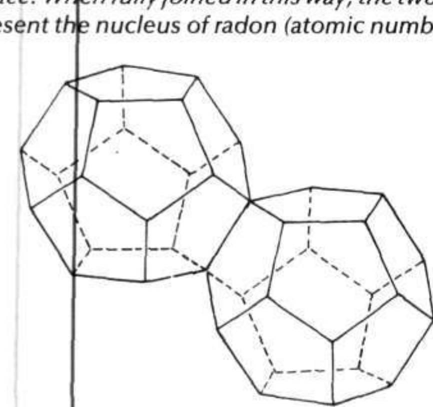


Figure 10
HINGING THE TWIN DODECAHEDRA
To go beyond radon (atomic number 86), the twin dodecahedra open up, using a common edge as if it were a hinge.

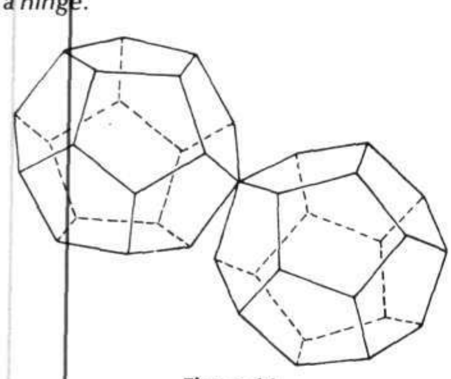


Figure 11
BREAKING THE HINGE
To create 91-protactinium, the hinge is broken at one end, staying attached at the other end.

Iron has 30 neutrons, palladium 60. The sum of the edges of the tetrahedron (6), cube (12), and octahedron (12) is equal to 30. The tetrahedron fits within the cube such that the midpoints of its edges lie one on the center of each cubic face (Figure 12). Within the tetrahedron, can sit an-

Continued on page 28

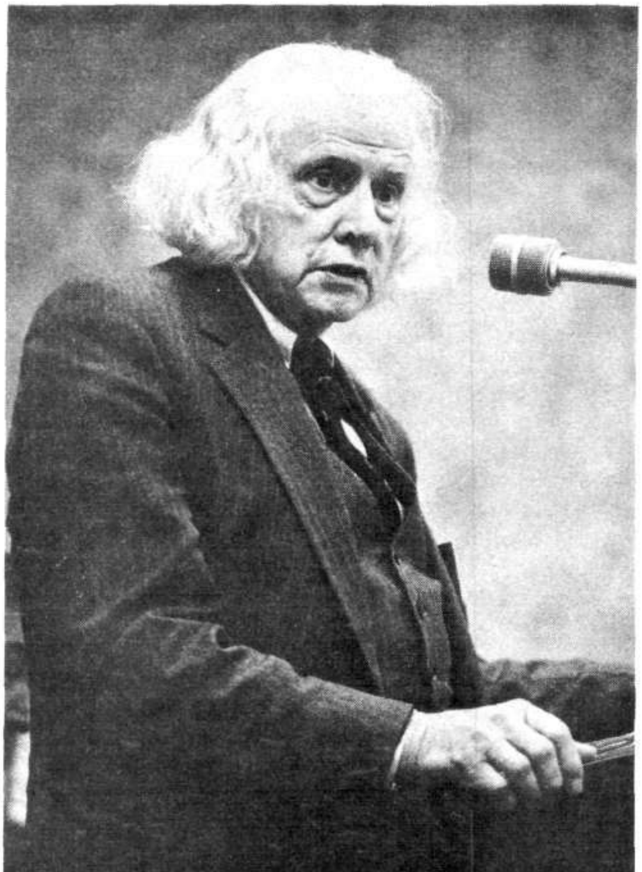
DR. ROBERT J. MOON:

'Space Must Be Quantized'

Robert J. Moon, professor emeritus at the University of Chicago, discussed the idea that led to his hypothesis of the geometry of the nucleus in an interview published in Executive Intelligence Review, *Nov. 6, 1987. His remarks are excerpted here.*

The particular experiment that provided the immediate spark leading to the development of my model of the nucleus was one by Nobel Prize winner Klaus von Klitzing.

Von Klitzing is a German who looked at the conductivity of very thin pieces of semiconductor. A couple of electrodes are placed on it. The electrodes are designed to keep a constant current running through the thin semiconductor strip. A uniform magnetic field is applied perpendicular to the thin strip, cutting across the flow of the electron current in the semiconductor strip. This applied magnetic field, thus, bends the conduction electrons in the semiconductor so that they move toward the side. If the field is of sufficient strength, the electrons become trapped into circular orbits.



Philip Ulanowsky

Dr. Robert J. Moon: "I began to conclude that there must be structure in space, and that space must be quantized."

This alteration of the paths of the conduction electrons produces what appears to be a charge potential across the strip and perpendicular to the original current flow, producing a resistance. If you measure this new potential as you increase the magnetic field, you find that the horizontal charge potential will rise until a plateau is reached. You can continue to increase the magnetic field without anything happening, within certain boundaries, but then once the magnetic field is increased beyond a certain value, the potential will begin to rise again until another plateau is reached, where, within certain boundaries, the potential again does not increase with an increasing magnetic field.

What is being measured is the Hall *resistance, the voltage* across the current flow, horizontal to the direction of the original current, divided by the original current.

All of this was done by von Klitzing at liquid hydrogen temperatures to keep it cool and prevent the vibration of particles in the semiconductor lattice, a silicon semiconductor. The current was kept constant by the electrodes embedded in it.

Under these special conditions, as the current is plotted as a function of the magnetic field, we find that plateaus emerge. There are five distinct plateaus. At the highest field strength the resistance turns out to be 25,812.815 ohms. As we reduce the field, we find the next plateau at 12,906 ohms, and so on, until after the fifth, the plateaus become less distinct.

The theory is that the strong magnetic field forces the electrons of a two-dimensional electron gas into closed paths. Just as in the atomic nucleus, only a definite number of rotational states is possible, and only a definite number of electrons can belong to the same state. This rotational state is called the Landau level.

What we have here is a slowly increasing magnetic induction, and resistance increases until plateau values are found. At these values, there is no further drop in voltage over a certain band of increased magnetic induction. Some electrons now appear to travel through the semiconductor as if it were a superconductor.

The question I asked myself was, why at higher field strengths did no more plateaus appear? Why did no higher plateau appear, for example, at 51,625 ohms? At the lower end it was clear what the boundary was—at the point at which six pairs of electrons were orbiting together, the electrons would be close-packed, but the magnetic field was too weak to create such a geometry. However, I asked myself what the limit was at the upper end.

This was what led to my model of the structure of the atomic nucleus. I started out by considering that the orbital structure of the electrons would have to account for the occurrence of the plateaus von Klitzing found, and I realized that the electrons had to be spinning together in pairs as well as orbiting. That was the significance of the upper boundary occurring at the value of 25,000-plus ohms.

I first concluded that this happens because the electron has a spin. It spins around its axis and a current is produced by the spin, and the spinning charges produce a little magnet.

According to Ohm's law, the current is equal to the field divided by the resistance, so that the resistance is equal to the field divided by the current. Von Klitzing found that the resistance in the last plateau was 25,812 ohms. I wanted to find out why this was the last distinct plateau.

First of all, I realized that the electrons seem to like each other very well. They travel around in pairs, especially in solid-state materials such as semiconductors. The spins will be in opposite directions, so that the north pole of one will match up with the south pole of the other.

Well, as long as we are limited to a two-dimensional space, then we see that by the time we get six pairs orbiting, we will have close packing. We see a geometry emerging, a structure of the electron flow in the semiconductor.

Now, the Hall resistance is determined by Planck's constant divided by the ratio of the charge squared. But we also find this term in the fine structure constant. Here, however, the Hall resistance must be multiplied by the term ($\mu_0 \times c$) [c = the velocity of light]; in other words, we must take the ratio of the Hall resistance to the impedance of free space. We can look at this as a ratio of two different kinds of resistance, that within a medium to that within free space itself.

This led me to look for a three-space geometry analogous to that which I had found in the two-dimensional space in which the Hall effect takes place. I began to wonder how many electron pairs could be put together in three-space, and I saw that one might go up to 68 pairs plus a single electron, in order to produce 137, which is the inverse of the fine structure constant.

Well, that's the way ideas begin to grow. Then it becomes very exciting. And then you begin to wonder, why these pairs, and why does this happen?

Space Has a Structure

The velocity of light times the permeability of free space is what we call the impedance of free space. There is something very interesting about the impedance of free space. According to accepted theory, free space is a vacuum. If this is so, how can it exhibit impedance? But it does. The answer, of course, is that there is no such thing as a vacuum, and what we call free space has a structure.

The impedance of free space is called reactive impedance, since we can store energy in it without the energy dissipating. Similarly, radiation will travel through a vacuum without losing energy. Since there is no matter in free space, there is nothing there to dissipate the energy. There is nothing for the radiation to collide with, so to speak, or be absorbed by, so the energy just keeps there. This is what we call the reactive component.

It is "reactive," because it does not dissipate the energy, but is passive. And this equals 376+ ohms. This reactive impedance is one of the important components of the equation of the fine structure constant.

The equations for the fine structure constant will always involve the ratio, 1:137, and actually this ratio, as Bohr looked at it, was the ratio of the velocity of the electron in the first Bohr orbit to the velocity of light. That is, if you multiply the velocity of the electron in the first Bohr orbit of the hydrogen atom by 137, you get the velocity of light.

The orbiting electron is bound to the hydrogen atom around which it is orbiting. This stuck in my mind for several years. Immediately as you begin looking at this ratio, you see that this is identical with the impedance in a material medium, like the semiconductor von Klitzing experimented with, compared to the permeability of space.

No Empty Space

Since the Hall resistance is dissipative, then we have here a ratio between two different kinds of resistance, a resistance within a material medium and a resistance of "space." That being the case, we are entitled to seek a geometry of space—or in other words, we are no longer able to talk about "empty space." From looking at von Klitzing's experiment, I was led to these new conclusions.

This is the equation for α, the fine structure constant:

$$1/\alpha = 2h/(e^2\mu_0 c).$$

Another conclusion I was able to draw, was why the number "2" appears in the fine structure constant. Well, it turns out that the 2 indicates the pairing of the electrons. And when you get this ratio, this turns out to be 1:137. So you have the ratio of the impedance of free space, which is nondissipative, over the impedance in a material media, as measured by von Klitzing, which is dissipative, giving you approximately 1:137. We have seen major advances in semiconductors in recent decades which permit us to make very accurate measurements of the fine structure constant.

Today, we have even better methods based on superconductors. In a superconductor, the impedance will be very low, like that of free space. There is no place for the electron in the superconductor to lose energy.

As a result of this, I began to conclude that there must be structure in space, and that space must be quantized. Of course, I had been thinking about these ideas in a more general way, for a long time, but looking at von Klitzing's work in this way, allowed me to put them together in a new way, and make some new discoveries.

other smaller tetrahedron, dual to its parent (Figure 13). The connection of the midpoints of the edges of the other four solids creates, respectively, the cuboctahedron—from the cube or octahedron—and the icosidodecahedron—from the icosahedron or dodecahedron (Figure 14).

These are the key concepts of geometry needed to see how the neutrons are lawfully placed on the already existing structure of the nucleus. Once this is done, it can be seen that the periodicity of Meyer and Mendeleyev's periodic table is completely coherent with this new view of the nucleus. *The points of completion of the proton shells define the points of greatest stability of the nucleus, reflected in the abundancy of these elements, while the completion of the neutron shells corresponds to the ends of the periods of the periodic table.* The neutron shells also have a highly symmetric and sometimes complete configuration in the elements for which the proton shells are complete. This is all readily seen in the table of neutron configurations I have hypothesized (Table 2).

The structure begins with a helium nucleus, or alpha particle—a tetrahedron containing two protons and two neutrons at its four vertices. To go on to the third element, lithium, the protons must move outward to start building up their first shell on the vertices of a cube. The two neu-

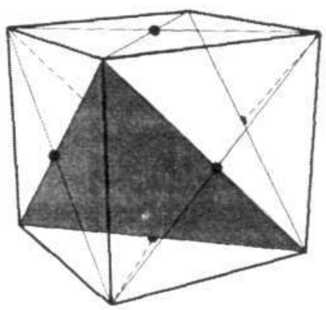


Figure 12
TETRAHEDRON INSCRIBED IN A CUBE
Every cube implies a tetrahedron. Four diagonally opposite vertices of the cube form the vertices of the tetrahedron. The six edges of the tetrahedron form the diagonals of the cube's faces, and their midpoints are equivalent to the center of the cubic faces.

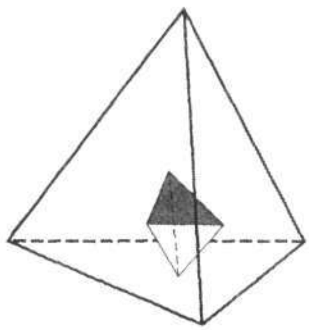


Figure 13
ALPHA PARTICLE AND TETRAHEDRON
The smaller dual tetrahedron, which represents the alpha particle, has an edge length only one third that of its parent.

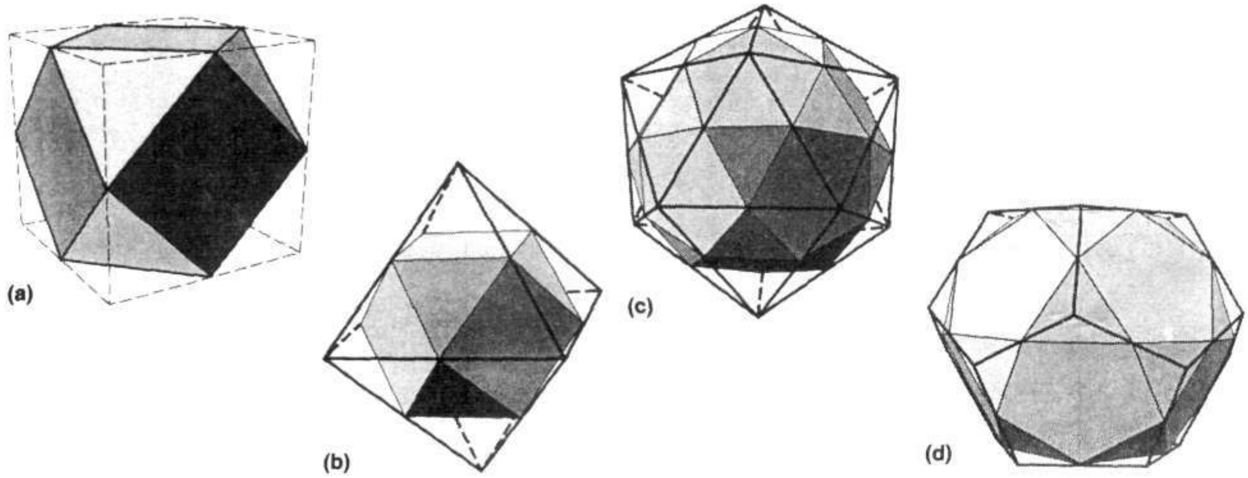


Figure 14
CUBOCTAHEDRON AND ICOSIDODECAHEDRON
The Archimedean solid known as the cuboctahedron can be derived by connecting the midpoints of the 12 edges of either the cube (a) or the octahedron (b). Similarly, the icosidodecahedron is derived by connecting the midpoints of either the icosahedron (c) or the dodecahedron (d).

trons that were on the vertices of the alpha particle have no need to leave. However, any additional neutrons will place themselves at the centers of the faces of the cube, which is the same place as the midpoints of the edges of the larger tetrahedron. (The smaller tetrahedron is called the alpha particle.) Thus, at 6-carbon-12, there are two neutrons on the alpha particle and four on the faces of the cube (Figure 15).[4] For clarity, here is another example: the proton structure of 8-oxygen-16 (Figure 16). Of the eight neutrons, two are on the inner alpha particle and six on the midpoints of the six edges of the larger tetrahedron (or, the same thing, the face centers of the cube), marking the completion of this shell. The eight protons locate on the eight vertices of the cube. Thus, not only is oxygen highly symmetrical with respect to its proton configuration, but also one of its neutron shells is complete.

Now, to go on to the end of the period, there are only two more places where the neutrons can go: that is, on the

Table 2
PROPOSED NEUTRON DISTRIBUTION CHART

Element	N=	Alpha particle	Edges of: Tetrahedron	Cube	Octahedron	Icosahedron	
2-He-4	2	2	Complete period				
3-**Li**-7	4	2	2				
4-**Be**-9	5	2	3				
5-**B**-10	5	2	3				
6-**C**-12	6	2	4				
7-**N**-14	7	2	5				
8-O-16	**8**	**2**	**6 Complete proton shell**				
9-**F**-19	10	4	6				
10-**Ne**-20	10	4	6 Complete period				
11-**Na**-23	12	4	6	2			
12-**Mg**-24	12	4	6	2			
13-**Al**-27	14	4	6	4			
14-Si-28	**14**	**4**	**6**	**4**	**Complete proton shell**		
15-**P**-31	16	4	6	6			
16-**S**-32	16	4	6	6			
17-**Cl**-35	18	4	6	8			
18-**Ar**-40	22	4	6	12	Complete period		
19-**K**-39	20	4	6	10	0		
20-**Ca**-40	20	4	6	10	0		
21-**Sc**-45	24	4	6	12	2		
22-**Ti**-48	26	4	6	12	4		
23-**V**-51	28	4	6	12	6		
24-**Cr**-52	28	4	6	12	6		
25-**Mn**-55	30	4	6	12	8		
26-Fe-56	**30**	**—**	**6**	**12**	**12**	**Complete proton shell**	
27-**Co**-59	32	—	6	12	12	2	
28-**Ni**-59	31	—	6	12	12	1	
29-**Cu**-64	35	—	6	12	12	5	
30-**Zn**-65	35	—	6	12	12	5	
31-**Ga**-70	40	—	6	12	12	10	
32-**Ge**-73	41	—	6	12	12	11	
33-**As**-75	42	—	6	12	12	12	
34-**Se**-79	45	—	6	12	12	15	
35-**Br**-80	45	—	6	12	12	15	
36-**Kr**-84	48	—	6	12	—	30	Complete period
37-**Rb**-85	48	—	6	12	12	18	
38-**Sr**-88	50	—	6	12	12	20	
39-**Y**-89	50	—	6	12	12	20	
40-**Zr**-92	52	—	6	12	12	22	
41-**Nb**-93	52	—	6	12	12	22	
42-**Mo**-96	54	—	6	12	12	24	
43-**Tc**-98	55	—	6	12	12	25	
44-**Ru**-101	57	—	6	12	12	27	
45-**Rh**-103	58	—	6	12	12	28	
46-Pd-106	**60**	**—**	**6**	**12**	**12**	**30**	**Complete proton shell**

remaining two vertices of the inner alpha particle. This is the configuration for 10-neon-20, the noble gas that ends the first small period. A similar situation, in which the neutron shells are completely filled, occurs with respect to the noble gases 18-argon-40 and 36-krypton-84, the latter with a slight perturbation.

At iron, the inner tetrahedron ceases to exist as a configuration for the neutrons, though, as we know, the configuration appears again as a mode of emission in the alpha decay of the heavier elements. Iron has an extraordinary symmetry for both its proton and neutron configurations, as shown in Table 2. Finally, at palladium, the symmetry is perfect and complete. The proton shells are entirely filled and so are those of the neutrons. Note that the neutrons always remain on the inside of the nucleus, one level deeper than the protons. Their existence outside this realm is precarious, where they have a half-life of only about 12 minutes.

The neutron configuration beyond palladium is structured on the same model, though it is not as simply represented since the figures making up the proton shells do not close until 86-radon. But the continuation of the same system all the way through the last natural element can be simply accounted for.

To close the case, let us take the last element, uranium. How, one might ask, can we account for uranium-238, which has 146 neutrons—considerably more than twice the 60 found in palladium? Recall that there were a few empty spaces left over on the faces of the icosahedron. When the octahedron was fit inside, its vertices took up only 6 of the 20 faces, leaving 14 open. Counting both "halves" of the uranium nucleus, that leaves 28 extra locations for the neutrons to fit symmetrically; 26 of them are used to create uranium-238, the preferred configuration. But uranium-240, the heaviest isotope of the last naturally occurring element, with a half-life of 14.1 hours, takes up all those possible places with its 148 neutrons.

Laurence Hecht, a geometer by avocation, worked closely with Robert J. Moon to elaborate Moon's hypothesis for the geometry of the nucleus.

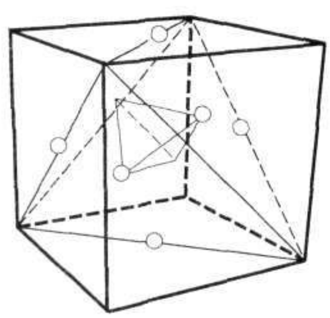


Figure 15
PROBABLE LOCATION OF CARBON NEUTRONS
In the author's scheme, the six neutrons in the carbon nucleus are positioned as shown: two on the vertices of the inner tetrahedron, four on the edge midpoints of the larger tetrahedron (which are the same as the face centers of the cube).

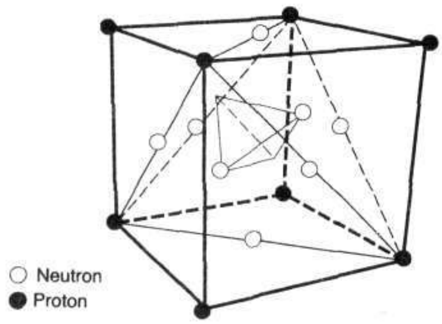


Figure 16
PROBABLE LOCATION OF THE OXYGEN-16 NEUTRONS AND PROTONS
Shown here are the likely locations of the eight neutrons (open) and eight protons (solid) in the oxygen-16 nucleus. There is a neutron on all six faces of the cube and on two of the four vertices of the alpha particle. Eight protons cover the eight vertices of the cube.

Notes

1. Dr. Moon developed his theory of the nucleus in spring 1986, shortly after his 75th birthday, while working at the Fusion Energy Foundation in Leesburg, Va. For a personal account of the development of his theory, see his two-part interview in the *Executive Intelligence Review*, Oct. 30, 1987, p. 31, and Nov. 6, 1987, p. 18.
2. All the Platonic solids can be formed by the intersections of great circles on a sphere, the great circle being the least-action path on the surface of the sphere, and the sphere the minimal three-dimensional volume created by elementary rotational action. The best way to see this is to consider the intersections of the great circles in a Torrianian, or Copernico-Pythagorean planetarium [cf. Johannes Kepler, *Mysterium Cosmographicum*, Dedicatory letter, trans. A.M. Duncan (New York: Abaris Press, 1981).]

