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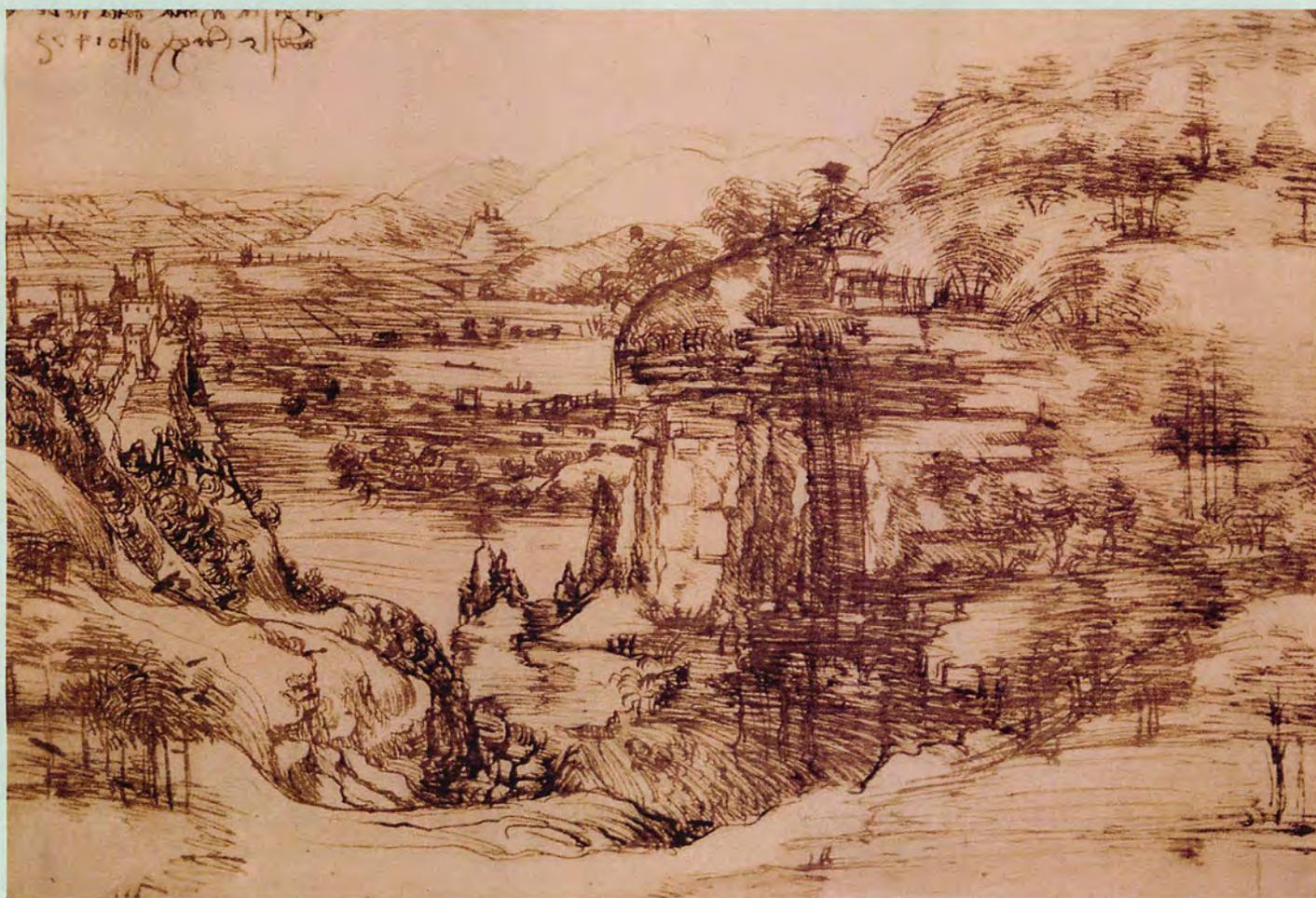
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21st CENTURY SCIENCE & TECHNOLOGY

Vol. 15, No. 2

Summer 2002

Features

17 **Leonardo da Vinci's Geology and the Simultaneity of Time**

Dino De Paoli

On the occasion of Leonardo's 550th anniversary, a look at some of the lesser known ideas of this universal genius: his revolutionary views of geology in a time when literal Biblical interpretations and Aristotelian materialism (such as "spontaneous generation") prevailed.