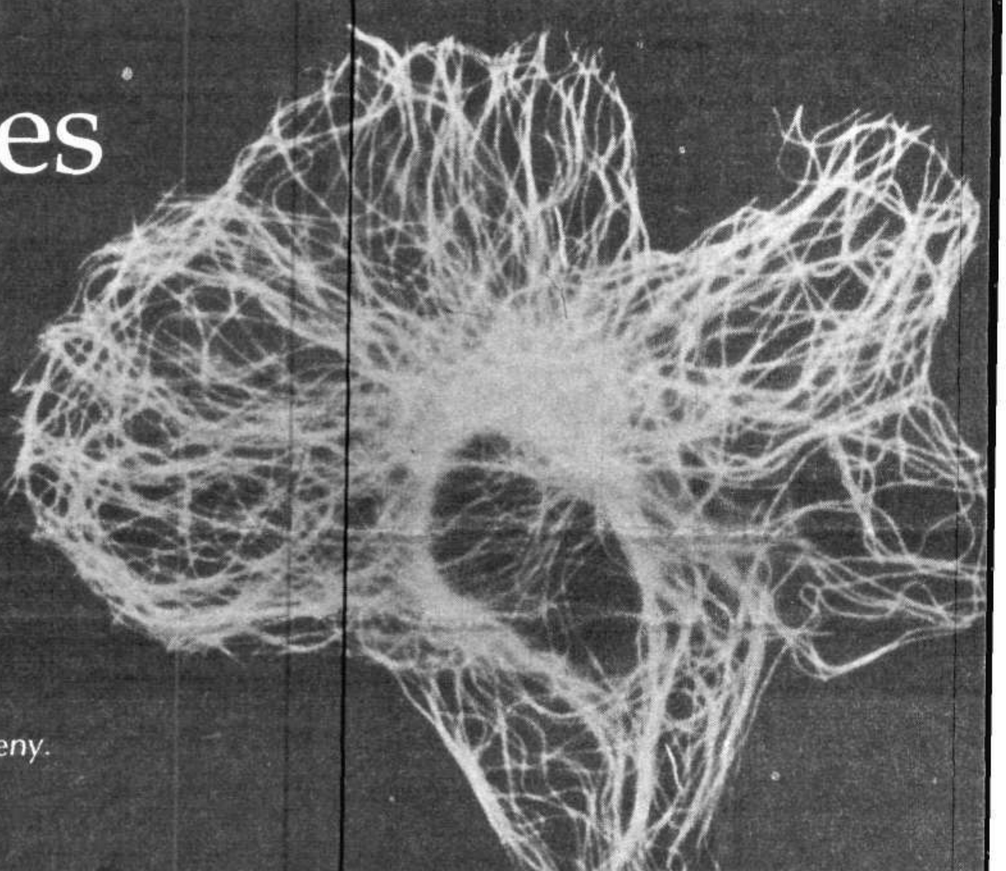
   In the device constructed by Giovanni Torriani to demonstrate Kepler's nested solid model for the solar system, the vertices of the regular solids are formed by the intersections of great circles. Three great circles intersect doubly to form an octahedron. Six great circles intersect triply in 8 places to form the vertices of a cube and doubly in 6 places over the faces of the cube. Fifteen great circles intersect 5-at-a-time in 12 locations, 3-at-a-time in 20 locations, and 2-at-a-time in 30 locations, forming respectively, the vertices of the icosahedron, dodecahedron, and icosidodecahedron.

   It is interesting that the tetrahedron is not uniquely determined in this construction, but is derivative from the vertices of the cube.
3. The divine proportion, also known as the golden mean or the golden section, defines the geometry of growth for living systems, plants and animals alike—from the seashell, to the leaf arrangement on a branch, to the proportions of the human body. It is also the characteristic ratio for nonliving processes in the very large and the small. The divine proportion divides a line so that the ratio of the full length of a line to its largest segment is proportional to the ratio of the segments to each other. When a decagon is inscribed in a circle, the ratio of the radius to an edge is the divine proportion. Designated mathematically as ϕ, the divine proportion ratio is $(\sqrt{5} + 1)/2$ or approximately 1.618.
4. This allows a speculation on the relation to extranuclear properties, viz. the carbon problem. Carbon has a tetrahedral bonding which is conventionally explained by the fact that the inner 1*s* orbital is held more tightly, while the four "valence" electrons do the bonding. Why? Now we can see that the tight bonding of the inner orbital might be caused by the alpha particle inside. For carbon, only four of the protons might move to the cube, locating themselves on the four vertices of the cube which correspond to a tetrahedral symmetry. These would be the four charges that determine the carbon bond. To maintain the charge symmetry, the other two would be held in the original alpha particle.

Curing AIDS by Mastering The Harmonies Of Cell Mitosis

No single biological question allows us to more directly confront the fundamentals of living processes—from curing AIDS to counteracting the aging process—than mitosis, the capacity of living organisms to grow, reproduce themselves, and transmit information to their progeny.

by Warren J. Hamerman



M. Schliwa, *The Cytoskeleton* (New York: Springer-Verlag, 1986), p. 50.

The geometric ordering of the cell is beautifully evident in this chicken embryo fibroblast, as seen by immunofluorescence microscopy.

Viewed from the standpoint of mitosis, the overall capacity of living organisms to reproduce themselves is virtually continuous. In the human being's bone marrow and other high mitotic areas, for example, 10-million cell divisions are occurring every second. The frontiers of 21st century biology will be shaped by science's success in understanding how this mitotic process is "tuned," its species-specific and tissue-specific harmonic laws, and the nature of the overall "musical system" within which healthy living forms have the freedom to lawfully develop, differentiate, proliferate, and evolve.

Just as surely as Johannes Kepler's discovery and Karl Gauss's later elaboration of the harmonies of the planetary solar system unveiled the mysteries of astrophysics, so too will the study of the harmonies of cell mitosis and cell division unveil the mysteries of the living process.

The unique biological feature of the slow-acting AIDS virus is that when it infects a cell, the genetic message or genome of the virus migrates to the nucleus, where it incorporates itself into the normal genetic message of the cell. Although the virus's genome succeeds in getting incorporated into the host cell's DNA, it may lie dormant across many cell divisions of the parent cell before the virus's message takes over, expresses itself while the cell is undergoing mitosis, and turns the cell into a virus "factory."

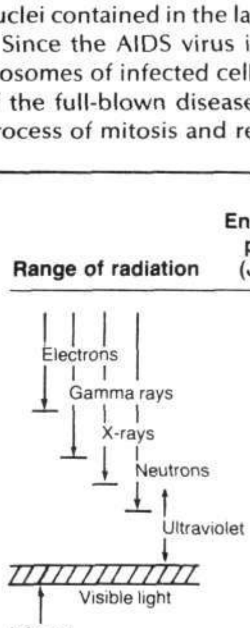
What is the nature of the "activation signal" that converts a latent infection into an actual one? This is one of the most central questions of AIDS research. There is currently a debate in the scientific community over whether the activation signal is an *antigenic* or a *mitogenic* stimulus, or both. (An antigenic signal refers to a stimulus from an antigen or protein specific to another disease to which the immune system is responding; a mitogenic stimulus results from a specific growth factor associated with cell division.) No matter what the origin, however, the signal's "tuning mechanism" must be governed by the same fundamental process, and it is theoretically possible to send the cell nucleus a "deactivation" signal instead of an "activation" signal.

Perhaps the most important biological clue to the unique nature of AIDS is that when the virus is activated, it causes the cells it infects to rapidly divide and grow, fusing or clumping together with hundreds and thousands of other cells, in a process often called *cell fusion*. The mitotic process in AIDS-infected cells looks exactly like the processes of reproduction that occur among the most primitive organisms in the evolutionary scale, such as the slime mold. The primitive slime mold grows in clumps in which one large mass can have hundreds and thousands of nuclei in the midst of a single cellular blob.

Cell fusion can be artificially induced and controlled in the modern laboratory by two means: First, and less efficient, is by various enzymes and chemicals, using the outdated technologies of molecular biology; second, and more efficient, is by "tuned" or "shaped" electromagnetic pulses, using the technologies of the 1990s and the 21st century in optical biophysics and bioelectromagnetics.

Cell fusion, however, is not just a phenomenon of laboratory experiments or primitive slime molds; it is the essence of what the AIDS virus does to the human body when the infection takes over. Medical doctors refer to the AIDS-caused cell mass or clump as a *syncytia* or *multinucleated giant cell* in the brain or other organs, because of all of the nuclei contained in the large mass.

Since the AIDS virus incorporates itself into the chromosomes of infected cells, the means for future outbreak of the full-blown disease state is reproduced in the very process of mitosis and replication of the infected tissues.



Range of radiation	Energy per photon (Joules)	Frequency ν (Hertz)	Wavelength λ (meters)
	10^{-11}	10^{22}	10^{-13}
	10^{-12}	10^{21}	10^{-12}
	10^{-13}	10^{20}	10^{-11}
	10^{-14}	10^{19}	10^{-10}
	10^{-15}	10^{18}	10^{-9}
	10^{-16}	10^{17}	10^{-8}
	10^{-17}	10^{16}	10^{-7}
	10^{-18}	10^{15}	10^{-6}
	10^{-19}	10^{14}	10^{-5}
	10^{-20}	10^{13}	10^{-4}
	10^{-21}	10^{12}	10^{-3}
	10^{-22}	10^{11}	10^{-2}
	10^{-23}	10^{10}	10^{-1}
	10^{-24}	10^{9}	1
	10^{-25}	10^{8}	10^{1}
	10^{-26}	10^{7}	10^{2}
	10^{-27}	10^{6}	10^{3}
	10^{-28}	10^{5}	10^{4}
	10^{-29}	10^{4}	10^{5}
	10^{-30}	10^{3}	

MEASURING ELECTROMAGNETIC RADIATION
Shown are the relationships of energy, frequency, and wavelength for the entire electromagnetic spectrum.

Therefore, the types of experimental approaches that give science the most advanced nonlinear spectroscopy of mitosis ought to be the basis for frontier AIDS research. Rapidly expanding the scientific knowledge base in this area not only will reveal some of the basic secrets of the living process itself, but also will open the way for future scientific research to intervene by "retuning" living cells away from unnatural "dissonances," like the deadly diseases of AIDS and cancer, as well as the unnatural aging processes.

To cure AIDS, and not just fight a losing war of attrition by "crisis managing" the clinical symptoms of a dying patient with chemotherapy, a scientist must cause the host cell line to "eject" the virus message during the course of mitosis. The goal is to cause the host cell to reproduce only the healthy portions of the DNA, and to *not* reproduce the portions of the nuclear DNA that contain the virus's message. Almost certainly, such a strategy will require at minimum 10 years of research on fundamentals. The key is not to base such intervention in the mitotic process on the "hit and miss" methods of molecular biology or biochemistry, which randomly try to find a unique gene, chemical, or molecule and then deduce its function through a series of trial-and-error experiments. Success requires the alternative, more advanced method of optical biophysics or nonlinear biological spectroscopy, the method of biological inquiry introduced by Louis Pasteur (1822-1895).

AIDS, Optical Biophysics, and Electrohydrodynamics

Optical biophysics is the study of the interaction of living substances with electromagnetic radiation over the entire range of wavelengths—from high-frequency gamma rays and X-rays to low-frequency radiowaves (see table). Today, these areas promise not only to give even more wonderful diagnostic and therapeutic methodologies to biology and medicine, but also to unlock the secrets of how living processes are "tuned."

Light, the basis of all biological activity, must be understood as a form of electromagnetic radiation that covers radiowaves, with wavelengths around 10^{-1} meters, to gamma rays, on the other end of the spectrum, with wavelengths around 10^{-11} meters. Historically, optical biophysics began in the visible range of the electromagnetic spectrum, which is just a tiny segment of the spectrum, from 4×10^{-7} to 7×10^{-7} meters. Spectroscopy refers to all the interactions of electromagnetic radiation with matter, including optical rotation, scattering, absorption, and emission.

One of the most exciting aspects of frontier optical biophysics is that there is no clear division between split-second precise diagnostics and screening on the one hand, and potential therapeutic interventions on the other. The scientist compares the unique spectral signatures of a healthy and diseased cell. At the moment he or she achieves a signal or spectra from those cells, the researcher also has the potential to "retune" or "detune" the source of the signal, and thus stop the spread of the disease.

In its broadest terms, the optical biophysics approach continues the classical electrohydrodynamic tradition that can be traced back to the studies of Leonardo da Vinci and Lucia Pacioli on the "golden harmonic" geometries appropriate to living forms and the filamentary "singularities" generated in hydrodynamic processes. This approach was continued through the work of Johannes Kepler, who studied the planetary musical intervals in the solar system, as determined by the five Platonic solids. This tradition was continued and enriched in the last decades of the 17th century by Gottfried Leibniz.

Leibniz influenced subsequent generations through his writings against the automatism and reductionism of Newton and Descartes, founding the method of *analysis situs* from the standpoint of a polemic against both of them. It is Leibniz's work, in fact, that carried science into the work of the great Göttingen scientists of the 19th century, Karl Gauss and his student Bernhard Riemann.

Bodies do not exist independently of position, and the geometric nature of space is not everywhere the same. In nature, the measure of the curvature is not everywhere constant. It was Gauss, Riemann, and their associates who laid the basis for our ability to apply geometric conceptions to basic electrohydrodynamic processes; they established the ability to study transformations from one phase space to another.

One would expect that only a mathematical-physics based upon synthetic geometry would be "pliable" enough to map biosyntheses through growth and development. Geometrically speaking, Riemann's approach to physics is centered upon the concept of an *n-fold extended manifold*, in which each phase space generates its own metrics and singularities. The nature of the series of manifolds is determined by the intrinsic generation of singularities through the series of transformations.

In his famous 1854 paper, "Hypotheses Which Lie at the Foundations of Geometry," Riemann cautioned that the ability to study nature faithfully, "just as far as the microscope permits," rests upon the geometric method the scientist employs: "Knowledge of the causal connection of phenomena is based essentially upon the precision with which we follow them down into the infinitely small."

Mitosis and Electromagnetics

Modern electron micrograph images of the ellipsoid spindle and other filaments in the mitotic process are more than visually suggestive of the phase space transformations in a harmonic self-ordering process of the sort depicted by Leonardo da Vinci in his studies of the golden proportion harmonics of plant and animal growth and the braided filaments and vortices displayed in hydrodynamics (Figures 1-3.

The first observations of the self-ordering of the ellipsoid spindle threads and the movement of the chromosomes along these protein "field lines" to the two poles through the various phase states of mitosis were made by biologist Walther Flemming (1843-1915), a little over a century ago. Working in Germany, Flemming first used the term mitosis in 1880 to describe the replication of the chromosome "threads." Slightly more than four decades later, the Russian biophysicist Alexander Gurwitsch (1874-1954), trained in Germany at the University of Munich, discovered the existence of mitogenic radiation in his famous experiments of rapid mitotic effects in onion roots. Over the past three decades, biologists have mastered the ability to synchronize cell cultures so that a large percentage of the cells is passing through the same part of the cell cycle at the same times.

Flemming was directly trained in the classic scientific tradition of Gauss, Riemann, and Riemann's physiologist associate, J. Henle, at the University of Göttingen, where he first studied medicine. Beginning in 1879, Flemming began to publish a series of major discoveries on the divisions in cell mitosis through his microscopic observations. In 1880, he proposed the term mitosis (the Greek word for thread) to describe the division in the cell nucleus that precedes full cell division, where he observed the chromosomes to line up on the threadlike spindle apparatus. In addition to the term mitosis, Flemming is also responsible for introducing the terms *chromatin, aster,* and *centrosome*.

Seventy years after Flemming's work, in 1952, two biologists succeeded in developing a method for the mass isolation of the mitotic apparatus, which led to the identification of the mitotic spindle, chromosomes, and asters as coherent structures. Simultaneously, biological studies of in vivo imaging focused on the continuous fibrous structures in the cytoplasm with the polarizing microscope and other means. By the late 1950s to early 1960s, the dynamic aspects of the spindle fibers were discovered. In the early

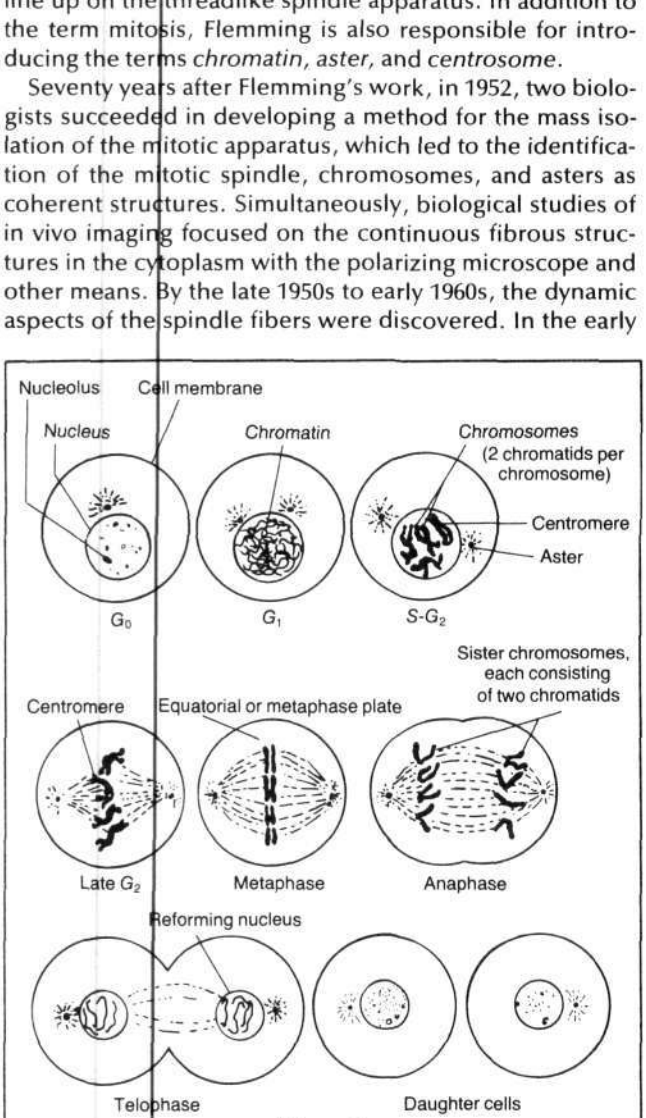


Figure 1
THE PROCESS OF MITOSIS

In living organisms the process of mitosis and cell division is virtually continuous. Although the "stages" of mitosis are useful to organize one's thinking about the continuous process, the curtain does not come down between acts, so to speak.

How Mitosis Occurs

Mitosis is the division of the cell nucleus into two daughter nuclei. Eukaryotic cells, the more advanced cells that are common in most plants and animals, undergo the complex nuclear division process of mitosis, while the more primitive prokaryotic cells reproduce through simple binary fission.

During the early 1950s, it became apparent from microspectrophotometry and from autoradiography studies that DNA synthesis itself occurred during a restricted period among these eukaryotic cells. In 1953, A. Howard and S.R. Pelc proposed the following terminology for the eukaryotic cell division cycle:

G_0 = the ground state or resting stage;
G_1 = the first growth phase before replication synthesis of DNA;
S = synthesis of DNA;
G_2 = the second growth phase after synthesis in which the cell prepares for the division process itself;
M = metaphase, in which the spindle fibers and bipolar orientation is well defined, the centromeres align on the *metaphase plate*, the chromatids unwind;
A = anaphase, in which the chromosomes move toward the poles along the spindle fibers;
T = telophase, in which the chromosomes regroup into two nuclei at each of the poles, followed by the development of a nuclei membrane separating two daughter cells.

The DNA synthesis and duplication of the chromosomes represent a relatively late event in the mitotic cycle, as scientists by the late 1950s were able to precisely measure (see Figure 4). In the multiplication of a mammalian cell with an average 25-hour multiplication cycle, the S period of DNA replication does not begin for 12 hours into the cycle. The S phase lasts for an 8-hour period, followed by a 4-hour G_2 period, and a 1-hour period for the metaphase-anaphase-telophase division process. The time of the division cycle varies according to differences in both species and tissues within the same species, and cellular environmental factors such as temperature and bioradiation conditions.

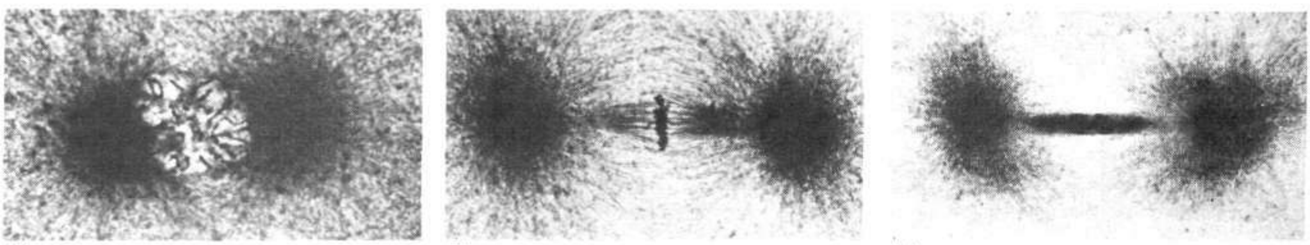
By the mid-1960s, it was known that in nearly all eukaryotic cells, there is periodic rather than a continuous synthesis of DNA, while in prokaryotic cells there is continuous synthesis. The question remaining is, what regulates this highly ordered *negentropic* process?

Mitosis Is Not Mechanistic

There are fundamental problems of reductionist-mechanistic theories in studying mitosis in living biological phase states.

First, *biochemical approaches* are limited by their mechanical model of complex interactions among fixed structures in which mysterious forces push and pull little hard molecules into or away from each other. Nonetheless, a cell may have as many as 100,000 chemical reactions per second; no amount of built-in structural templates or intricate interaction of so-called forces can regulate and coordinate such an intricate process. Many thoughtful biologists have recently published papers acknowledging that the field itself was troubled by a series of seemingly unsolvable "anomalies."

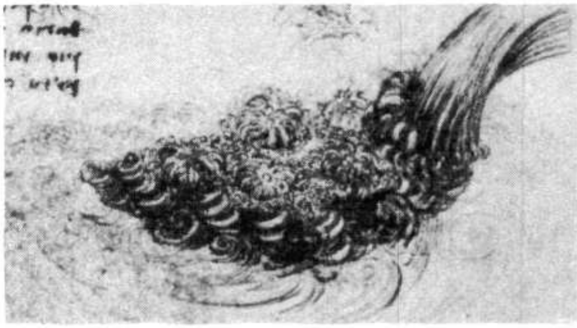
Are the chromosomes pushed or pulled to the poles along the spindle fibers during anaphase? If so, by what, how, and why? The spindle fibers have been analyzed to have an amino acid composition similar to that of the muscle protein actin. Do the two main proteins that are responsible for the force production in contracting muscle fibers—actin and myosin—appear at just the right moment in the right quantities to catalyze a muscle-like contraction among the



(a) (b) (c)

Figure 2
THREE PHASES OF MITOTIC NUCLEAR DIVISION
These photomicrographs show three successive phases of a mitotic nuclear division. In (a), the chromosomes are already visible in the center region where the spindle is organizing. The spindle is fully developed in (b) and the chromosomes are regularly aligned in its equatorial plane.

In (c) the two daughter sets of chromosomes have separated and each set is being drawn toward one pole of the spindle.