34 **ON A CONNECTION BETWEEN ELECTROMAGNETISM AND GRAVITATION The Action of a Magnetic Field on the Motion of a Pendulum**

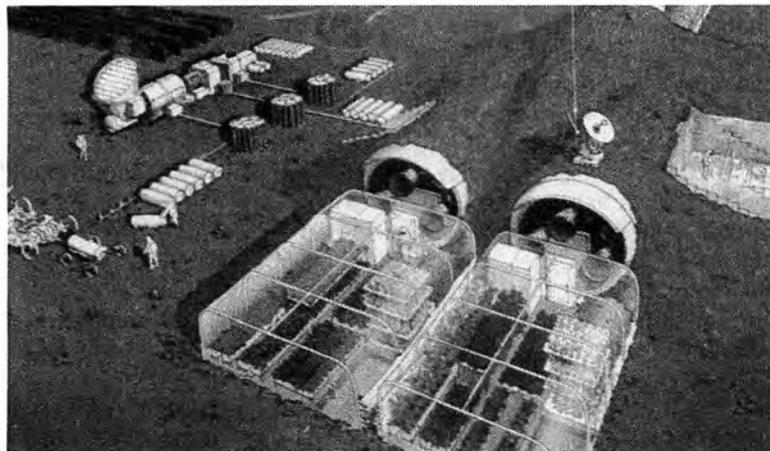
Maurice Allais

A glass pendulum oscillating inside a solenoid changes direction in response to changes in the direction of the electrical current. These experiments carried out in 1953, led the Nobel-Prize winning author to suspect a connection between electromagnetism and gravity.

41 **SPACE FARMING ON MARS Greenhouse Aboard MIR Shows Plants Can Thrive in Space**

Dr. Tania Ivanova

Astronauts living in space could be eating fresh vegetables and "space bread," milled and harvested from an onboard greenhouse. The seeds from these plants will grow the first food crops on Mars.



Artist's conception of a greenhouse on Mars.

Carter B. Emmart

On the cover: One of Leonardo's many landscape studies that include geological formations. Landscape, 1473 (pen and ink on paper) by Leonardo da Vinci (1452-1519), Galleria degli Uffizi, Florence, Italy/Bridgeman Art Library. Cover design by Alan Yue.

News

RESEARCH COMMUNICATIONS

8 A New View of Geodynamics
Sieghart Moser

9 When Light Governs the Expression of Genes
Emmanuel Grenier

COMMENTARY

12 Schizophrenic-Like Video-Game Disorder
Lyndon H. LaRouche, Jr.

IN MEMORIAM

15 Thor Heyerdahl
Rick Sanders

ASTRONOMY

50 100th Extrasolar Planet Candidate Found
Marsha Freeman

NUCLEAR REPORT

53 An Open Letter for Support of UNSCEAR
Zbigniew Jaworowski

SPACE

55 Bringing Developing Nations Into the Space Age
Marsha Freeman

FUSION REPORT

58 Putting Fusion Back on The Front Burner
Charles B. Stevens

59 Practical Fusion Power Is A Question of Political Will
Dr. Stephen O. Dean

Departments

EDITORIAL

2 Bring Back DDT, and Science with It!
Marjorie Mazel Hecht

4 LETTERS

10 NEWS BRIEFS

BOOKS

60 John Bardeen, Superconductivity, And Hall's Unanswered Questions
Laurence Hecht

Bring Back DDT, and Science With It!

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The 1972 U.S. ban on DDT is responsible for a genocide 10 times larger than that for which we sent Nazis to the gallows at Nuremberg. It is also responsible for a menticide which has already condemned one entire generation to a dark age of anti-science ignorance, and is now infecting a new one.

The lies and hysteria spread to defend the DDT ban are typical of the irrationalist, anti-science wave which has virtually destroyed rational forms of discourse in our society. If you want to save science—and human lives—the fight to bring back DDT, now being championed by that very electable candidate for the Democratic Presidential nomination, Lyndon H. LaRouche, Jr., had better be at the top of your agenda.

Sixty million people have died needlessly of malaria, since the imposition of the 1972 ban on DDT, and hundreds of millions more have suffered from this debilitating disease. The majority of those affected are children. Of the 300 to 500 million new cases of malaria each year, 200 to 300 million are children, and *malaria now kills one child every 30 seconds*. Ninety percent of the reported cases of malaria are in Africa, and 40 percent of the world's population, inhabitants of tropical countries, are threatened by the increasing incidence of malaria.

The DDT ban does not only affect tropical nations. In the wake of the DDT ban, the United States stopped its mosquito control programs, cutting the budgets for mosquito control and monitoring. Exactly as scientists had warned 25 years ago, we are now facing increases of mosquito-borne killer diseases—West Nile fever and dengue, to name the most prominent.

What DDT Can Do

Malaria is a preventable mosquito-borne disease. It can be controlled by spraying a tiny amount of DDT on the walls of houses twice a year. DDT is

cheaper than other pesticides, more effective, and *not harmful* to human beings or animals.