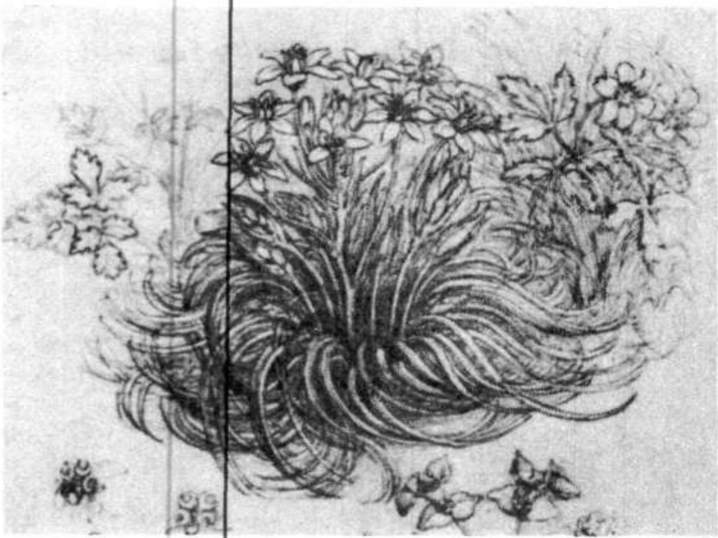


Figure 3
THE HYDRODYNAMIC TRADITION OF LEONARDO
Leonardo da Vinci's nature drawings depict not only the living form, but the process of growth involved. Right, a "star of Bethlehem" and above, a study of water falling into a pool. Both drawings are from the collection at the Royal Library, Windsor Castle.

spindle fibers and thereby tug the chromosomes to their respective poles? Or, do microtubules miraculously assemble at just the right moment to push the organelles apart, and do they then begin to disassemble again at just the right moment to pull the organelles together?

Second, *molecular biology approaches*—molecular genetics, genetic engineering, and recombinant DNA technology—cannot escape the mathematical limitations of a supersophisticated computer-tape model where the genomic "software" is presented as a linear code readout. Despite the effectiveness of genetic engineering technologies as the basis for performing all sorts of useful and wonderful interventions into the cell process, the methodology behind the engineering is completely inadequate for understanding fundamental *causality* in the reproduction process.

It has been possible, for example, to completely sequence the genetic code of the rapidly mutating AIDS virus without understanding how or why it biologically interacts with the cell.

For instance, molecular biologists themselves know that their conception of a "point mutation" as a change in one so-called codon, or triplet base-pair sequence in the DNA "backbone," cannot deal with the rather regular phenomenon of "frame-shift mutations." The computer "language" of the linear code is post-World War II information theory, *in which the sequence of nucleotide bases in the DNA* molecule serves as a coded template for the synthesis of a linear tape sequence: DNA is transcribed into RNA, which is in turn translated into enzymes (protein), which catalyze all the cellular biochemical reactions. According to the dogma, one gene codes for one enzyme (protein). Yet, what causes the right amount of mitogenic polypeptide "growth factors" and the so-called regulatory peptides to appear in just the right amounts in the right place at the right time?

In real biological space-time, the DNA is superdensely packed into the nucleus; it is not a free-standing, neatly ordered stack of computer disks, or an elegant double-helical statue on its own pedestal, gently rotating in the wind. The completely unwound DNA from a single mammalian cell nucleus is approximately 50 centimeters (cm) long and it is packed into a nucleus whose diameter is 10 micrometers wide. In other words, were DNA to be conceived of as a single statue gently rotating on its own pedestal, it would have to fold upon itself 50,000 times simply to fit into the nucleus. The DNA in the body of one human being alone, if unwound, would correspond to the diameter of our planetary system—about 10 billion kilometers.

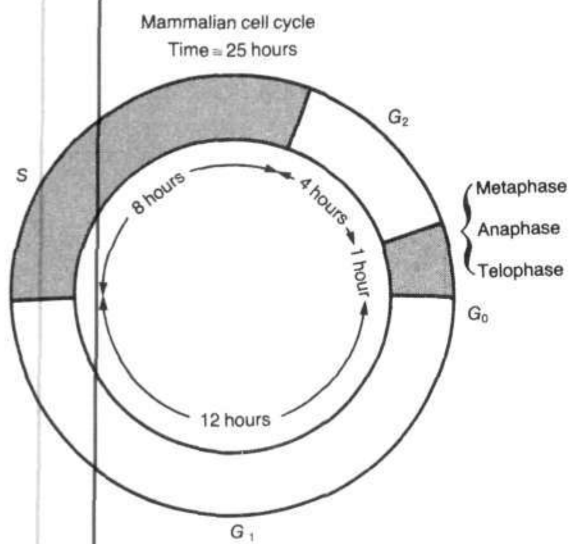


Figure 4
MAMMALIAN CELL CYCLE
By the late 1950s, scientists had measured the various stages in the approximately 25-hour multiplication cycle of a mammalian cell. G_0 represents the resting or ground state, where there is least action and greatest coherence; G_1 represents the growth before DNA replication; and S represents the DNA synthesis stage. Note that in G_1, radiation begins in the optical range and downshifts to the microwave range.

1960s, electron microscopists began to speak about mitotic *microtubules* or *paired fibrils*. By the mid-1960s, the lability of the fibrils of the spindle became the basis for an entire range of theories to explain the movement of the chromosomes.

Simultaneously, biophysicists have developed a growing arsenal of spectroscopic instruments with which to image, measure, and study the electromagnetic phase changes of the mitotic process in the small. Therefore, we are now at the beginning stages of a thrilling scientific era in which we can study the overall electromagnetic, spatial, and geometric characteristics of the developing cell cycle from the standpoint of a self-developing electromagnetic field, as described by Gauss. Indeed, no observer who is literate in the history of classical science can view the beautiful geometric ordering of the spindle fibers without thinking about the geometric and experimental work of Gauss and the school he initiated at Göttingen University—encompassing the work of the Weber brothers and later Riemann—on the nature of electromagnetic fields, the relationship between shifting electromagnetic flux densities and the nature of the surface as a whole, the generation of singularities intrinsic to the development laws of the process, and the self-ordering character of the overall process.

Over the past 15 years, biologists have focused considerable attention on studying the various filamentary components of the cytoplasm—microtubules, microfilaments, intermediate filaments, and associated proteins—which collectively have been given the unfortunate name "the cytoskeleton." This integrated system of molecules that provides cells with their shape and internal spatial geometry, far from resembling a rigid skeleton, displays the unmistakable characteristics of a sequence of phase space transformations first explored by Leonardo da Vinci.

One of the intrinsic problems of modern biology is that so many detailed images of once-alive cells have been published, that people have a mental image of a static flat surface on a plane adorned with various structures. Electron micrographs, for instance, which magnify images up to 200,000 times, can be made only by first killing the sample, slicing it very thin, pouring heavy metal stains over it, and placing it in a vacuum for viewing. Unfortunately, the dead *ultrastructures* one then views through this method can easily be suggestive of a nonhydrodynamic, mechanical process.

Science has strayed far from the classical method epitomized by the *electrohydrodynamic* tradition. While an immense amount of knowledge has been accumulated by modern biologists on the mechanics and structure of the *mitotic process, very little is actually understood about* what causes the difference between healthy dividing cells and cells that are *provirus* (replicate the means of infecting other cells), tumor cells, and aging cell lines.

As a series of recent review articles by leading cell biologists has emphasized, despite all that is now known, the study of mitosis may be at a dead end in terms of understanding the basic biological causality of the process. A self-reproducing cell line cannot be explained as a sequence of "bags of enzymes" or "little biochemical factories" fueled by a closed-cycle heat engine and directed by a supercomputer center with a fantastically complicated computer-tape software program with built-in nonlinear pathways. Such models cannot make the "jump" from one cell to its daughters. They cannot explain how or why a cell may "throw out" a virus particle from its own genetic material.

New Research Directions

There are three scientific research efforts in optical biophysics that converge on a common concept in expanding our knowledge base about the mitotic process: The work of Professor Sydney Webb of Canada; various U.S. researchers at Los Alamos National Laboratory, the University of New Mexico, and Lawrence Berkeley Laboratory, working on advanced circularly polarized microscopes; and Dr. Fritz-Albert Popp of the Kaiserslautern Technology Center in West Germany. Each line of research has demonstrated unique experimental data that show variations in the optical biophysics characteristics of cell life over the course of cell mitosis. These three very different experimental setups, support a common hypothesis: Over the course of the cell division cycle the electromagnetic radiation spectra vary.

For his part, Webb has studied the harmonic properties of living cells, utilizing millimeter microwaves and Raman spectroscopy, and found that the biologically effective frequencies formed a definite nonlinear series, suggesting that they all were related via the "harmonics" of some fundamental oscillatory mode or modes in living processes. Raman scattering and Raman resonance spectroscopies give information on molecular vibrations that cause upshifts and downshifts in the frequency of light that hits and is scattered by the sample. Although the frequencies changed with time and nutrition, their nonlinear relationship did not.

Webb discovered that in every healthy growing cell, two definite series could be clearly demonstrated: the healthy cell undergoing mitosis was "tuned" differently than the cancerous cell. While healthy cell growth had two definite harmonic series, mouse mammary carcinoma cells (those with cancer) formed *three* and sometimes *four* series. Furthermore, Webb observed that in mitosis there is a difference between the tuning of the mother cell and the daughter cells. In a result which may be related as well to the aging process, he observed that each cell-division cycle seems to start from a slightly higher energy level so that each new generation of cells has to exert more energy in reproduction. Raman spectroscopy of the living cell at rest found that such cells were Raman inactive. However, under mitosis, the cell progresses to higher-frequency oscillations.

In the experiments with circularly polarized light at the laboratories mentioned above, researchers utilized a special spectroscopic technique which enables them to map transformations in the molecular structure—its spatial organization—by the pattern in which it interacts with circularly polarized light (Maestre et al. 1985). What is measured is circular dichorism (CD), the difference in absorption cross section exhibited by a sample when it is illuminated successively with right- and left-circularly polarized light. As a

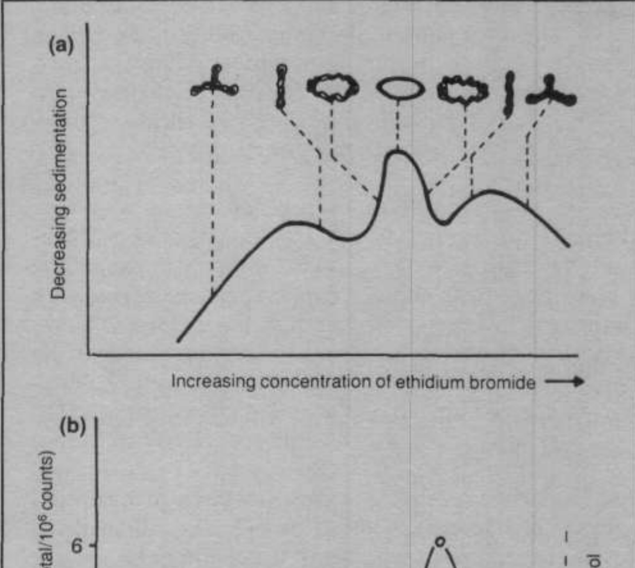


Figure 5
DNA AS THE CELL'S 'LASER'

The double helical organization of DNA with its "golden" geometric proportions gives it the potential to "store," "upshift," and "transmit" photons in the form of coherent electromagnetic action, according to F.-A. Popp. A correlation between the unwinding and rewinding of DNA with a parallel increase and decrease of photon emission from the DNA is shown in (a). Ethidium bromide (EB), a red dye, intercalates itself into the DNA molecule, thereby unwinding its superstructure, a process than can be established by DNA sedimentation. After the complete unwinding of the DNA (circular form in the center), it renews rewinding in the opposite spin direction. Shown in (b) are ultraweak cell photon emissions after treatment with EB solutions. The lowest curve (after 1 hour) already shows the same EB concentration dependency seen in (a).

result of this research, a related phenomenon of light scattering was discovered, called *circular intensity differential scattering* or CIDS.

These technologies have been used to study Chinese hamster cells through the cell cycle. As the cells progressed through the mitotic cycle, their spectral data shifted remarkably, as the chromatin first replicated and then organized into "handed" superstructure geometries that differentially scattered circularly polarized light. As the cell marched through its cycle, the spectral data clustered in three main spectral regions: (1) the region above 290 nanometers (nm), or the scattering region; (2) the 250-290 nm regions, which conform to nucleic acid absorption; and (3) the region below 240 nm, which is characterized as the area of maximum protein absorption.

This spectroscopic technique is based upon the insights of Louis Pasteur into the relationship between the geometric "handedness" of biological molecules, the way they rotate, fold, and organize space, and their optical activity interaction with polarized light. Thus, the research on the cell cycle gives a unique scientific "window" into the way in which the spatial organization varies over the course of the cell cycle.

Mitogenic Radiation

Finally, Dr. Fritz-Albert Popp's work presents the most general insights into the process of radiation variation over the course of the cell cycle. Popp has devoted his life's work to studying coherent ultraweak photon emissions from living tissues. Using cucumber seedlings, he has demonstrated that photon emission is most pronounced when cells are rapidly dividing, as in the seedling stage. He has demonstrated experimentally and theoretically that the biophoton luminescence originates from an electromagnetic field with a surprisingly high degree of coherence. The DNA can be conceived of as the cell's "antenna," having the potential to store and then retransmit biophotons, or coherent electromagnetic radiation.

Popp's hypothesis is that the biomolecule with the highest information density, DNA, is the best candidate for the site of the biophoton regulatory radiation and that it functions as an *exciplex* laser. In DNA, excited molecule complexes or exciplexes are generated when one portion of the complex takes in a photon and stores it in a relatively long-living metastable state of excitation. The localized area has been described as an "excited energy trap" and characterizes many of the most interesting biological "antenna" molecules—for example, DNA, RNA, chlorophyll, and ATP. Transitions into exciplex states are synchronized and are capable of coherent photon emissions.

The living cell can be conceptualized as a light-receiving and light-absorbing system, which is "pumped" like a laser by its own metabolism (Figure 5). Mitosis is a method by which the cell creates a higher state of coherence in tissue. After division two cells are coherent with each other in terms of frequency and harmonic ordering. The critical event is the triggering of the cell from the G_0 (resting phase) to the G_1. In the G_1 phase, the radiation starts in the optical range and then shifts downward into the microwave range as the cell division process proceeds:

> This phenomenon of "ultraweak" photon emission from living cells and organisms which is different from bioluminescence, exhibits an intensity of a few up to some hundred photons per second and per square centimeter of surface area. Its spectral distribution ranges at least from infrared (at about 900 nm) to ultra-

violet (up to about 200 nm). . . . There are distinct correlations of photon intensity and conformational states of DNA, or DNase activity during meiosis. At present there exists no further doubt about the physiological character of biophoton emission, since it exhibits just the same temperature dependence as it is characteristic for most of the physiological functions [Popp 1986].

Popp has constructed a laboratory means to measure the low-level luminescence, which corresponds to the intensity of a candle at a distance of about 10 kilometers, and this has allowed him to reap a rich amount of experimental data in exploring "mitogenic radiation."

Popp is building on much earlier work by the German-educated Russian scientist Alexander Gurwitsch, who discovered mitogenic radiation as a lawful extension of applying the classical scientific conception of the electromagnetic field to biological phenomena. In a 1912 paper, Gurwitsch first introduced the conception of the *biological field.* Since genes act in different cells in a coordinated fashion, as in the development of certain tissue-specific cell lines from the same embryo, obviously there is some type of supracellular command.

Beginning in 1904, Gurwitsch began to study the morphological field in various embryos. In a series of experiments beginning with research on the development of shark brains in 1912, Gurwitsch studied the coordination of large numbers of cells that behaved as a common suprageometric living form: the biological field. He pursued his work on sea urchin eggs and began to study the remarkable synchronization of mitosis in a developing living form. Up through a certain stage of divisions of the blastomeres, all cell divisions are synchronous and produce the same results, as they share a common surface. Then, the mitotic divisions begin to exhibit cellular differentiation. How is this highly complex process coordinated?

Gurwitsch came to the conclusion that mitosis is regulated through a *radiation* phenomenon. Early in the 1920s, he studied the meristems of onion roots. Plant meristems are the areas with one of the highest mitotic indices in the living world (the mitotic index is the ratio between the number of cells undergoing mitosis to the total number of cells). Through these famous experiments, Gurwitsch developed a cellular resonance theory based upon a conception of what he called *mitogenic radiation.* He found that the potential for mitosis is relative to the size of the cell colony.

Gurwitsch demonstrated that the radiation was in the ultraviolet portion of the electromagnetic spectrum. In his experiment, he observed a large increase in the number of cell divisions of an onion root, when a second onion root was brought near to the first. When quartz glass, which does not absorb in the ultraviolet region, is placed between the two onion roots, the enhanced cell divisions occurred just as if there were no glass separating them. However, when normal ultraviolet-proof window glass was placed between the two onion roots, the "mitogenic effect" stopped. After World War II, as a result of the development of sensitive photon counters, scientists began to detect extremely weak emissions from dividing animal and plant cells.

Among the most fruitful explorations of radiation phenomena in cell division are those of Professor Sydney Webb, who has conducted a several-decades-long exploration of the harmonic properties of living cells across the cell division cycle. He found that when cells were exposed as aerosols to periods of semidehydration and various doses of electromagnetic radiation, the cells could not tolerate simultaneous "step-down" changes in both their carbon and nitrogen supply until at least one cell division had been allowed to occur in the altered nutritional environment. As long as the cells were allowed to "adjust" *through the process of mitosis* to the changed nutritional environment, the cell line would survive. This occurred despite the fact that the mother cell did not do well in the stressed environment.

In other words, when experiments exposed a cell to nutritional changes, the cell's response was to produce two daughter cells equipped, so to speak, with an adjusted enzymatic molecular constituency. This could be measured, for the mother cell line conducted mitosis at a much slower rate than the daughter cell line. Neither the standard assumptions of biochemistry nor those of molecular genetics can explain the causality of such a process. Webb looked to the conception of what is called the *electrohydrodynamic* field in basic physics for an approach to such questions.

Webb began in the early 1950s by studying the relative stability of some plant viruses under the stresses of dehydration and radiation, and his experiments proceeded to investigate the role played by "bound" water molecules in the structure and function of macromolecules and complexes of them in the living process. As a by-product of this work, he hypothesized that biologically bound water should absorb microwaves.

Webb extensively studied the bioeffects of microwaves on cells as their age and nutrition varied. *His work has established that the cell responds only to certain frequencies of waves, and that the particular frequencies change with its age and nutrition.* In other words, the effects are "expressed" through mitosis.

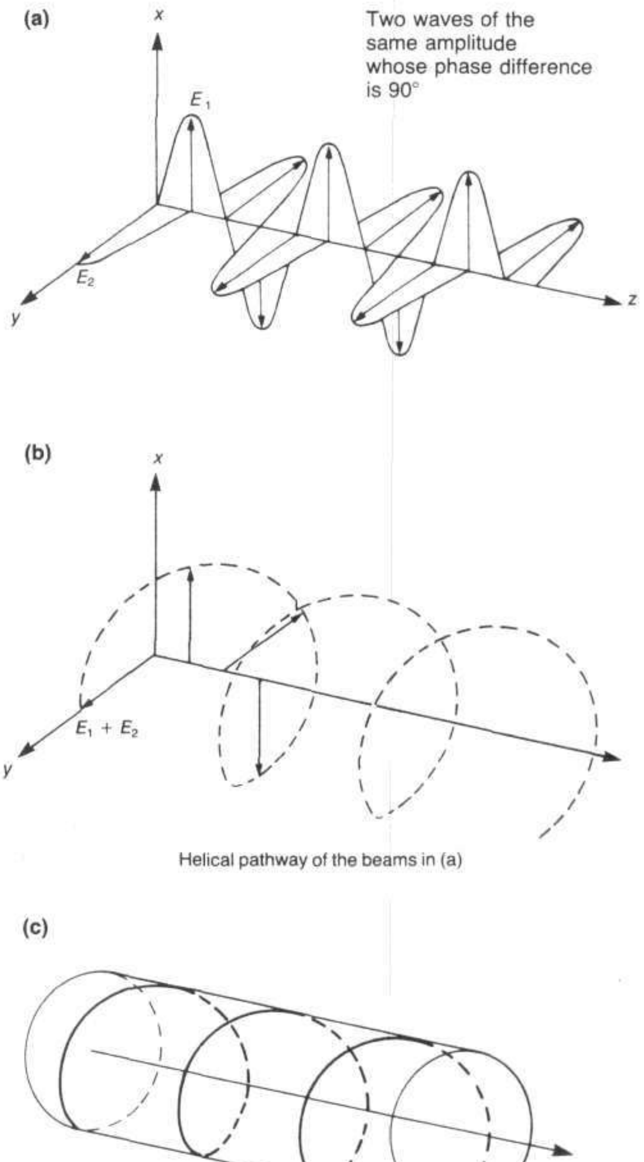
The frequencies able to change the rate of RNA synthesis in the living cell differ from those able to effect the synthesis of protein and DNA. However, the RNA made under irradiation from a frequency able to alter protein and DNA synthesis has a small molecular weight, which suggests that the coding from DNA to protein via messenger RNA is "uncoupled."

Like many crystals, the cell has to be activated to respond to these waves. In its active state (post mitosis), the cell not only can receive electromagnetic energy but also can *amplify* it. This would play a crucial role when the individual oscillations of macromolecules are not simply added together but "shift" to a new coherent ordering frequency as the macromolecules form complexes.

More recently, Webb has used Raman spectroscopy to show the internal oscillations of whole cells. Instead of the very complicated spectrum of lines that would be expected from the large number of ongoing individual oscillations, there was no spectrum at all in the resting stage, G_0. Once the cell mass was activated, however, by addition of a suitable nutrient containing a usable oxidizable carbon source,

Figure 6

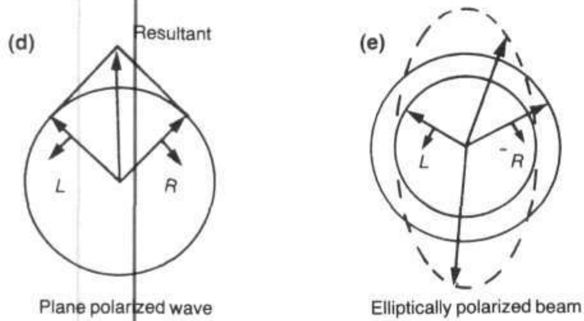
SCHEMATIC OF CIRCULARLY POLARIZED BEAMS



Circularly polarized light is composed of two waves of the same amplitude whose oscillations are not in the same phase. In (a) the phase difference between the two waves is π/2 or 90°. One beam is polarized along xy *and the other is polarized 90° phase-shifted along the* yz *axis. Thus, when the phase difference is π/2 and the amplitudes are equal, one wave superimposed on the other will generate a helical pathway. The helical pathway of circularly polarized light of π/2 radians phase difference is illustrated in (b) and (c).*

Two beams—one left circularly polarized and the other right circularly polarized are superimposed on one another in (d) and (e). The beam is left circularly polarized if the rotational action goes around counterclockwise looking at the beam head-on, and right circularly polarized if the rotational action is clockwise. Two circularly polarized beams of equal amplitude are shown in (d) where the E *vector is rotating in a right-handed* (R) *and left-handed* (L) *sense. The resultant of these two components is a plane-polarized wave.*

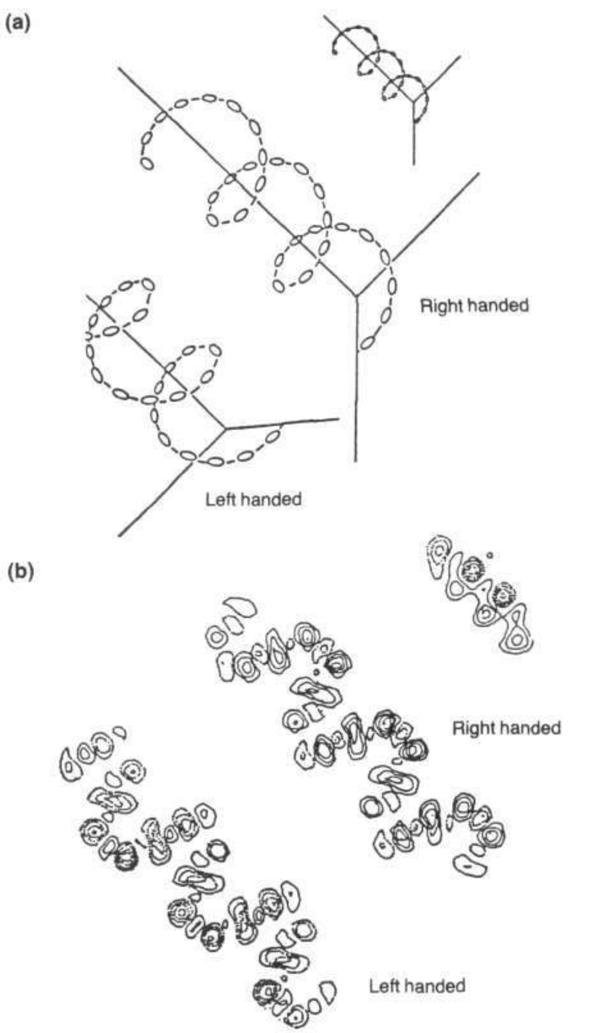
The classic geometry for circular dichroism (CD) studies is shown in (e). The left and right circularly polarized beams have different amplitudes after passing through the biological sample. In other words, (e) shows that two circularly polarized beams combine to give an elliptically polarized beam. The sample interacts with the beams to alter their amplitude depending upon the geometric organization of the sample being studied—both the way in which the molecular sample organizes its own space and the way it folds upon itself.



a Raman spectrum appeared. Later when the spectra were analyzed with respect to time, lines between 200 and 3,400 cm^{-1} were found to gradually move to higher frequencies, while those between 5 and 200 cm^{-1} moved to lower ones.

Interestingly, just before cell division, the spectrum became essentially devoid of lines except for one or two lines of high intensity and high frequency, around 2,100 cm^{-1}, which suggested that all available energy at this stage was devoted to the division process. Webb comments on the work:

A recent mathematical analysis of the lines above 200 cm^{-1} has shown that they all emanate from 2 to 4 fundamental modes; that is, all lines appear to be the nonlinear "harmonics" of 2 to 4 fundamental in vivo oscillations. The implication, therefore, is that, because these lines move to higher frequencies as the cell progresses through its life cycle, each successive metabolic step it makes requires a higher energy input, thus higher and higher energies must be directed to and concentrated in given areas of the cell as it ages. . . .



Source: Keller et al., 1985. "Imaging of Optically Active Biological Structures by Use of Circularly Polarized Light," *Proceedings Nat'l Acad. Sci.* **82**:401 (Jan. 1985).

Figure 7
IMAGING BIOLOGICAL STRUCTURES WITH CIRCULARLY POLARIZED LIGHT

Shown in (a) is a model of how optically active biological structures are imaged by use of circularly polarized light. Of the three helices, the two large helices are equal in size (pitch = 600 nm, radius = 300 nm, three turns long) but have opposite handedness; while the small helix (also three turns long) has a pitch of 200 nm and radius of 100 nm.

The image of the three helices using the circular differential approach is shown in (b). The light is incident from the bottom; the point of view is looking down from the top. Continuous contours indicate positive values for the circular differential image, while dotted contours indicate negative values. The incident wavelength is 60 nm. The circular differential image is achieved by subtracting the values of images formed under alternating beams of right- and left-circularly polarized light.

[T]he daughter cell does not begin its cycle with the fundamental oscillations of the parent generation, but with ones of the next higher harmonic; thus every generation asexually produced seems to require slightly higher energies to begin its cycle [Webb 1985].

Other analyses on the Raman lines below 200 cm^{-1}, which *remain longer during the cell's lifetime although moving* slowly to lower energies, correspond to the fundamental and harmonics of a solitary wave known as a soliton, traveling through large macromolecules and complexes of them. A soliton is the opposite of a water wave, which quickly dissipates to a series of ripples.

To study the relationship between a soliton theory and the movement of oscillations to lower frequencies as the cell aged, Webb constructed a histogram of the lines seen in eight Raman spectra taken at the same time in the life cycle of *Escherichia coli* cells. In addition to the bacterial cells, he *studied normal and tumor* cell lines.

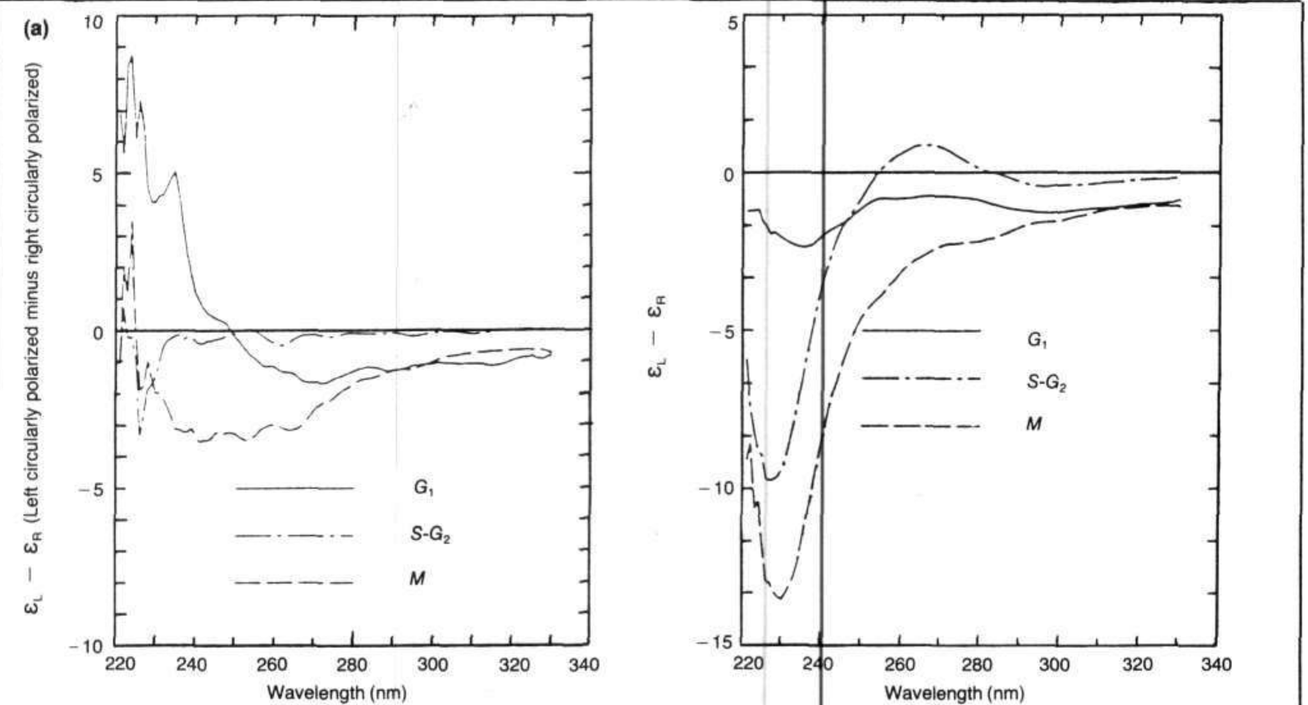
Mitosis and Advanced Spectroscopy

How can the electromagnetic radiation variation through the cell replication cycle be precisely discerned? Furthermore, can the process give a unique "signature" in such a way as to present any clues of the interrelationship between the tuning and folding of the superhelical tertiary structure of biological molecules? In short, is there a "phase angle" relationship, which can be characterized as a Gaussian complex function with two intertwined rotational action *components—a strictly geometric angular momentum* component per se as well as an electromagnetic radiation (tuning) action component?

One such spectroscopic approach which goes in the direction of such a complex signature of living processes has been pursued since the 1970s at the Los Alamos National Laboratory in New Mexico, the University of Arizona, the University of California at Berkeley, and the University of Texas.

Studies of synchronized cell populations, in which mitotic cell populations passed through the same stage of the *mitotic cycle at the same time, have been conducted* by various scientists. Both circular dichroism or CD spectra and circular differential scattering or CIDS spectra have been obtained for single Chinese hamster cells. The laser flow cytometer and a static cuvette system have been attached to a microscope that looks at the differential absorption (CD) and the differential scattering in intensity (CIDS) when left- and right-circular polarized light are alternately placed on a sample. This spectroscopic technique is particularly sensitive to mapping the primary, secondary, and tertiary structures of biological macromolecules.

The theory behind this technology rests upon the breakthroughs made by Louis Pasteur 140 years ago. Pasteur established that there was a direct relationship between the way in which a biological molecule organized space—namely, how it was curved and folded, whether in a left-handed or a right-handed direction—and the way in which the molecules acted upon plane-polarized light. Pasteur called the action of the substance in shifting the polarized light, its "optical activity." Since the angle degree to which



Source: Maestre et al., 1985. "Circular Dichroism Studies on Single Chinese Hamster Cells," *Biochemistry* **24-19**:5152.

Figure 8
MEASURING THE ELECTROMAGNETIC SIGNALS OF THE CELL CYCLE WITH CD/CIDS
The different stages of the mitotic process give clearly different electromagnetic signals when studied with the CD/CIDS technology. These cell samples were synchronized to ensure that the signals of cells in the G_1 phase, the S-G_2 phase and the M phase could be studied separately. The three distinct spectra of the cell cycle stages can be seen in (a). The spectra take into account readings with two different types of lens magnification. The raw data for the three cell stages as a function of wavelength with a 32× magnification are shown in (b).

the polarized light was shifted to the left or right could be precisely measured in a polarimeter, precise knowledge of what Pasteur called the "molecular dissymmetry," its geometric spatial organization, could be precisely adduced.

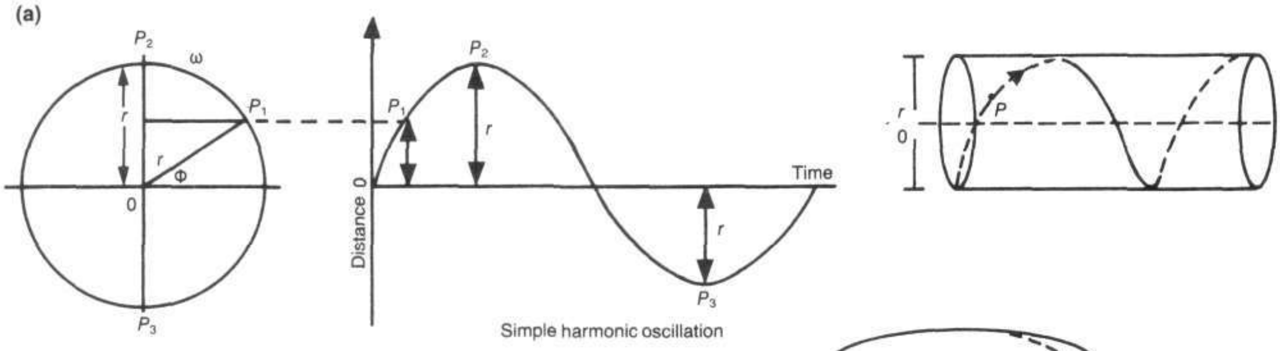
The modern spectroscopies of CD and CIDS are based upon sophisticated adaptations of Pasteur's approach. When a sample is alternately illuminated with successive beams of first right- and then left-circularly polarized light, the geometry of the sample will determine how it differentially absorbs or scatters the light (Figures 6 and 7).

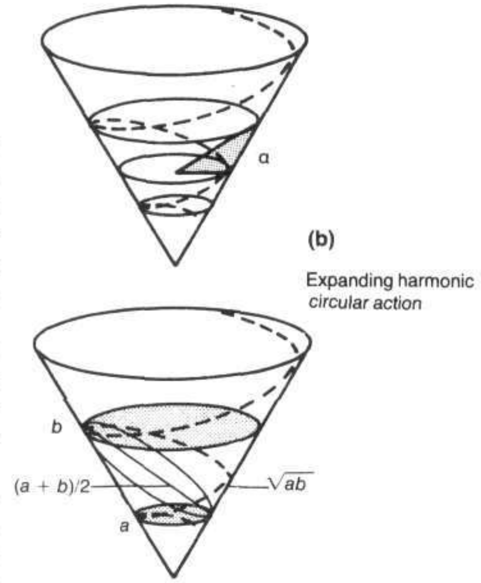
When the scientist is looking at the differential rates of absorption of the left- and right-polarized light the technique is called *circular dichroism.* CD spectra have been used to map the folding patterns of structures ranging from small "handed" molecules, of the order of nucleic acid monomers, to very large biological structures like intact bacterial cells, cell nuclei, and eukaryotic cells in solution.

As the scientific work proceeded, the CD spectra seemed to have certain unexplained "tails" or signals in a range where they should not have occurred—namely, in scattering regions. These scattering contributions appeared in cases where very large organizations of substance—for example, eukaryotic cells and cell nuclei—were being studied. It was then realized that these "differential scattering" spectra were extremely important. They reflected the higher-order "handedness" or spiral orientation and folding of the biological materials being studied.

In short, biological materials exhibit a preferential light scattering for either left- or right-circularly polarized light depending not only upon how the material is organized (as a double helix, for example) but also upon the way that it folds upon itself in the substance being studied. The differential scattering mode (CIDS) is particularly sensitive to mapping the higher-order "handedness" of the way in which biological helices fold upon themselves, since the technique is based upon the preferential light scattering of right- or left-circularly polarized light.

Using special techniques the scientists obtained several different samples where the cells were predominantly in one of the four stages of the cell cycle. They then measured 398 cells in the CD/CIDS microscope by scanning over the wavelength with a 32-power and a 100-power objective. The reason for the two different power objectives is that each captures different amounts of scattered light. In 39 cases, the same cell was measured with both the 32- and 100-power objective. In short, the CD/CIDS was measured by the microscope as a function of cell cycle position, on single Chinese hamster cells randomly selected from the four different stages of the cell cycle: 18 from G_1, 5 from S, 2 from G_2, and 14 from M. Dramatic results were obtained showing





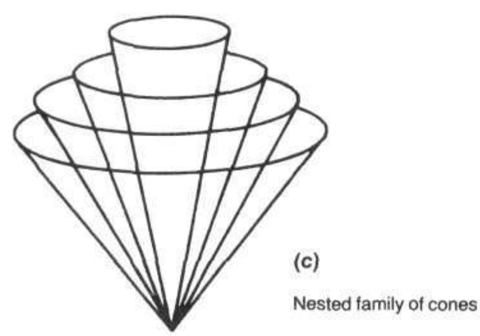


Figure 9
THE HARMONICS OF CIRCULAR ACTION

Circular action is a simple harmonic oscillation, as shown in (a) where point P *rotates around a circle with a constant angular speed* ω *and constantly changing direction. In simple harmonic motion, the frequency of oscillation* ν *is independent of the amplitude of the oscillation, in this case, the radius* r. *The foot of the perpendicular from* P *to a diameter moves with a simple harmonic motion. The angle* Φ *is the phase angle.*

The circular action maps onto a graph as a simple sine wave oscillation about 0, or as a self-similar spiral on a cylinder. The phase angle is what defines motion in such maximum-minimum functions. In circular action, of course, the minimum action generates the maximum area. The point P *is at a minimum at* P_3 *and a maximum at* P_2.

The phase angle relationship appropriate to growing, self-reproducing systems is shown in (b), where a self-similar spiral on a cone represents expanding harmonic circular action. The action defined by a transverse cut at a *has a smaller area of action than a circle cut at* b. *The phase angle* α *from the center of the cone to each level of growth defines an expanding self-similar spiral around the surface of the cone.*

A tranverse cut from circle a *to circle* b *is an ellipse. Gauss explored this elliptical geometry, determining that the geometric mean* $\sqrt{ab}$ *between circles* a *and* b *is found at one half-cycle of the self-similar spiral. The arithmetic mean* (a + b)*/2 is found at one-half the distance between circles* a *and* b.

The Göttingen school established by Gauss and advanced by Riemann thought about the phase angle relationships in terms of a family of nested cones (c). In such a complex system of self-ordering growth, the phase angle defines both a geometric-angular and a frequency-amplitude harmonic system.

different spectra for each of the four stages of the cell cycle (Figure 8). As shown in the figure, the spectra clustered in three wavelength regions.

Toward a Riemannian Biology

The most fundamental aspect of metabolism at the cellular level is that the very substances that synthesize and react with one another could not exist without the mitotic process in that cell's ancestors. There is a wealth of experimental evidence to show that living cells do not operate according to the statistical kinetics of test-tube chemistry. In fact, cellular metabolism itself refutes the so-called Second Law of Thermodynamics. The immense number of reactions and movement of molecules from place to place in the cell during metabolism occurs without any appreciable change in heat energy from the 37-degree Celsius level. Therefore, any "bioenergetics" approach that is posed in terms of the heat energy units and scalar concepts like the calorie is inadequate to study the living process.

While nearly all cellular oxidations and syntheses revolve around the way in which energy-rich phosphorous substances and carbon compounds interreact, the energy released and stored by "phosphorylating" biomolecules like ADP and ATP does not operate on the principles of a fixed-technology steam engine. The "energy" used in metabolism is present in the spatial organization and bonds of the enzymes and other macromolecules that were produced in a prior cell generation. In other words, two daughter cells are endowed with the vibrational or bond energies provided to them from the nutrients supplied by the mother cell before mitosis. The primary activity of the cell is not self-nourishment but perpetuation of the species through the process of cell-multiplication. Herein rests the key to approaching the nonlinear directionality and development of life—cellular electrohydrodynamics.

As ever more advanced techniques of nonlinear biological spectroscopy and imaging of in vivo systems in the angstrom dimensions and femtosecond time scales become developed, science is able to learn and see more about the electrohydrodynamic nature of these processes.

Not accidentally, the basic phenomenon encountered "in the small" in the living cell resembles many of the same geometric qualities of two other frontier domains of modern science—plasma physics and astrophysics. From a simple phenomenological standpoint, the filamentary structures—"paired" vortices, left- and right-handed filamentary singularities, solitons, and so forth—encountered in the past two decades or so in force-free electron-dense plasmas in fusion energy research regimes "in the small," have many of the same fundamental geometric characteristics as the various astrophysical geometries observed in galaxies "in the large."

What is the nature of a related scientific hypothesis that addresses the question of the harmonic ordering of cell life through generations of self-development and reproduction?

Our hypothesis can be posed in the following summary form: First, the living cell operates according to a tuning principle whereby the particular harmonic frequency ratios vary over the course of the various stages of mitosis and the cell cycle as a totality.

Second, the internal variations in frequency, which can vary with the age, nutritional environment, and stage in the cell cycle, appear to be tuned themselves to an overall harmonic that has the characteristic of being both species-specific and tissue-specific. Thus, what is critical is not a fixed particular frequency but the tuning ratios as a totality.

Third, the "conductor of the orchestra," so to speak, which regulates the tuning of the cellular orchestra, is DNA, functioning as a laser-antenna that broadcasts to the cell. During the cell cycle, the electromagnetic radiation has the quality of downshifting and then upshifting again to characteristic frequencies on the electromagnetic spectrum. The act of mitosis restores the coherent harmonics otherwise downshifted in the process of cellular life.

There is a potentially knowable interrelationship between tuning and the geometric ordering, the folding of the super-helical tertiary structure in biological molecules. In short, there is a "phase angle" relationship, which can be characterized as a Gaussian complex function with two rotational action components. The Gaussian approach to complex functions is based upon the geometric mapping of self-similar spiral action around a cone (Figure 9). The process of self-similar spiral action around the cone determines a given frequency in growing amplitude. The next degree of action is the transformation among a "nested" family of cones. The rotational action or phase angle has an angular momentum component as the harmonically determined action proceeds upwards around the cone. When the geometric field being studied is the electromagnetic flux density in a living organism, the "upshifts" and "downshifts" in electromagnetic wave action propagating through the process reflect a process of tuning action.

As Louis Pasteur proved more than 130 years ago, biological substances organize space, as they spiral and fold on one another, in left- and right-handed helical geometries. The essence of our hypothesis is that the geometric self-ordering of the biological material is thoroughly interrelated with its tuning properties. The overall character of the biological phase state in which these nonlinear photo-acoustical effects occur is electrohydrodynamic.

In sight of the 21st century, we are just walking through the entrance-way into a marvelous domain where there are common underlying principles to the living process, plasma physics, and the heavens. No more enriching pursuit for scientific research can be proposed than for mankind to embark upon a crash scientific effort to explore in depth the basic musical system that orders these processes. Through centuries past, we have already learned that the most fruitful scientific approach to studying these processes is electrohydrodynamic. In this regard, based upon all we now know, the biological phase state appears to have an integrated tuning and geometrical character that is actually knowable by man.

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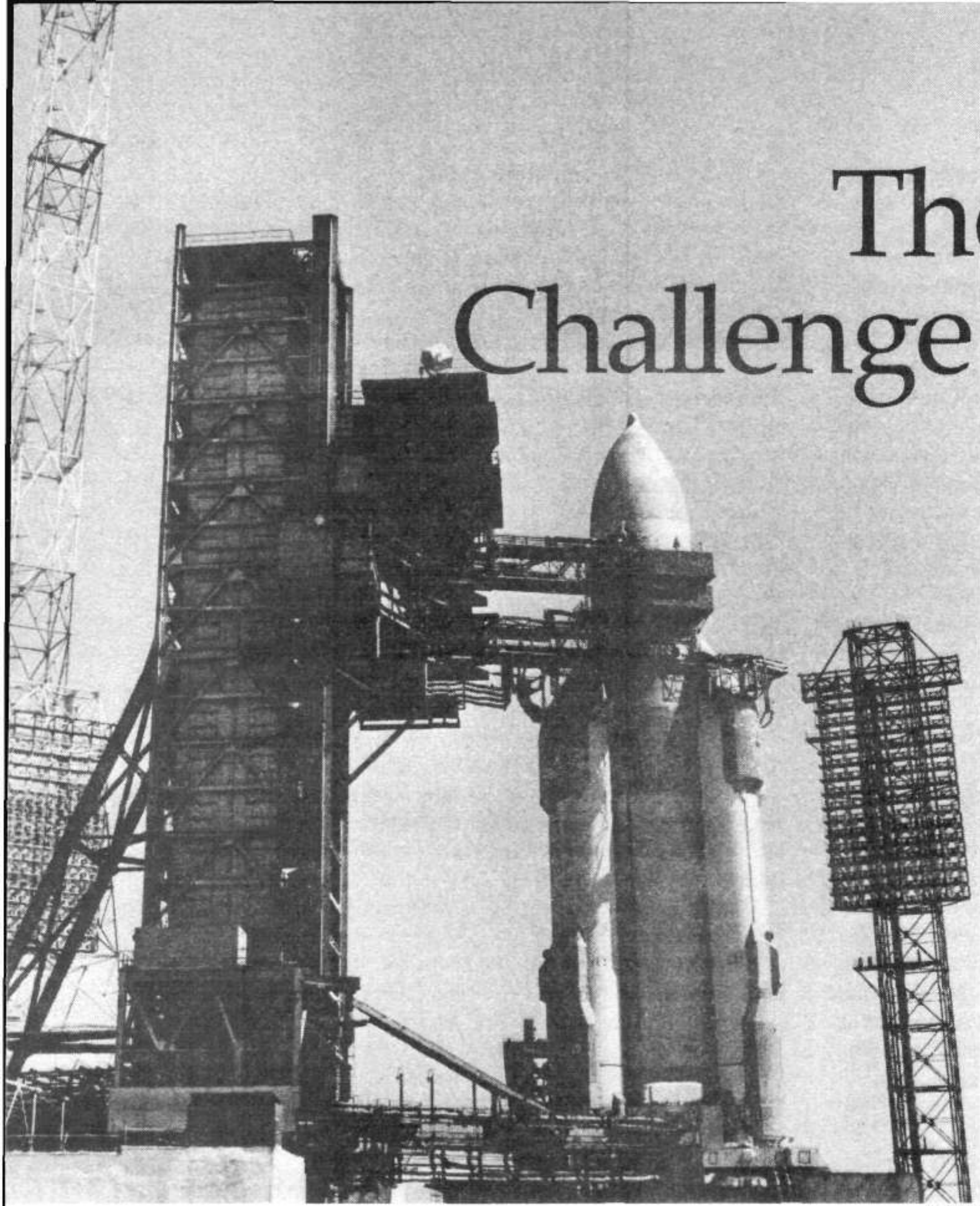


The Soviets Challenge the U.S. in Space

Contrary to their disinformation campaign, the Soviets have already "militarized" space and can now threaten every satellite the United States has in space.

by Marsha Freeman

Sovfoto

One of the best kept secrets from the American public is the fact that every U.S. satellite and spacecraft can now be attacked by a Soviet antisatellite system, that these capabilities have already been tested, and that the Soviets are readying new space capabilities for the next decade that will enable them to totally dominate space. At the same time, U.S. antisatellite systems have been outlawed by congressional fiat and canceled by budget cuts.

A deliberate campaign of disinformation has led most Americans to believe that the United States has the same military space capabilities as the Soviets. In polls taken in the past two years, more than 70 percent of the respondents said they thought the United States has an anti-ballistic-missile (ABM) system, and more than 60 percent said the United States has an antisatellite (ASAT) system. America has neither.

The media and the friends of the Soviets have told Americans that any new military capabilities the Soviets threaten to develop are a reaction to U.S. programs, such as the Strategic Defense Initiative (SDI), and that it is U.S. programs that are "escalating the arms race." But the Soviets have always been years ahead of the United States in planning, developing, and deploying military space systems, although they do not admit that often. However, even General Secretary Gorbachev, in a November 1987 interview, admitted that the Soviets have been working on SDI research for years.

The heavy-lift Energia, with its four strap-on boosters, can carry about 100 metric tons to low-Earth orbit.

Americans are told that, like the United States, the Soviets have never, and would never, develop an offensive weapons capability in space. The United States is blamed for "militarizing space" for just *planning* to develop an SDI and ASAT capability. The United States has never been told about the Soviets' *four* ASAT systems or the Soviets' tests to orbit nuclear bombs.

Soviet propaganda would have Americans believe that the Soviet manned space station program is a civilian program just like the U.S. Space Shuttle because Americans are allowed to see snatches of it on television. Americans have no idea that *there is no Soviet civilian space program,* nor any system that is not overseen by the Soviet Strategic Rocket Forces.

The alarm was sounded at a January 1988 conference in Huntsville, Ala., called "Red Star 2000," where U.S. analysts of the Soviet space program documented that less than 5 percent of the Soviet assets in space at any one time are related to their space station program, and more than two thirds of their spacecraft launched each year are for entirely dedicated military missions (Figure 1). Overall, there are Soviet space capabilities developed by the military that are used for multiple purposes and missions, including science, technology development, and industry.

One argument used by apologists for the Soviets is that U.S. technology has a commanding lead over Soviet technology and, therefore, Soviet antisatellite and other military systems are no real threat to America. Although it is true that, for example, the Soviet first-generation antisatellite system is only between 60 and 75 percent effective, considering that the United States has *no* such system, this is a grave strategic imbalance. Furthermore, next-generation ASATs now undergoing testing will soon supersede this 1960s Soviet system.

The point is that the United States dismantled its one ABM system 15 years ago in order to comply with the ABM treaty, while the Soviets have scores of documented violations of the same treaty, including multiple ABM systems that now have ASAT capabilities.

Most so-called surprises, when the Soviets surface new technologies, have proven to be just another case in which the U.S. public has been deliberately kept in the dark about ongoing Soviet developments. Because the media never cover ongoing Soviet research and planning and long-term development, people in the United States think that the Soviets will always "surprise" us with space spectaculars, like the launch of Sputnik and last year's test launch of the Energia, and that this country has no way of knowing what the Soviets are doing, or of being prepared.

The United States cannot meet the Soviet challenge in space simply by trying to match what the Soviets do in space, system for system. The Soviets treat space the way they treat land, sea, and air—as a "theater of military operations," and only secondarily as an important technology driver, a place to show off and garner international prestige, and a possible location for protected industrial production capacity. The Soviets know that in today's world, warfare cannot be successfully conducted in any theater, without the control of space.

Does that mean that the Soviet space program is always successful? Not by any means. Does it mean that the United States cannot catch up to what is an appalling operational Soviet space superiority? Obviously not. It means recognizing that despite failure and even significant loss of life, Soviet programs have continued because they are considered to be strategically necessary. The contrast to the U.S. delays in getting the Shuttle back into operation needs no comment: It is past time for the U.S. space programs, from rocket launchers to man-in-space (which barely exist at this time), to operate from the same principle.

Space War-Fighting Capabilities

In order to be able to "call the shots" in space, the Soviets have to have a full array of assets in place at all times; be able to replace any malfunctioning or damaged spacecraft in a matter of hours; have people in space available to do emergency repair, reconnaissance, or other work; be able to maintain robust networks of satellites in case a conflict in space should disable any satellite; and maneuver satellites on orbit quickly to provide extra support in crisis areas anywhere in the world. The Soviets can meet all of these requirements.

There is no U.S. or Soviet ship on the ocean, plane in the sky, or batallion of troops on the ground anywhere in the world that does not depend upon space-based communications, navigation, electronic intelligence, and reconnaissance. In this sense, the outcome of any Soviet conflict anywhere will be decided in space.

Lest people be misled, however, the Soviets have not only concentrated in developing *defensive* capabilities to protect their assets and make sure the United States cannot interfere with Soviet access to space. In a presentation at the January 1988 "Red Star 2000" conference, Vice Admiral William Ramsey, deputy commander and chief of the U.S. Space Command, reported that the Soviets have been "sniping" at U.S. low-Earth orbiting satellites.

Over the past few years, a number of incidents have been reported of interference with U.S. reconnaissance systems by Soviet ground- and sea-based laser systems. Most recently, United Press International reported Jan. 24 that U.S. intelligence sources believe the Soviets fired ground-based lasers to cripple optical equipment on board a U.S. satellite that was attempting to scan the major Soviet launch center at Tyuratam. On Oct. 2, 1987, a U.S. military pilot, flying near Hawaii where the Soviets were conducting missile tests, had her eyesight disturbed for about 10 minutes, from what was believed to be a flash of laser light aboard a Soviet ship in the area.

Advanced ASAT Systems

At present, while Congress has put a halt to the testing of any U.S. antisatellite system, the Soviets have no less than *four* different systems that can be used to cripple or destroy satellites in orbit.

The first-generation Soviet ASATs became operational in the 1970s (Figure 2). Using radar guidance, the ASAT homes in on its target and explodes near enough to throw out deadly shrapnel—not terribly sophisticated, but about 70 percent effective. A second-generation orbital ASAT system, tested until 1982, was not as successful. This system, which used infrared homing devices and single-orbit pop-up launches, has apparently been put on hold for possible further development. Unlike the United States, the Soviet Union never throws anything away, even if it does not work the first time.

Three other Soviet ASAT-applicable systems and technologies are already operational or on their way to becoming operational.

Critics of U.S. defense have stated that since the Soviet orbital ASAT has not been tested for 10 years, it is no longer "operational." Soviet space experts have pointed out that the ASAT launch vehicle, the SL-11 booster, is fully operational and is launched about five times per year to orbit radar ocean reconnaissance satellites. According to the De-

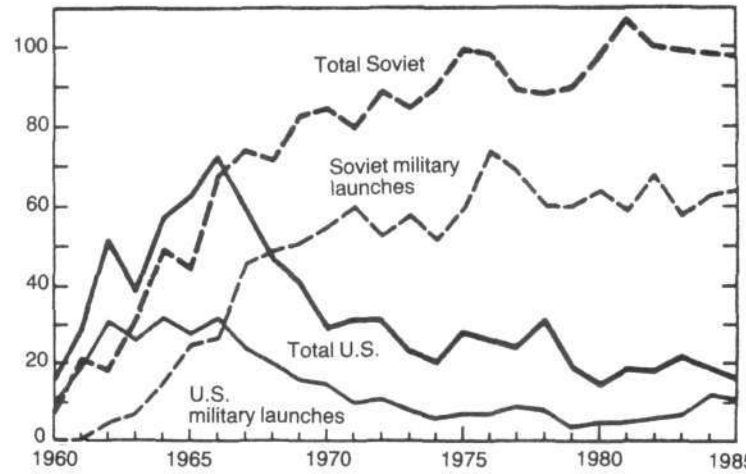


Figure 1
SOVIET AND U.S. SUCCESSFUL LAUNCHES
The dramatic increase in Soviet launches from 1960-1975 and the steady rate of about 100 launches per year for the past decade have been primarily the result of increased dedicated military missions, about two-thirds of all launches.

Source: U.S. Department of Defense.

partment of Defense, the Soviets have stored ASATs and boosters, and could launch several per day at any time, from each of two launch pads at the Tyuratam launch facility.

Nicholas Johnson, a noted Soviet space analyst with Teledyne Brown Engineering, has pointed out that the last test in the unsuccessful second-generation orbital ASAT series was very significant. When it was launched on June 18, 1982, it was linked to the most impressive display of strategic war-

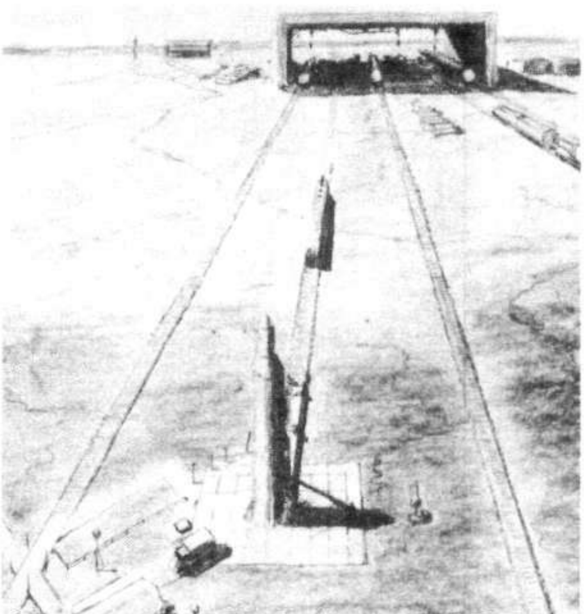


Figure 2
SOVIET OPERATIONAL ANTISATELLITE FACILITY
The operational antisatellite interceptor is launched at Tyuratam. The facilities are designed to support several launches per day.

Source: U.S. Department of Defense, *Soviet Military Power*, 1985.

fighting capability ever carried out. In one seven-hour period that day, the Soviets launched two test intercontinental ballistic missiles, two antiballistic missiles, one submarine-launched ballistic missile, and one SS-20 intermediate-range ballistic missile. In addition, during the "chase" phase of the ASAT test, the Soviets launched two other unrelated satellites, something that had never been done before. These launches represented the replacement of Soviet satellites negated by Allied forces during a military engagement. The overall exercise required coordinated command, control, and intelligence from a number of disparate launch sites to a number of space assets aimed at different targets.

Even if all the Soviets had was their 60 to 80 percent effective first-generation orbital ASAT, "it only takes very few effective launches to negate our capabilities," stated Air Force Secretary Edward Aldridge in congressional testimony in August 1987, because "the numbers of [U.S.] assets that exist are very small."

The "Soviets consider their ASAT an integral part of their military force structure and have used it in war exercises on several occasions," Aldridge said. "Failure to have a U.S. ASAT would be equivalent to having a World War II situation in which enemy reconnaissance aircraft could overfly our forces uncontested."

In today's situation, American commanders would find themselves trying to operate without being able to communicate with, locate, or deploy their assets.

While the Soviets have their orbital ASAT as a proven technology, three other systems also exist. The first is the set of Galosh exoatmospheric interceptors that make up an ABM system surrounding Moscow. These missiles could be targeted against low-orbiting satellites as they pass over the Moscow region, killing spacecraft up to about 150 kilometers.

The second is the set of ground-based lasers at the Sary Shagan test site, which have already been blamed for "sniping" at U.S. satellites. In addition, in fall 1986, *Aviation Week* magazine reported that French SPOT satellite images confirmed that "a massive Soviet strategic defense program is under way to develop lasers for both ASAT and missile defense operations" at Nurek, on a 7,500-foot high mountaintop near the Afghan border, 25 miles south of Dushanbe. According to *Aviation Week,* laser and possibly microwave facilities were under development at Nurek, powered by the Brezhnev hydroelectric dam 10 miles away. Satellite images revealed three domed buildings, each 33 feet in diameter, believed to be laser mounts. There is also evidence of a tracking station for tracking objects and pointing the lasers.

A month after this report, syndicated columnists Evans and Novak linked this Nurek facility to the blinding of a U.S. satellite with a high-powered microwave transmitter.

These ground-based directed-energy systems would not be able to accomplish a "hard kill" of a satellite beyond a few hundred kilometers, but can cause general component damage to spacecraft up to about 1,000-kilometers altitude and targeted component damage all the way up to geosynchronous orbit. This involves damaging the satellite sensors picking up signals for a particular part of the electromagnetic spectrum by transmitting light in specific frequencies (Figure 3).

In addition, the Soviets can use electronic warfare, or radio-electronic combat, to jam the uplink and downlink communications of U.S. satellites from their ground transmitters. And by knowing the operating frequencies of the satellites, the Soviets can even "take over" their operational control by sending false commands. With this multitiered antisatellite capacity, the Soviets can protect any of their space assets against attack by, presumably, the United States. However, so far, the systems have been engaged in a threatening and provocative *offensive* capacity.

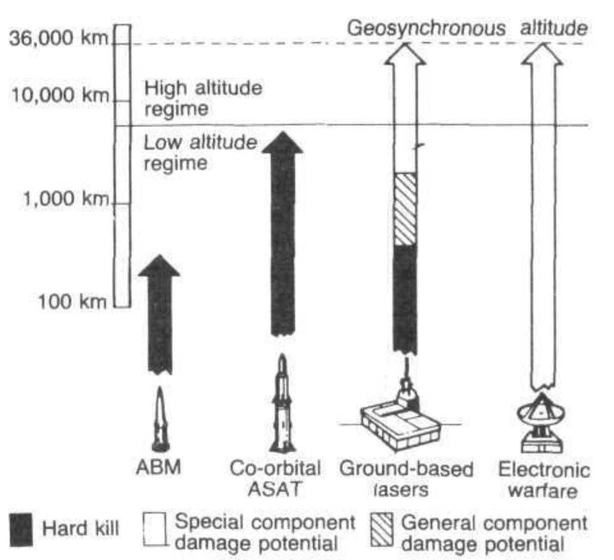


Figure 3
POTENTIAL SOVIET ANTISATELLITE WEAPON SYSTEMS
The Soviets can now damage U.S. satellites from low-Earth to geosynchronous orbit, using a variety of available technologies.

Source: Nicholas Johnson, Teledyne Brown Engineering.

The combined Soviet SDI and ASAT programs allow the Soviets to checkmate the United States and its allies in space and, therefore, in every other theater of potential military combat.

Defense-in-Depth Launch Capability

In order to dominate any field of battle, it is necessary to have duplicative and redundant capacities, quick response times, and system integrity under battle conditions. By applying the principles of mass production to both their launch vehicles and spacecraft, building and maintaining redundant and robust ground facilities, never throwing away any design or hardware, and keeping military control over all

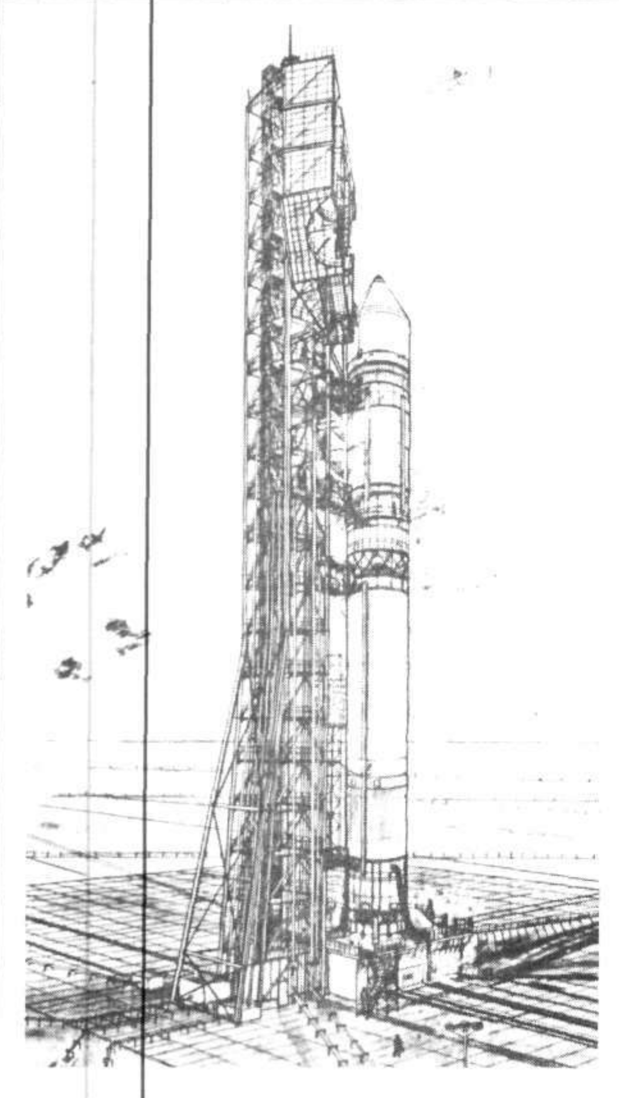


Figure 4
SOVIET MEDIUM-LIFT BOOSTER ON LAUNCH PAD
The SL-16 medium-lift booster, introduced into the Soviet fleet in 1985, has a very simple and efficient launch facility.

aspects of the space program, the Soviets have achieved this defense in depth.

While the United States is struggling to requalify its launch vehicles and get all four of them flying, the Soviets are flying nine operational boosters and will qualify the new Energia, perhaps this year. The Soviets have a launch infrastructure that includes more than 100 launch pads, three major launch sites, a new medium-lift booster (the SL-16, Figure 4) introduced in 1985, and the Energia Saturn-V-class booster.

Even if we admit that U.S. satellites are technologically superior to the Soviets and therefore need to be launched less frequently, the problem of lack of redundancy is a serious one in time of war. This is further complicated by the U.S. shortfall in launch capability.

Meanwhile, the Soviets have launched as many as eight separate payloads atop one booster. Over the years, they have conducted two launches within 24 hours on 25 different occasions. Twice, two launches have been carried out within an hour of each other. On Jan. 16-17, 1986, three missions were launched using three different families of boosters.

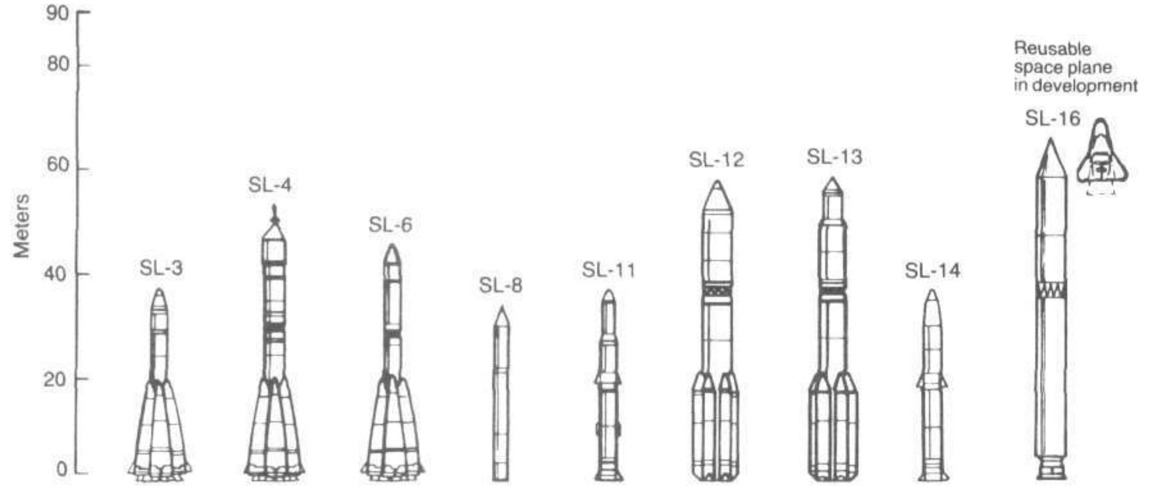
Soviet vehicles do not spend as much time on the launch pad as U.S. vehicles do, largely because of the more extreme climate. The payload is mated to the vehicle and brought out to the pad horizontally on rail cars. There it is put in a vertical position, fueled, and launched. Many vehicles, therefore, can be prepared in parallel in sheltered production facilities, occupying the launch pads only a short time before an actual launch.

For the past decade, the Soviets have averaged about 100 launches per year. Until recently, however, only about half of the satellites would still be in operation at the end of the year in which they were launched. The reason was that many satellites, particularly photo reconnaissance satellites, did not last longer than a few weeks, requiring frequent replacement. In fact, photo recon has been the most active Soviet program, with 28 missions per year.

According to data presented by Nicholas Johnson, however, annual mission-days for these satellites has tripled since 1980. The first-, second-, and third-generation photo recon satellites lasted only a couple of weeks, but the fourth-generation spacecraft were operational for nearly two months, and the fifth-generation advanced satellites now in use have pushed the technology to more than eight months. Soviet space expert Saunders Kramer reports in the November/December 1987 issue of *The Space Times* that Kosmos 1810, the sixth spacecraft in the fifth-generation series, operated for 259 days last year. Interestingly, although Soviet photo recon satellites stay in orbit much longer now, launch rates have not dropped. Instead, the Soviets are able to have two or three in operation at the same time, not just one.

The photo recon satellites have also upgraded their technology. In 1982, the Soviets finally introduced digital electronic imaging with Kosmos 1426, with the capability of transmitting data instantaneously to ground stations. For years, the Soviets had dropped film canisters from the satellites, and waited to develop the pictures on the ground.

The Soviets plan their economy in five-year plans, and they plan their space program in multiples of five-year plans.



	SL-3	SL-4	SL-6	SL-8	SL-11	SL-12	SL-13	SL-14	SL-16
Lift-off weight (kg)*	290,000	310,000	310,000	120,000	180,000	680,000	670,000	190,000	400,000
Lift-off thrust (kg)*	410,000	420,000	420,000	160,000	280,000	900,000	900,000	280,000	600,000
Payload to 180 km (kg)*	6,300	7,500	2,100	1,700	4,000	19,500	19,500	5,500	15,000+
	(A)	(A)	(A)	(C)	(F)	(D)	(D)	(F)	(J)

* Approximate

Figure 5
SOVIET LAUNCH VEHICLE ARSENAL
These statistics for the Soviet launch vehicle arsenal were released in 1985, and confirmed the anticipated use of the medium-lift vehicle as the booster for the Soviet space plane.

According to Charles Vick, an historian at the Alabama Space and Rocket Center and an expert on the Soviet space program, the Soviets plan on a 40-year production lifetime for any major system, and therefore invest in the production facilities, manpower, and other infrastructure required for the long-term.

As in the U.S. program, nearly all Soviet boosters were originally developed as missile launchers, and then extended to other uses as they became available. The A-class rocket, used in 1957 to fly the world's first ICBM as well as Sputnik, remains in production today. It has flown more than 1,000 times, and is still used to launch all of the manned missions. It carries 7.5 metric tons of payload to low-Earth orbit. Could the Soviets replace it with a more snazzy rocket? Probably, but the philosophy appears to be, "if it isn't broken, don't fix it."

The C series of vehicles, used recently to test the tiny subscale Soviet spaceplane, made its debut 21 years ago and launched Soviet ASATs in the 1960s. The D series, better known as the Proton, was not originally a military missile, and has been used for the last 15 years to launch Soviet Salyut space stations and the Mir. The Proton, which the Soviets are now trying to market internationally, has the capability to carry at least 44,000 pounds (20 metric tons) to low-Earth orbit, and with additional upper stages, has launched the Soviet planetary and lunar missions. (The full array of launchers is shown in Figure 5.)

Although all except one of the early series of Soviet boosters is still in production and use, it does not mean that changes have not been made. The Soviet approach, in launch vehicles and all systems, has been an evolutionary, not "revolutionary" one—making incremental improvements over time. In the Soviet space program, nothing is thrown away, and if one is watching closely, nothing should be a big surprise.

The 20-Year Lineage of Energia

In 1964, NASA administrator James Webb became the butt of jokes when he went before Congress to fight for the money to build the Saturn V rocket to take astronauts to the Moon, and stated that the Soviets were already developing a "superbooster." Dubbed "Webb's giant," the Soviet G-1 booster was undoubtedly the launcher being developed to make cosmonauts the first men on the Moon. This massive vehicle, as later pieced together by Soviet space analysts, had between 12 and 14 million pounds of thrust (compared to 7.5 million for the Saturn V). The payload it would carry would be smaller than that of the Saturn V, because it used the less efficient all-petroleum fuel, compared to the more energetic liquid hydrogen the United States was planning for the two upper stages of the Saturn.

Charles Vick reported at the "Red Star 2000" conference in January that the Soviets had wanted to start testing the G-1 in 1967, when the United States was flight-qualifying the Saturn V, but technical problems prevented a full test. In his 1981 book, *Red Star in Orbit*, James Oberg reported that the Central Intelligence Agency stated at a 1976 briefing that the first test of the G-1 ended in an explosion on the launch pad in June 1969.

At the "Red Star 2000" conference, Vick presented startling remote-sensing photos taken by Landsat that still show the damage done by that catastrophic failure when the vehicle did not clear the launch tower but fish-tailed over and exploded. As Vick described it, shrapnel was thrown over a large area and damaged an identical launch pad 500 meters away. A huge crater remained, and there were probably numbers of casualties.

Vick proposed that that 1969 failed test (which he placed on July 4) was to be a mission to the Moon. The Soviets had also fueled up a Proton booster 30 miles away, with a lunar Zond spacecraft on it, he said, and they were planning to launch it after the G-1, to do an Earth-orbit rendezvous and go on to the Moon (either manned or unmanned).

The G-1 was tested twice more. According to Oberg, in a 1971 test, it exploded in flight when the first stage malfunctioned, and the program was ended after a similar failure in November the following year. However, these failures did not mean that the Soviets gave up either on the idea or on the design work required to finally build a heavy-lift booster. Technology developed for the G-1 was transferred to the program that eventually produced the Energia.

According to Vick, the Soviets had successfully tested a lunar landing module in Earth orbit in the late 1960s. Even though the manned lunar program was canceled in the early 1970s, he believes that the Soviets continued to im-

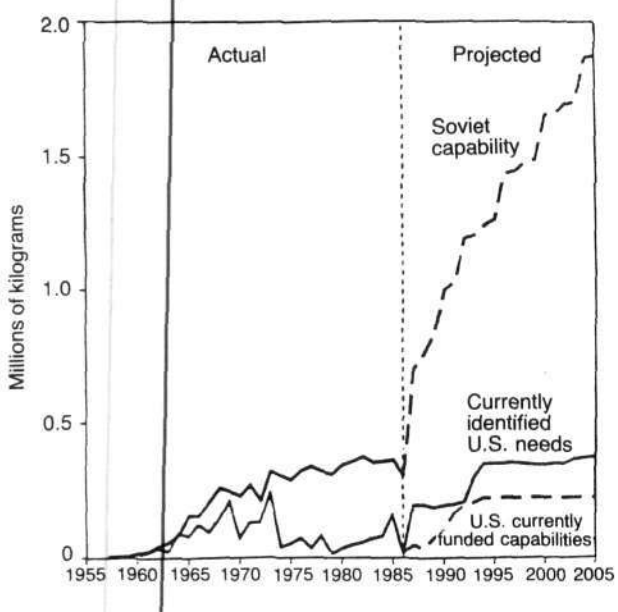


Figure 6
PAYLOAD-TO-ORBIT CAPACITY, SOVIET AND U.S.
The projected Soviet launch capability with the medium-lift booster and the Energia dramatically outstrips "current needs," as envisioned by the Department of Defense. The Soviets, however, have planned to deploy new systems to use this capacity.
Source: U.S. Department of Defense.

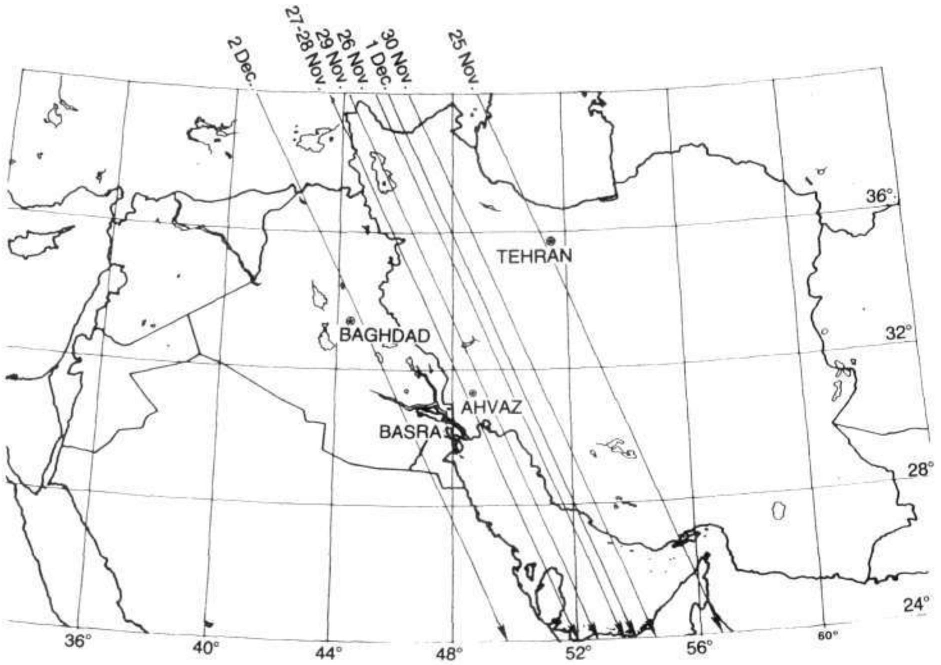


Figure 7
SOVIET REACTIVE CRISIS MONITORING CAPABILITY

The Soviets can quickly change the orbit of photo reconnaissance satellites to "linger" over world hotspots, as they did in late 1987 to monitor the Persian Gulf War.

Source: Nicholas Johnson, Teledyne Brown Engineering.

prove and refine the lander. "It remains a shelf item that they can pull off the shelf," he stated, "which has continued to be updated avionics-wise, to be flown. If you added an aeroshell, you could do a Mars landing with it," Vick told the "Red Star 2000" conference.

Vick reports that years of hard work later, the Soviets had a heavy-lift "pathfinder" vehicle (the precursor to Energia) under development by 1983. It closely resembled Energia, but had six rather than four strap-on liquid boosters, with each booster apparently 10 meters higher than those on the Energia. Vick also thinks it is likely that the Energia launch was not the first use of liquid hydrogen in the Soviet program, and that a liquid hydrogen upper stage was first tested in 1985 on the medium-lift SL-16.

The Energia the world saw on television will be in production for decades. It is currently configured with four strap-on boosters, and can carry about 100 metric tons to low-Earth orbit (the Saturn V had a payload capacity of 125 metric tons). Vick pointed out, however, that the addition of more strap-ons and advanced upper stages could take the Energia up to 250 metric tons of payload capability. (The U.S. proposed heavy-lift vehicle, meanwhile, is enmired in a budget fight.)

The new medium-lift SL-16, plus the Energia (SL-17), give the Soviets a massive increase in payload-to-orbit capacity (Figure 6). If the Soviets were merely planning to continue their 100 launches per year with a similar mix of spacecraft as today, would they need all of this additional launch capability?

But why should anyone assume that the Soviets are not going to deploy the systems they have been developing for decades, such as their Strategic Defense Command or space-based directed energy ASATs? Why spend years developing them, if you are never going to use them? The watchword here should be, "Think Soviet."

Quick Response Capability

A war-fighting capability means the battle-readiness of a given system; it is not an abstract technological capability. According to Vice Admiral William Ramsey, it takes the Soviets a *few hours* to ready a military spacecraft and launch it, while it takes the U.S. *90 days*. The Soviets launch on demand, he stated at the "Red Star 2000" conference, and we "only launch on schedule." This severely limits our ability to respond to any crisis.

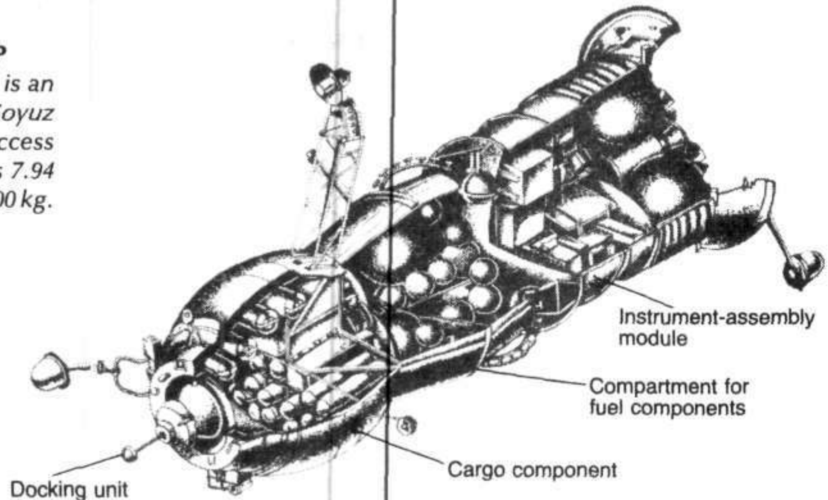
As an example of this capability: *Defense Daily* reported in fall 1987 that on Christmas Eve 1986, the Iranians had launched a troop offensive in the Shatt Al-Arab waterway toward an assault on the Iraqi city of Basra. Within 24 hours, the Soviets launched Kosmos 1810, which stayed in a low circular orbit for three days to observe the area, rather than immediately moving into its planned operational orbit.

What about spacecraft already up there? At any one time, the Soviets have about 150 satellites in orbit, and an estimated 70 percent are performing military missions. Another 20 percent or so perform both military and civilian functions, and the remaining satellites are nonmilitary and scientific.

The argument is often made that since each one of the U.S. reconnaissance, communications, and other satellites is more technologically advanced than the Soviets', the fact that they have so many more makes no difference. However, our handful of satellites cannot be maneuvered quickly to respond to a crisis. What the Soviets have done in this regard is quite impressive.

Nicholas Johnson has carefully documented this quick-

Figure 8
THE PROGRESS CARGO SPACESHIP
The unmanned Progress resupply ship is an economical modification of the Soyuz spacecraft with a perfect record of success since its debut in 1978. The Progress is 7.94 meters long with a payload of about 2,300 kg.



Source: American Astronautical Society, *Soviet Space Programs 1980-1985.*

response capability in his 1986 "Soviet Year in Space" report and in an excellent volume published by the American Astronautical Society, *Soviet Space Programs 1980-1985.* In a typical low-Earth orbit, a satellite will circle the planet moving between 1 and 3 degrees west in each pass, due to the rotation of the Earth. If the altitude of the satellite is changed, however, it is possible to maneuver it to take smaller "steps" and stay in a particular region for a longer period of time.

One example Johnson gave at the "Red Star 2000" conference was the Soviet reaction to an escalation in the Persian Gulf War during November and December 1987. Figure 7 shows how the Soviets dropped the orbit of existing reconnaissance satellites in order for them to "linger" over the critical area to provide a real-time close-up view of the ground fighting.

This in-orbit maneuverability, and launch-on-necessity capability allows the Soviets to respond to any existing crisis or support a military operation of any kind *anywhere on the globe.*

Soviet Man-in-Space Programs

The most recognized and public part of the Soviet space program is the space station effort. As Charles Vick commented, Soviet "manned systems are considered essential for the national defense."

U.S. astronauts have remarked from the beginning of the space program that what they can see with the unaided eye in orbit cannot be captured photographically. In-orbit observation by a human crew is still a technically superior, real-time method of observation even to today's highly advanced photo reconnaissance and Earth-resources observing satellites.

The Soviets, like the United States, plan to use the unique skills of a crew in space to be able to perform many services, such as repair, refueling, and refurbishment of unmanned space assets. Four years ago, Space Shuttle astronauts demonstrated the ability to leave their spacecraft, recapture, repair, and redeploy a malfunctioning satellite. Observers expect a Soviet Mir crew to demonstrate and use—perhaps some time this year—a manned maneuvering back-pack

Early Soviet Space Station Successes and Failures

In the first decade of the Soviet space station program, there were as many failures as successes, but this did not deter the Soviets from continuing station development and deployment.

SALYUT 1
Launched April 19, 1971.
Soyuz-10 launched April 22, failed to dock with station.
Soyuz-11 mission launched June 6; after 24-day mission, the three cosmonauts died on reentry.

SALYUT 2
Attempted launch on July 22, 1972, but the Proton booster failed. Soviets denied it was a failed space station mission.

SALYUT 2
Launched April 3, 1973; in orbit for 22 days out of control, it was never manned.

KOSMOS 557
Launch May 11, 1983 of what seemed to be a new station. It failed in orbit and the Soviets denied it was a space station.

SALYUT 3
Launched June 24, 1974; in operation for 3 months, for military missions.
Soyuz-14, launched July 3, docked for 14 days.
Soyuz-15, launched August 26, but the crew failed to link up with the station.

SALYUT 4
Launched Dec. 26, 1974; in operation for 2 years.
Soyuz-17 launched Jan. 10, 1975; crew at station for 30 days.
Soyuz-18 launched April 5; had an engine malfunction and did not dock.
Soyuz-18 launched May 24; crew had a 63-day mission.

SALYUT 5
Launched June 22, 1976 with a one-year military mission.
Soyuz-21, launched July 6; mission ended abruptly.
Soyuz-23, launched Oct. 14; link-up failed.
Soyuz-24, launched Feb. 7, 1977; lasted 17 days.

Building Space Station Infrastructure: A Decade of Advances

1977 — Salyut 6 launched. First space station with 2 docking ports, to accommodate more than one spacecraft at a time. Test of a new heavy station module, Kosmos 929, nearly the size of the Salyut, which did not dock with Salyut 6 but was a test of later large supply vessels.

1978 — First robot supply mission, docking an unmanned Progress supply ship to the Salyut 6 station. The ability to resupply the station allowed the cosmonauts to stay longer than their small supplies from the Soyuz would carry them. The Progress also performed the first in-orbit refueling. A record 96 days in orbit was established, and then surpassed the same year on a 140-day mission. Visiting cosmonauts docked with the station and created the first dual-station mission.

1979 — A record 175 days in orbit was performed, and the modified, upgraded Soyuz-T spacecraft made an unmanned test flight.

1980 — The man-in-space record was extended to 185 days, and the first manned Soyuz-T mission occurred. This was the first 3-man crew since the space fatalities in 1971.

1981 — The first heavy station module, Kosmos 1267, weighing 15,000 kg, docked with the Salyut 6 station, doubling the size of the complex.

1982 — A record of 211 days in orbit was established. Salyut 7 was launched in April, with improved navigation capabilities.

system similar to that the Shuttle astronauts have used.

The United States has designed an entire series of large Earth-orbiting astronomical observatories, beginning with the Hubble Space Telescope, to be taken care of in orbit by astronauts. Reportedly, the KH-12 advanced U.S. photo reconnaissance satellite is also designed to be refueled from the Shuttle. Refueling is needed to help the spacecraft maintain a stable orbit against the small atmospheric drag in space and also for maneuvering and orbital plane changes.

The Soviets undoubtedly plan to perform the same kinds of operations from their constantly manned space platforms. Any space-based assets that the Soviets would want to keep in orbit over long periods of time—such as directed-energy ASAT and SDI systems—would have to be maintained in this way. This is especially true since they have had difficulty in developing the technology for long-lived electronics, components, and systems.

The currently orbiting Mir station and its attachments allow the Soviets to have cosmonauts circling above the Earth all the time. This capability was not a crash effort, but one that was built and evolved over 20 years. Because the Soviets have not had a heavy-lift vehicle until the Energia, the basic size and weight of the Mir is the same as the first Soyuz, which was launched in 1971.

The Soviets have increased the range of functions that can be performed from the stations and, most important, the amount of time crews can stay on them, by adding pieces to the stations and, over time, improving all of the systems involved. In some cases, this has been necessary because more sophisticated technology was apparently not available to the program.

The Soviet space station program has had many failures, and it has taken the lives of a number of cosmonauts; *but it has never been canceled, or, from what we can tell, suffered budget cuts.* It has been stopped for periods of nearly two years after fatalities or close-calls for redesign and reevaluation, but it has always moved forward toward specific goals.

The early space stations, through the late 1970s, were short-lived facilities that could accommodate crews only for a matter of weeks. Two of the first series of five were entirely military, and at least two failed to reach orbit. There were four failures out of nine attempts to dock with the early stations. (The early history is summarized in the box on page 51.)

Building the Space Infrastructure

At present, the Mir houses the cosmonauts and provides them with the basic necessities and accommodations for life in orbit. An enormous amount of infrastructure is required to keep the cosmonauts up there. During 1987, the Soviets launched 11 missions and vehicles, weighing over 900 tons, to the Mir, including 7 unmanned supply ships. The Soviets have only expendable vehicles to launch; therefore, out of the total tonnage, only 200 tons were supplies, the rest being the expended vehicles.

Cosmonaut crews started their climb toward today's world record of 326 days in space in 1978, when Salyut 6 was launched with an important innovation: a second docking port that could accommodate unmanned cargo ships.

Every couple of months, cosmonauts are visited by an unmanned Progress supply ship, which brings them fuel, food, mail, some scientific equipment, gases to replace some of the atmosphere they lose when they take space

In the past 10 years, the Soviets have incrementally improved their space station technology and capability, fixed the systems that failed in the previous decade, and continued to add new infrastructure every year through their man-in-orbit program.

1983

First augmentation of power was performed by cosmonaut EVAs (spacewalks) adding new solar panels to Salyut 7, which increased the available electrical power by 50 percent. Kosmos 1443, a heavy station module weighing 20 metric tons, was added to the station. Soyuz-10A cosmonauts on their way to Salyut 7 barely escaped catastrophe when their booster caught fire on the launch pad.

1984

A record 237-day flight was accomplished. For the first time, six cosmonauts were on board the Salyut at the same time, for a period of two weeks. A record seven EVAs were done that year.

1985

The first in-flight crew rotation, where the space station was not left empty when a crew left, but was replaced with a crew that overlapped its stay. The Soviets also had the first unplanned early return of a crew, because of a health emergency.

1986

The Mir space station was launched in February, with a five-port docking module to accommodate a total of six spacecraft that could be attached to the core Mir station. The first crew made the first interstation and interorbital transfer, going from the Mir to Salyut 7 and then back to the Mir.

1987

With the launch of the Kvant laboratory module, the presence of a Progress resupply ship, and the Soyuz craft that brought the cosmonuats, Mir became the first four-spacecraft space station complex. At the end of December, a record 326-day flight was ended, and the first manned flight of the upgraded Soyuz-TM was flown.

walks, and water. The Progress (Figure 8) is 7 metric tons at launch and brings about 2.3 tons of cargo to orbit. It is loaded with trash when its mission is completed, and sent to a controlled burn-up reentry through the Earth's atmosphere.

The Progress is a very small craft, however, and in 1977, the Soviets began testing a very large unmanned specialized Kosmos station module. The first, Kosmos 929, did not dock with the Soyuz 6, but Kosmos 1267, launched in April 1981 and weighing 15,000 kilograms, was attached to the station for 460 days.

A second operational module, Kosmos 1443, was attached to Salyut 7 in early 1983. According to Nicholas Johnson, this module, which weighs 20,000 kilograms, nearly as much as the Salyut itself, took over primary control of certain station functions, like attitude control (firing small engines to keep the station pointed to the correct orientation). As shown in Figure 9, the specialized module has its own solar panels, giving it an independent energy supply.

One important feature of these heavy modules, which helps solve another limitation on the Soviet manned program due to the lack of a Shuttle-type vehicle, is the fact that the front end of the large module is a return capsule. When separated, this capsule can carry 500 kilograms of materials back to Earth. In comparison, when a Soyuz returns to Earth with a crew from the station, it can bring only 200 kilograms of material back with it.

A third module, Kosmos 1686, launched in September 1985 to Salyut 7, was there for more than 200 days. Johnson stated at the "Red Star 2000" conference that these heavy Kosmos specialized modules will be outfitted differently for various missions, such as materials processing factories, biomedical experiment laboratories, Earth-resource observatories, and astrophysics laboratories. "We may see one attached to Mir," Johnson stated. "It could be used as an emergency return vessel for cosmonauts."

With the new emphasis by the Soviets on commercializing some of their space technology, they have offered potential customers either a fully outfitted module that they will fly, or an empty one that the customer can outfit himself!

Last year, the Soviets added another piece of infrastructure to their space station (Figure 10), the Kvant (Quantum) module. Described as an astrophysics laboratory by the Soviets, actually, according to Johnson, the Kvant is much more. About the same mass though different in shape from the previous heavy station modules, about half of Kvant is a propulsion unit, which is the part docked with Mir. Of the other 11 tons in the second piece, about 10 percent, according to Johnson, is the observatory, with various kinds of telescopes. The Kvant has a host of experimental and operational facilities, including an electrophoresis unit but, most important, it has a set of gyro units for stabilization of the entire spacecraft complex. Using the gyros, the crew can change the attitude of the station to point instruments, or orient the windows for specific observations, without using up precious propellants.

As a matter of fact, when a spacecraft approaches the Mir to dock with one of the five ports of the multi-docking module, the spacecraft is held still and the Mir is rotated until it is in the proper position. According to Johnson, the Soviets experimented with these kinds of gyros earlier on the Salyut 5.

The scientific instruments onboard Kvant have been de-

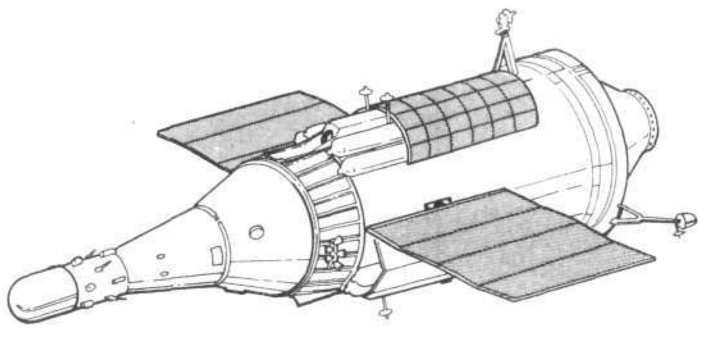
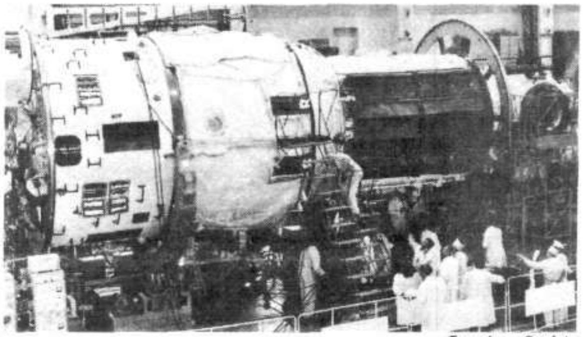


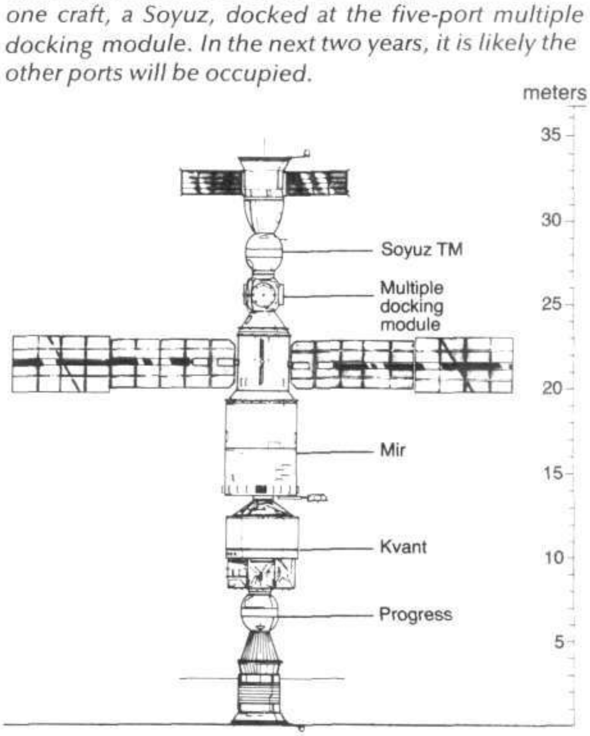
Figure 9
THE KOSMOS SPECIALIZED MODULE
This space station module, which is about the same size as the Mir core, can be used for many functions and provides it own power and return capsule.

Source: Nicholas Johnson, Teledyne Brown Engineering.



Tass from Sovfoto
The Mir orbital research station in an assembly and testing shop.

Figure 10
SCHEMATIC VIEW OF THE SOVIET MIR COMPLEX
The current four-spacecraft Mir complex has only one craft, a Soyuz, docked at the five-port multiple docking module. In the next two years, it is likely the other ports will be occupied.



Source: Robert A. Sweeney, Teledyne Brown Engineering.

scribed as having a one-year lifetime. But Johnson stated that the Kvant is a permanent attachment, because these other functions are actually primary.

It is expected that all six of Mir's docking ports will be filled with various specialized laboratories and modules over the next couple of years, along with the Soyuz craft that bring the crews and the Progress supply ships that bring cargo. There is no precise agreement among experts as to when the Soviets will take a quantum leap and perhaps use the Energia to deploy a station that is significantly larger than the Salyut-Mir variety. However, the Soviets certainly will have the launch capability to do that by the early 1990s.

The so-called purely scientific Soviet missions, such as their lunar and planetary exploration, were not all successful in the 1960s, but have scored some impressive results in the past few years. These have included radar mapping missions at Venus and the Vega encounter at Halley's comet. These accomplishments have been aided by the participation of scientists and equipment from the East bloc countries, Western Europe, and the United States, but also represent a maturing—a catching up—of Soviet technology. Over the next decade, the Soviets' public scientific emphasis will clearly be on Mars, with at least two unmanned missions, including one this year, under development.

The Soviets are also developing a reusable space shuttle-type system and an hypersonic craft, and they have already tested a subscale mini-spaceplane.

In every significant military and military-related space capability in space, the Soviets have outpaced us. Like the Soviets' conventional superiority in Europe, their development of radio frequency weapons, their offensive strategic superiority in nuclear weapons, and their capabilities in strategic defense, their overwhelming superiority in space is a direct challenge to the United States and its allies.

Marsha Freeman, an associate editor of 21st Century, *writes frequently on the space program.*

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Fusion Report

Continued from page 13

tured in a "blanket" and converted to electricity by means of a steam cycle.

The positively charged alpha particles, however, deposit their energy within the plasma, and are therefore the key to achieving ignition, when temperature and particle density are sufficiently great for a sufficient time. Both the CIT and the various designs for scale-up are designed to achieve a sufficient flux of alpha particles to sustain the fusion process for the first time in a man-made reactor.

The planning for a prototype working reactor must be done in parallel with the construction of the CIT. An international flagship effort was launched when President Reagan met Soviet leader Gorbachev at Geneva in 1985. Out of that meeting came an agreement to collaborate in the design of ITER—the International Thermonuclear Experimental Reactor. The European Community and Japan have since joined the project, which at this stage is only a commitment to three years' design and R&D work, at a cost of $16 million per year for each of the four parties. The resulting design could be adopted by any one or any combination of the parties.

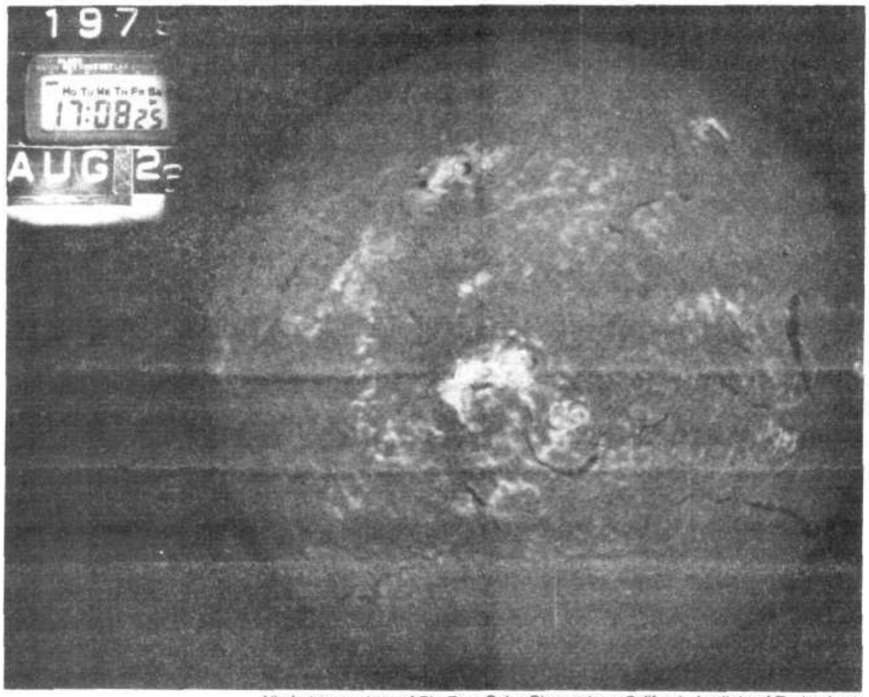
Headquarters for the project will be the plasma physics institute at Garching, near Munich, West Germany. The European Community's own project that parallels ITER, the Next European Torus (NET), is also headquartered at Garching.

The scale and features of ITER are promising—5 minutes' burn time, a blanket module for tritium breeding, and probably superconducting magnets. Although still fairly nebulous in conception, ITER is thought of as being completed by the year 2005 at a cost of about $3 billion. The prevailing mythology here in the United States is that this country could not afford to build such a machine by itself.

If we are to develop fusion as a commercial energy source, both the CIT and ITER must be built.

Inspecting Our Closest Star: The Sun

by David Cherry

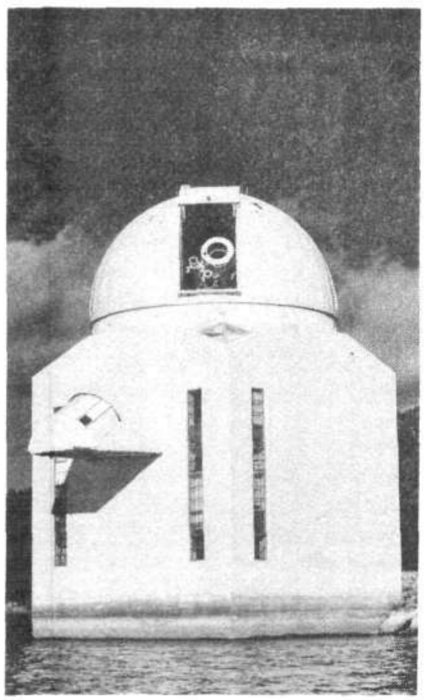


All photos courtesy of Big Bear Solar Observatory, California Institute of Technology.

The entire disk of the Sun as seen in "hydrogen light," a narrow wavelength range emitted by excited hydrogen atoms, known to astronomers as the Hα *spectral line. Hydrogen light discloses the chromosphere, normally invisible to us because of the brightness of the photosphere beneath it. All the photographs here were taken in hydrogen light.*

The Sun's magnetic fields control the chromosphere, but have little effect on the photosphere because it is denser. Both layers are partially ionized gas—plasma.

The bright area just left of center in this Aug. 26, 1979 photo is an enormous solar flare. The less bright patches in its immediate neighborhood are the terminations of magnetic lines of force that emerge from the flare. The dark curving lines are solar prominences, bright when seen against the sky, dark against the disk.



Big Bear Solar Observatory is built in the middle of a lake. Since water changes its temperature more slowly than land, the air in the path of the telescope suffers less local convection as the Sun warms the Earth. The observatory issues "Bear Alerts" reporting solar phenomena likely to affect space flight and electromagnetic transmissions on Earth.

One of the most exciting frontiers in solar astronomy is helioseismology, the study of the Sun's pulsations or oscillations. While some stars observed at a distance are seen to pulsate in a simple mode—expanding and contracting in a steady rhythm, the Sun's pulsations are a different phenomenon.

In fact, the oscillations observed at close range in the Sun are a complex of thousands of individual modes of oscillation. In the quadrupole mode (which has two axes), the ends of one axis travel outward while the ends of another axis at right-angles to it are moving inward. This oscillation is superimposed on an octopole mode (four axes), and so on.

Prof. Ken Libbrecht at the California Institute of Technology, together with T.L. Duvall and other astronomers of the National Solar Observatory at Kitt Peak, Ariz., have just published exhaustive lists of solar oscillation frequencies in the Jan. 15 issue of the *Astrophysical Journal*. These oscillations are the only means of directly detecting what is going on deep within the Sun.

Libbrecht's more recent data have produced measurements of the differential rates of rotation of the Sun's gases to a depth halfway to its center—by tracking the oscillations. Images taken once a minute are processed at the National Science Foundation supercomputing center in San Diego, where three-dimensional Fourier transforms

A sunspot spews out a great surge in this July 26, 1981, photo. A "surge" is an organized outflow along nearly parallel trajectories, which typically occurs near large sunspots.

Sunspots are surface manifestations of magnetic fields embedded more deeply in the Sun. What causes sunspots to appear and disappear is not clearly known. The magnetic field strength at the center of a sunspot is typically 3,000 or even 4,000 gauss. ◄

► *A spray from the Sun's surface, June 6, 1972. In contrast to a surge, a spray is material expelled from a flare near the surface—less collimated and faster than a surge.*

are used to reconstruct the oscillation patterns from the image data.

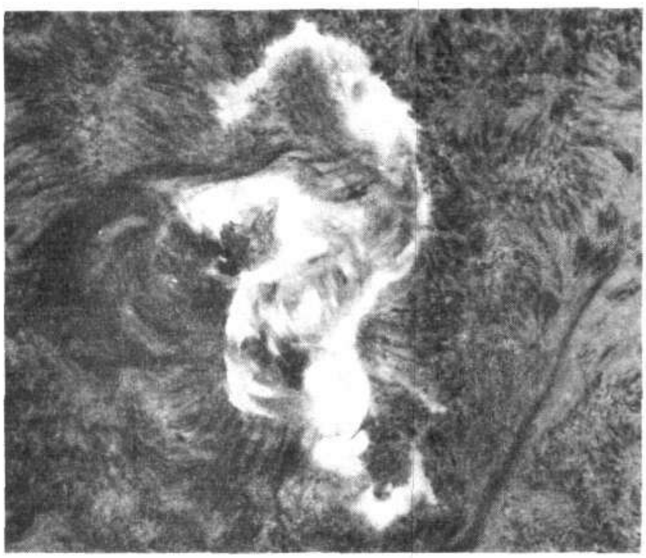
Helioseismology has also confirmed the long-held theory of energy transport inside the Sun. It was believed that all energy emerging from the Sun's core was transported outward by radiation to three-quarters of the radial distance, at which point convection became necessary in addition to radiation. Helioseismology has confirmed this picture, and has provided a fairly precise measurement of where the boundary between the two regions lies.

Is there any connection between solar oscillations and sunspots? Only that certain surface modes of oscillation are suppressed by the presence of sunspots. We are now on the rise of the 11-year sunspot cycle after two years of almost no sunspot activity. The accompanying photographs feature sunspots and related magnetic phenomena on the Sun's surface, all taken at the Big Bear Solar Observatory, a facility of Caltech located east of Los Angeles.

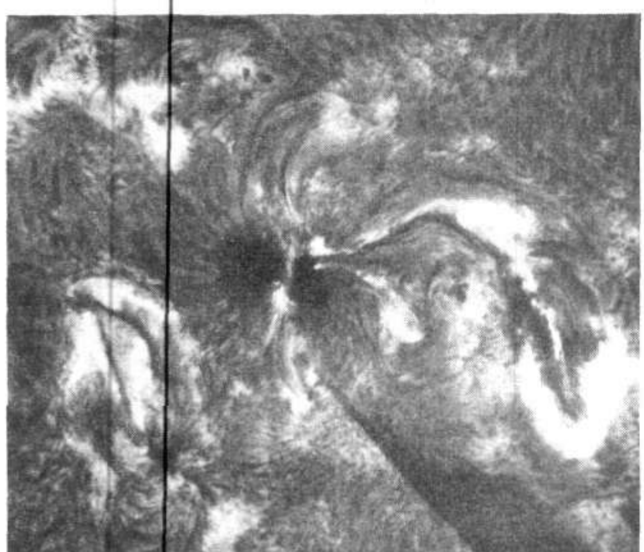
The Budget Seesaw

Solar astronomy was well supported by NASA, the National Aeronautics and

Continued on page 58



The Sea Horse Flare, one of the greatest solar flares ever observed, photographed Aug. 7, 1972. The Earth would measure about 3 or 4 millimeters across in this photo! Solar flares may last from 10 seconds to several hours. Flares emit vast amounts of X-rays and ultraviolet light, causing disturbances of the ionosphere. They also emit electrons, protons, and heavy ions, some of which penetrate Earth's atmosphere and cause magnetic storms and aurorae.



An active region with paired sunspots, each with a diameter about that of the Earth. To the right of the spots a solar flare is in progress (bright area). A large, dark, feather-shaped prominence is at the lower right.

Prominences occur along the boundaries between magnetic fields of opposite sign, where the connecting magnetic field lines are horizontal and can support these "solar clouds."

Resources

Continued from page 17

took about three years, found the airlift method to be more efficient for this use than hydraulic power.

In the "airlift" approach, a large pipe, 1 to 2 feet in diameter, stretches down from a ship to the ocean floor. Air pumped from the ship bubbles into the pipe from a tube outside the pipe about halfway down the pipeline. You can envision how this works by doing a simple experiment with a straw and a glass of water.

Put your finger over the top end of a clear plastic straw, immerse the straw in a glass full of water, and then release your finger from the end of the straw. You will see the water quickly move upward inside the straw, until it reaches the same level as in the rest of the glass.

In the airlift approach to mining nodules, pumping air into the pipeline near the bottom end of the line creates the same situation that occurs with the straw and the glass: The instant you remove your finger from the straw, water flows upward. Seawater continues to flow into the pipeline (or straw) at the ocean floor (or bottom of the glass), as long as air continues to be pumped into the pipeline. As more air is added, more seawater will tend to flow into the pipeline to reach the surface level of the ocean.

The moving water drags the nodules into the pipeline just like a vacuum cleaner sucks in dust and dirt with moving air. The water, the nodules, and the air flow upward together through the pipe and to the ship. There the nodules are collected and the water is returned to the ocean. A trial system with a 6-inch-diameter pipeline has already brought nodules from 3 miles deep in the Atlantic Ocean—a steel "straw" 3 miles long!

Once these nodules have been collected and taken to shore, the work of actually "mining" the valuable metals begins. The chemical reactions that form the nodules lock the metals tightly in combination with other, less useful materials. Chemical engineers now face the challenging problem of designing the chemical treatments needed to free the minerals themselves from these compounds.

Stuart Lewis

This manganese nodule from the ocean floor contains recoverable amounts of cobalt, nickel, and copper. Millions of tons of these metals in nodule form wait to be mined.

How soon will we be vacuuming the sea on a regular basis to provide us with these valuable metals? This depends on the economic situation and the funds available for development of the technology and use of the resources. Initial estimates for nickel, for example, were that considerably fewer investment dollars would be needed to mine the nodules than to develop an equivalent land deposit. And, the total energy required to produce a pound of nickel from the nodules is about half that required for conventional mining.

In the near future, the car that you buy or the computer that you use may be manufactured using metals that came from manganese nodules, born millions of years ago in the depths of the ocean.

Christopher Crowley is a mechanical engineer working for Creare, an advanced technology consulting firm in New Hampshire.

Inspecting Our Closest Star

Continued from page 57

Space Administration, in the 1960s. Then as its funding shrunk, NASA decided to sharply reduce its support for ground-based research. This left solar work dependent almost entirely on the National Science Foundation, where there is no office for solar astronomy as such, and funding comes through the solar-terrestrial program, which is devoted chiefly to the effects of the Sun on Earth's atmosphere.

Solar astronomers are now campaigning in the scientific community and in Congress for funds to build the High Resolution Solar Observatory (HRSO), a 1-meter telescope for observing the Sun from above Earth's atmosphere. This means getting images with 10 times the resolution of the photos accompanying this article!

According to Prof. Harold Zirin of Caltech: "We can't break through the resolution barrier without getting above the atmosphere. We need high-resolution images to examine the small-scale processes that are driving everything. We want to understand the physical processes taking place on the Sun's surface." Zirin and Allen Title from Lockheed are the principal investigators in charge of the work that HRSO will do, while NASA is in charge of building the telescope.

HRSO is the latest version of a project that has been canceled, revived, and scaled down several times since it was originally conceived in 1965. It is unclear whether the observatory will go up with the Shuttle, ride on the Space Station, or go into orbit on its own vehicle. As a Sun-synchronous free-flier, HRSO would cost $200 to $300 million by current estimates. Zirin said: "It will eventually fly. The great difficulty has been the politics of NASA. We kept it alive by fighting in back rooms of Congress, where there is some understanding of the importance of solar astronomy."

Zirin put HRSO in perspective in his April 1987 testimony to Congress: "The real achievement of the space program is to get people to focus on Mars, Jupiter, solar flares, the whole universe around us. These expenditures are justified because our country needs forefront science to compete in the world of the 21st century and we will not do it by cheap labor or our good looks. The Space Shuttle and the space station are fine projects, but we will just be driving empty trucks around if the cost overruns eat up all the payload money and there are no experiments to fly. And if NASA does not support the laboratories there will be no one to devise and build the payloads. Right now we seem to have neither trucks nor cargo."

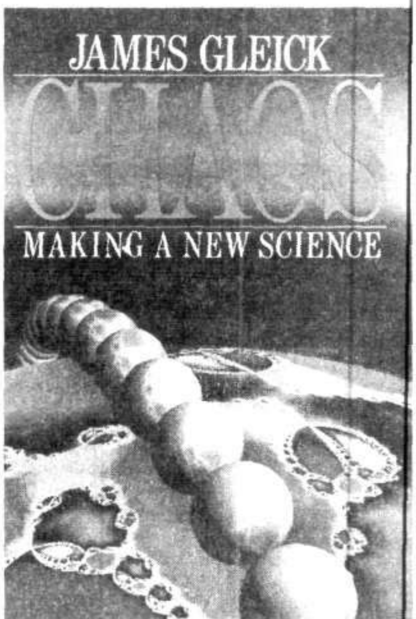
Chaos Theory and Population

Why There Are No Limits to Growth

by Carol White

Chaos—Making a New Science
by James Gleick
New York: Viking Press, 1987
$19.95, 352 pp., hardbound

The Beauty of Fractals
by H.O. Peitgen and P.H. Richter
New York: Springer-Verlag, 1986
$35, 199 pp., hardbound



The study of nonlinear recursive functions has gained a new appeal with the wider availability of computers. Now it is possible to study the behavior of these functions—stepwise differential functions where the rate of growth of the function is transformed as the function grows—in great detail. One of the hottest items today is chaos theory, which is based upon these models.

Chaos—Making a New Science by James Gleick gives a broad popular overview of the subject, while the *Beauty of Fractals*, by Peitgen and Richter, is more technical and full of beautiful computer graphics. Both books are interesting.

This review will deal with an aspect of chaos theory treated by both authors that concerns population. Not only is population growth a controversial political topic, but one particular model for population turns out to be central for chaos theory. This is not so surprising, since population growth is in many ways the perfect paradigm for the abstract study of how processes develop.

The new interest in the population function has developed because it can be shown that at the point of a phase change from ordered to disordered growth, the function exhibits a series of highly regular periodic oscillations, where the rate of oscillation increases with the rate of growth of the population. The key to the function is how quickly the growing population hits a barrier—in this case its assumed *carrying-capacity*.

Applied to a situation such as oscillations in international stock markets, this function would point to the fact that the apparent frequency of a bounce-back after a downswing, far from being a good sign of a healthy tendency to recovery, is instead a danger signal that the whole process is going out of control. The analogue to carrying-capacity here would be the state of the real economy as opposed to the rate of speculative growth!

Although the application of computer modeling and computer graphics to study this function is certainly interesting, the model is limited to one aspect of phase change: What happens when you approach a natural barrier and fail to go over it. Essentially, this is like studying in detail the situation of airplanes that were destroyed by turbulence before the sound barrier was successfully crossed. Already in the 19th century, Bernhard Riemann elaborated the theory of how shock waves form. His theory still provides the basis for practicable solutions for safely traveling faster than the speed of sound.

Riemann's discovery transformed modern mathematical physics, but his approach was in keeping with the school of science that believed in the continued perfectibility of God's universe. This is in sharp contrast to those who pose instead that the universe must devolve because of a supposedly overriding law of entropy. According to Riemann, who was a Christian Platonist, small-order changes in the microcosm—what are known as singularities—create the potentiality for new dimensions of progress and development.

In his own day, Riemann was the opponent of a Newtonian school of physics, typified by LaPlace, who believed that if we knew the initial position and velocity of every bit of matter in the universe we could predict its future development, from now through eternity. Modern chaos theorists, with the help of the computer, have shown that this is indeed an illusion. Because the universe is not made up of independent particles, but is a system that interacts with itself through a process of feedback, small-order differences can be blown up into major deviations over a sufficiently long time period.

This sensitive dependence upon imperceptible differences in initial conditions has been taken up as a philosophical basis for asserting the existence of freedom in the universe—much as the Heisenberg uncertainty principle was used in the past. This is in sharp contrast to the method of Riemann, which associates freedom with a positive vector toward progress. Essentially, for Riemann the geometry of phase changes is a moment in the broader geometry that describes an evolving universe.

Is There an Absolute Barrier?

Since the days of Parson Malthus, in the beginning of the 19th century, an influential school of thought has argued that there are natural limits to population growth. According to these Malthusians, any nation that attempted to violate these limits would suffer retribution in the form of plagues, starvation, and other so-called natural disasters.

Malthus made the case that although the number of people increased according to a *geometric* rate of growth, the ability of that population to sustain itself could increase only by *arithmetic* increments. Today, the modern theorists who argue Malthus's case have coined the term carrying-capacity to describe the alleged "limits to growth." In the 19th century as well as today, the hidden assumption of the Malthusian arguments is that man's technology will remain fixed.

The formula used by the chaos theorists is the algebraic form of Malthus's theory, discovered by P.F. Verhulst in 1845. For a simple growth function, the rate of growth can be determined by subtracting the difference between two neighboring terms and taking that difference as a ratio of the first $[(X_{n+1} - X_n)/X_n) = R]$. This gives us a simple recursive function $X_{n+1} = f(X_n) = (1 + r)X_n$, where r is a constant value of R. After n years, the population size is $X_n = (1 + r)^n X_0$.

However, if one believes that there

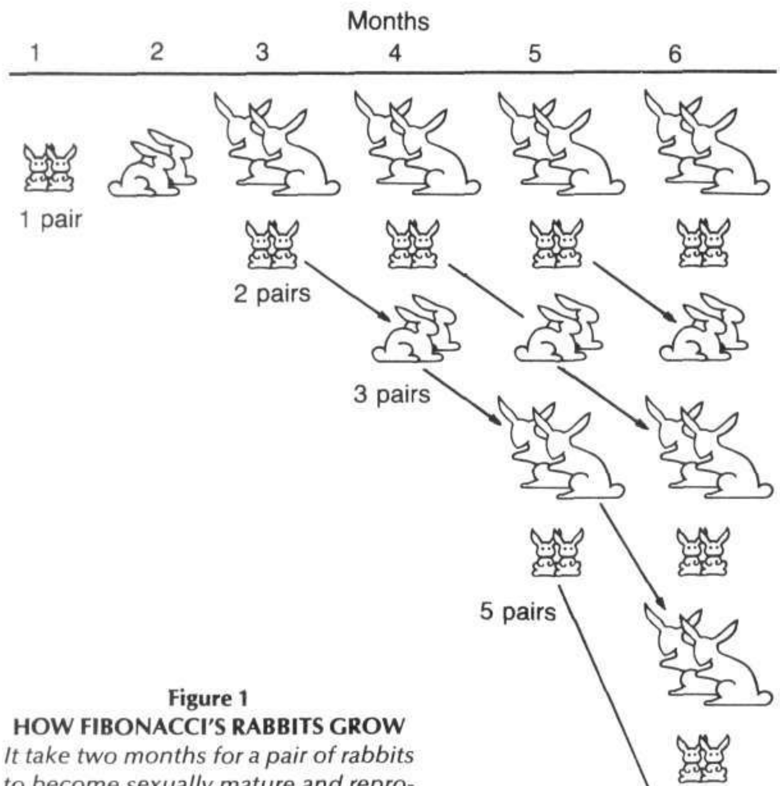


Figure 1
HOW FIBONACCI'S RABBITS GROW
It take two months for a pair of rabbits to become sexually mature and reproduce. Each month thereafter, they reproduce one pair of rabbits—Fibonacci's famous series.

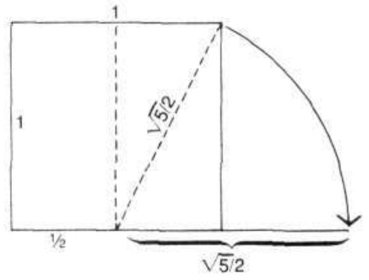


Figure 2
CONSTRUCTION OF A GOLDEN MEAN RECTANGLE
Take a square and fold it in half, and then fold this in half again, diagonally. Extend one side of the square by the length of this diagonal, beginning to measure off the diagonal from the midpoint of the square. The rectangle thus produced will be a golden mean rectangle. This construction can be replicated beginning with any arbitrary rectangle and it will rapidly approach the shape of a golden mean rectangle.

is an absolute limit on the carrying-capacity (we may assign the limiting value of the population the value of 1), then one must assume that the rate of growth is no longer constant, but is modified by the difference between the size of the population and its limit $[R = r(1 - X_n)]$. This leads, by simple algebraic substitution, to a transformed function $X_{n+1} = (1 + r)X_n - rX_n^2$.

The interest in the function emerges from the fact that if we begin with a population size under 1, the function will approach its limit—but only providing that r is less than 2. When r equals 2, an instability occurs, which is resolved as a periodic oscillation between two population levels. To achieve this, we can go to $r = 2.3$, and study the behavior of alternating terms of the function $X_{n+2} = f[f(X_n)] = F^2(X_n)$.

These values will remain stable until r reaches the value of $\sqrt{6}$, when a fourfold oscillation begins. This period doubling continues until the value of $r = 2.470$, at which the process remains unstable. An interesting geometric relationship emerges between the limiting values of r, the values at which phase changes occur. If we treat these values as branch points and take the ratio of the differences in r, between neighboring branch points, this value will approach 4.669. . . as n increases—a value known as the Feigenbaum number, after its discoverer. The formula for this is $(r_n - r_{n-1})/(r_{n+1} - r_n)$.

The Fibonacci Series

The study of recursive functions is not new. Indeed, as long ago as the start of the 13th century, the mathematician Leonard of Pisa (also known as filius [son of] Bonacci, or Fibonacci) was asked to develop a population function to study the unrestrained population growth of rabbits. The function he developed, the famous fibonacci series, also has a wide area of applicability: It turns out that r in this case will approximate the golden mean more and more closely.

Thus, this function turns out to be an excellent model for the development of such disparate structures as seashells, the human body, and the formation of galaxies. It governs the spacing of leaves around a plant stem and the distances of the planets from the Sun. The fibonacci series is determined by a simple rule: The next term in the series is equal to the last term added to the one before it. If we begin the series with the number 1, it progresses as follows: 1, 1, 2, 3, 5, 8, 13, 21, . . .

This model of population growth is important because it actually shows how the division of labor in a population allows the nurturing of future potentialities. In the case of the rabbit population, obviously young rabbits do not add to the carrying-capacity of the rabbit population, which will eventually strip the vegetation upon which it depends for food. But in the case of humans, it is precisely the nurturing (which emphatically includes education) of young that provides the pool from which technological innovation emerges. It is the succession of such technologies that have raised us, as a species, from a population potential of around 10 million to one of at least 5 billion.

Fibonacci's model was simple. He supposed that two rabbits produce a pair of young (one of each sex) every month, and that it takes two months for the pair to sexually mature and then begin to reproduce (Figure 1). Thus, there is a lag between the birth of a pair of rabbits and their joining the reproductive cycle. The population is increased each month, by adding a new cohort equal to the number of rabbits that are alive the previous month, to the total living rabbit population. The series increases as follows: 1 the first month, 2 the second month, 3 the third month, 5 the fourth month, 8 the fifth month, 13 the sixth month, and so on.

The golden mean may be represented algebraically by the proportion $1/\Phi = \Phi/(1 + \Phi)$. This is equivalent to stating that a line is divided into two segments, such that their ratio is equal to the ratio of the whole line to the larger segment. Solution of the quadratic equation allows construction of the golden mean using a 1 by 2 right triangle, which will, of course, have a hypotenuse equal to $\sqrt{5}$. The golden mean will be approximately equal to 1.618.

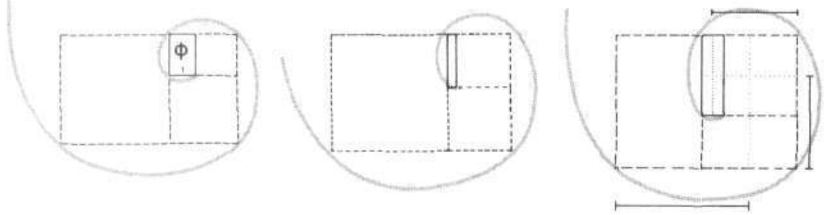
This allows us to use the following construction to aid in drawing a golden-mean spiral that grows by the ratio Φ for every 90°-rotation (Figure 2): Take a square and fold it in half and then fold this in half again diagonally. Extend one side of the square by the length of this diagonal, beginning to measure off the diagonal from the midpoint of the square. The rectangle thus produced will be a golden mean rectangle. Now extend it on its longer side by constructing a square on that side.

Then construct a new square on what is now the longest side of the new rectangle. Continue this process, rotating 90° with each new addition [Figure 3(a)]. Then mark off the approximate curvature of the spiral by connecting these vertices. The center of the spiral will be located within the first golden mean rectangle, and can be determined by connecting a pair of opposite vertices—one from the first rectangle and one from the second (whose dimensions are the golden mean and the golden mean squared.)

This gives one diagonal and a pair of vertices, one from the latter rectangle and an opposite vertex from the rectangle whose sides are the golden mean squared and the golden mean cubed. These radii will rotate by 90° as the spiral moves from vertex to vertex.

A Golden-Mean Geometric Series

Because of its unique properties of



(a) (b) (c)

Figure 3
A SPIRAL GEOMETRY TO MODEL GROWTH

A spiral is used to indicate a rate of growth over time. A golden mean spiral (a) can be constructed starting with a golden rectangle. It is a logarithmic spiral whose radius grows by the ratio Φ every time it completes a 90° rotation.

Using the same method of construction but beginning with any arbitrary rectangle (b), a golden mean spiral can be approximated.

The spiral in (c) models the case where the reproductive rate is 50 percent (only one rabbit, of alternate sex, is produced each month by a mature pair of rabbits). Construct a rectangle as before, adding a square to one of its sides. This time, however, first divide the rectangle in half by folding its long sides against each other.

Now place the square whose dimensions are the same as the long side of the rectangle so that it lies against the fold rather than the edge of the rectangle. Continue the process as above, each time making a square of the longer side and appending it to a midsection fold—rotating around the four sides of the box.

At each completed rotation, the radii would be first 6, then 10, then 13, 18, and so on, to approximate the growth rate of 1.4.

self-similarity, a golden-mean geometric series is built up by adding the last two terms in the series to produce a successor. Applying this same method to building up a series, starting with any two arbitrary values, will produce a series (after the first several terms) that converges more and more closely on a golden mean series.

Thus we can replicate the construction above beginning with any arbitrary rectangle and it will rapidly approach the shape of a golden mean rectangle [(Figure 3(b)]. One such famous series is the fibonacci series, but we could equally well begin with any two numbers—such as 5, 100, 105, 205, 310. . . .

To see how this works, it is useful to write the golden mean series so that each of the successive terms is expressed in terms of the first two terms—1, Φ, (1 + Φ), (1 + 2Φ), (2 + 3Φ), (3 + 5Φ), (5 + 8Φ), . . . Were we to have begun with any two arbitrary terms, let us say 5 and 100, then we could write the series as 5, 100, (5 + 100), (5 + 2 × 100), (2 × 5 + 3 × 100),. . .

The golden mean expresses the harmonious sectioning of an object. Its asymmetry indicates a direction of growth, but its unique role for all living beings (including the growing universe itself) is not determined by this harmony. Rather, harmony is a reflection of a lawfully determined progression.

A universe of objects appears to grow by accretion, but consideration always shows us an underlying geometric rate of expansion. The simplest model of such geometric expansion is a logarithmic spiral on a cone (Figure 4). Each completed rotation of the spiral represents the passage of a unit of time. By comparing the radii of circular cross-sections of the cone at two such successive instants of time, we can measure the rate of increase of action over the period.

A better model would have two degrees of freedom—in other words, be doubly conical. The second degree of freedom can be represented by the widening of the vertex angle of the cone. In this more complex model, the spiral represents a rate of growth and the vertex angle of the cone may represent an increase or decrease in carrying capacity of an economy.

On a wider cone, a spiral of a given pitch will accomplish a greater amount of action in each rotation [Figure 4(c)]. Here, the radius of the cone indicates the level of the economy at the beginning of a given period of development, while the vertical axis of the cone measures the frequency of the spiral, and indicates how the economy grows from that period forward.

Retarded Potential and Growth

Doubly conical functions are nonlinear wave functions—and they are recursive. As they propagate through a medium, they transform the medium, their own form, and ultimately their very mode of propagation. In the example above, we might think of a given level of technology as the medium in which new inventions are first created, and then through which they must be propagated if the technology is to be transformed and its productive potential increased.

In the case of rabbit reproduction, the nurturing environment provided by the parent rabbits for the maturing young is the medium of propagation for the reproductive potential of the population.

The difference between the doubly conical or Riemannian fibonacci model and the Verhulst model is simply that the limiting value of the population will also vary. In other words, carrying-capacity is a relative, but not an absolute limit. It defines a barrier like a shock wave. To surmount that barrier, a new pathway to progress must be found—a higher-order Riemannian surface.

We start with a base-line economy, which, taken as a whole, we represent as a unit. Within the economy there is a division of labor, so that half of the available productivity is used to reproduce the economy from one period to

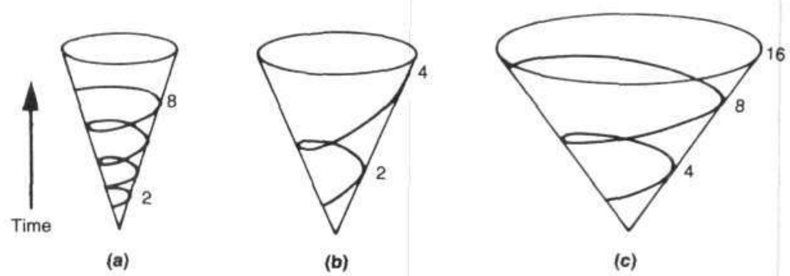


Figure 4
CONICAL SPIRALS MODEL
DIFFERING CARRYING CAPACITIES

In the same length of time, populations (a) and (c) quadruple, but the frequency of the rate of reproduction of population (a) is three times greater than that of population (c). Populations (b) and (c) are reproducing at the same rate but population (c) is greater to begin with.

The horizontal radial dimension indicates the level of the population at the beginning of the spiral wave, and population at later times is determined by the frequency of rotation of the spiral (assuming that one completed rotation represents a specified action, for example, doubling the population).

If we assume that the population of all three cones is below the so-called carrying-capacity of their respective economies (as represented by the vertex angle), then the population is likely to be running into trouble unless its "cone" (that is, carrying-capacity) is expanded.

the next, while the other half develops new, higher technology potentials that will be used to increase the productivity of the work force as a whole in the next period.

The productivity available for reproducing the economy will expand, as will the part devoted to science, research, and development. If we suppose that the portion of the work force whose effort is devoted to supporting the population is able to generate double the action needed to sustain itself each period, then in this simplified model, the economy will grow according to the fibonacci series (and the rate of profit generated by the productive section of the work force will be 100 percent).

Suppose, instead, a more realistic model in which the portion of the population dedicated to support can generate only a 50 percent surplus over and above its own needs. Then we will have a series that develops according to the numbers 1, 1, 1.5, 2, 2.75, and so on. Other examples of such a series might occur, such as 6, 10, 13, 18, 24.5, 33.5,. . . or starting with 4 and 100, 4, 100, 102, 152, 203, 279, 380.5,. . . In each instance neighboring terms of the series will converge to the ratio 1.366. Rather than increasing r for the population as a whole, we may instead suppose a rise in the potential of the productive portion of the population.

A greater rate of increase would occur, if instead of taking half of the preceding figure we took some other multiple of it. For example, if the multiple were 10, as in the series 1, 4, 14, 54, 194, 734, 2,674, 10,014, the rate of growth as measured by the ratio of neighboring terms would converge to 3.7.

The shift in the rate of growth might be represented by increasing the number of rotations of the spiral in a given period of time; or, if we think of the spiral as representing an economy, the economy can arrive at the same result by another pathway. It may achieve a transformation in which new potentials emerge as a result of the adoption of more advanced technologies. The shift to a fusion-based economy would effect such a global change.

Carol White is editor-in-chief of 21st Century.

AIDS Study

Continued from page 15

worse than that. If AIDS does get concentrated temporarily in the lower socio-economic classes, we might lose 30 years of civil rights, which I've worked personally very hard for since the '50s. I'd hate to see that go down the drain. . . .

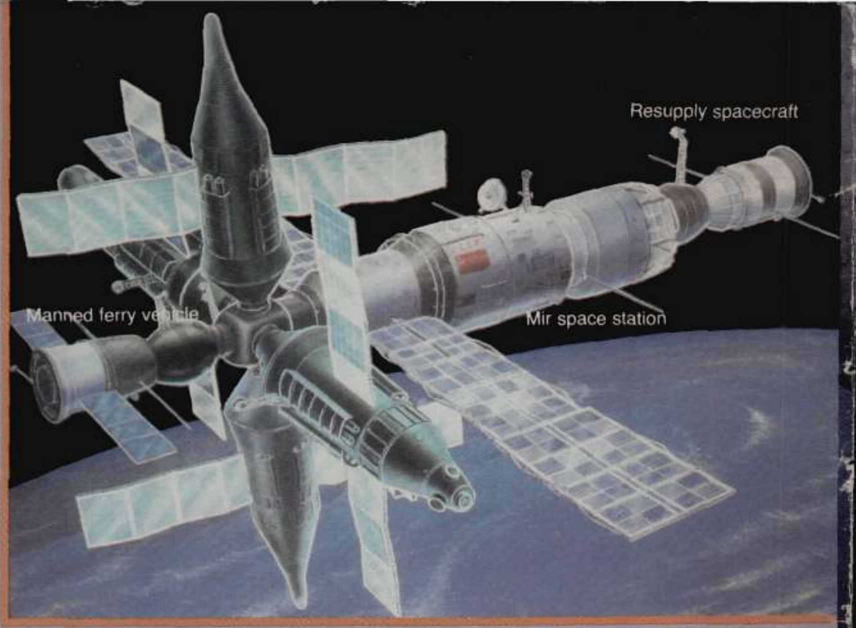
Question: Is acceptance of testing growing?

Yes, more and more people are grudgingly accepting it. My AIDS study started in a very funny manner. My son is 23; he is in graduate school and he co-authored one of my papers on this. We were just shooting the breeze about AIDS, and I said to him, "I think we're going to have to start testing people." And he said: "Dad, you're being a fascist pig." So rather than screaming at him, I said, "Hey look. Let's just do a simple model. Write down the epidemiological equations, and program them." He went down to the computer and worked for a few hours, and then came back to me and said: "My God. It's worse than I thought."

In This Issue

THE GEOMETRY OF THE NUCLEUS

How is space filled? The cover story by Laurence Hecht presents a fascinating hypothesis on the geometry of the nucleus that accounts for the occurrence of the 92 natural elements as well as the periodicity of the periodic table.



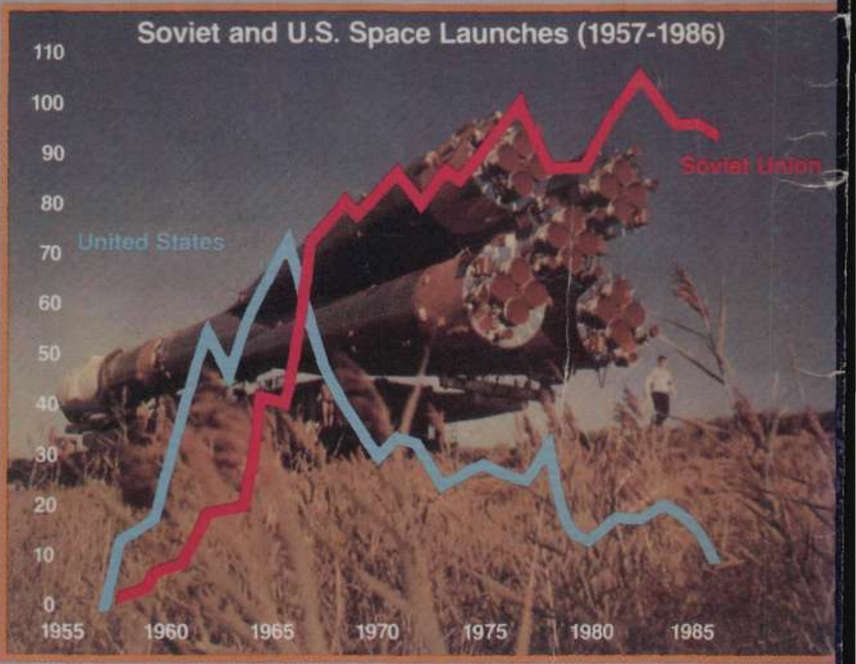
U.S. Department of Defense

Artist's conception of the completed Soviet space station complex, Mir. At present, the multiple docking module (left) has four empty ports.

THE SOVIETS HAVE ALREADY MILITARIZED SPACE!

The most shocking fact about the Soviet space program is that the Soviets have already made space a battlefield, with the operational capability of attacking every U.S. satellite and spacecraft. As Marsha Freeman spells out in chilling detail, the Soviets are years ahead of the United States in planning, developing, and deployment of military space systems, while the United States has no operational antiballistic missile system, no antisatellite system, and a shrinking civilian and military space program.

Can the United States meet the Soviet challenge? Yes, but the first step is sweeping away the lies and disinformation promoted by the Soviets and their U.S. friends.



U.S. Department of Defense

Soviet launches have averaged 100 per year for the past decade, with military missions making up two thirds of all launches. In the background is the Soviet launch vehicle SL-4, which is used to place cosmonauts, resupply vehicles for the Mir, and other payloads into orbit. It is transported to the launch pad by rail.

False-color electron micrograph of AIDS viruses (magnified 37,500 times). One is seen emerging from a stricken white blood cell of the immune system. The red cores at the center of the viral spheres hold the AIDS genetic program.

Professor Luc Montagnier, Pasteur Institute/CNRI/Science Photo Library

MITOSIS AND A CURE FOR AIDS

We can find a cure for AIDS, but probably not using the traditional methods of molecular biology. Warren J. Hamerman reviews the exciting new work on the harmonics of mitosis (cell division) and optical biophysics, and demonstrates how this line of research is the quickest path to understanding living processes—and stopping—AIDS.