Even where mosquito populations have developed resistance to DDT, it is more effective (and less problematic) than alternative chemicals. The reason is that mosquitoes are repelled by the DDT on house walls and do not stay around to bite and infect the inhabitants. This effect is known as "excito-repellency," and has been shown to be a dominant way that DDT controls malaria-bearing mosquitoes, in addition to killing them on contact.¹ Studies have demonstrated this for all major species of malaria-bearing mosquitoes.

It costs only \$1.44 per year to spray one house with DDT. The more toxic substitutes cost as much as 10 to 20 times more and require more frequent applications, making spraying programs prohibitively expensive. In addition, replacement pesticides have to be applied more frequently and are more toxic.

Banned to Kill People

DDT came into use during World War II, and in a very short time saved more lives and prevented more diseases than any other man-made chemical in history. Millions of troops and civilians, in particular war refugees, were saved from typhus because one DDT dusting killed the body lice that spread that dread disease.

Why was DDT banned, 30 years after its World War II introduction and spectacular success in saving lives? The reason was stated bluntly by Alexander King, founder of the Malthusian Club of Rome, who wrote in a biographical essay in 1990, "My chief quarrel with DDT in hindsight is that it has greatly added to the population problem." King was particularly concerned that DDT had dramatically cut the death rates in the developing sector, and thus increased population growth.

As King correctly observed, the incidence of malaria, and its death rates, were vastly reduced by DDT spraying. To take one example: Sri Lanka (Ceylon) had 2.8 million cases of malaria and more than 12,500 deaths in 1946, before the use of DDT. In 1963, after a large-scale spraying campaign, the number of cases fell to 17, and the number of deaths fell to 1. But five years after the stop of spraying, in 1969, the number of deaths had climbed to 113, and the number of cases to 500,000. Today, malaria rates have soared in countries that stopped spraying. In South Africa, the malaria incidence increased by 1,000 percent in the late 1990s.

The Silent Spring Fraud

The campaign to ban DDT got its start with the publication of Rachel Carson's book *Silent Spring* in 1962. Carson's popular book was a fraud. She played on people's emotions, and to do so, she selected and falsified data from scientific studies, as entomologist Dr. J. Gordon Edwards has documented in his analysis of the original scientific studies that Carson cited.²

As a result of the propaganda and lies, the U.S. Environmental Protection Agency convened scientific hearings and appointed a Hearing Examiner, Edmund Sweeney, to run them. Every major scientific organization in the world supported DDT use, submitted testimony, as did the environmentalist opposition. The hearings went on for seven months, and generated 9,000 pages of testimony. Hearing Examiner Sweeney then ruled that DDT should *not* be banned, based on the scientific evidence: "DDT is not carcinogenic, mutagenic, or teratogenic to man [and] these uses of DDT do not have a deleterious effect on fish, birds, wildlife, or estuarine organisms," Sweeney concluded.

Two months later, without even reading the testimony or attending the hearings, EPA administrator William Ruckelshaus overruled the EPA hearing officer and banned DDT. He later admitted that he made the decision for "political" reasons. "Science, along with economics, has a role to play . . . [but] the ultimate decision remains political," Ruckelshaus said.

The U.S. decision had a rapid effect in the developing sector, where the State

Department made U.S. aid contingent on countries not using any pesticide that was banned in the United States. The U.S. Agency for International Development discontinued its support for DDT spraying programs, and instead increased funding for birth control programs.

Other Western nations—Sweden and Norway, for example—also pressured recipient nations to stop the use of DDT. Belize abandoned DDT in 1999, because Mexico, under pressure from the United States and NAFTA, had stopped the manufacture of DDT, which was Belize's source. Purchases of replacement insecticides would take up nearly 90 percent of Belize's malaria control budget. Mozambique stopped the use of DDT, "because 80 percent of the country's health budget came from donor funds, and donors refused to allow the use of DDT," reported the *British Medical Journal* (March 11, 2000).

The World Bank and the World Health Organization, meanwhile, responded to the rise in malaria incidence with a well-publicized "Roll Back Malaria" program, begun in 1989, which involves *no* insect control measures, only bed nets, personnel training, and drug therapies—a prescription for failure.

POPs Convention Is Genocide

In 1995, despite the official documentation of increases in malaria cases and malaria deaths, the United Nations Environment Program began an effort to make the ban on DDT worldwide. UNEP proposed to institute "legally binding" international controls banning what are called "persistent organic pollutants" or POPs, including DDT. Ratification of the POPs Convention, finalized in 2001, is now pending in the U.S. Senate, where it has the support of the Senate Committee on Environment and Public Works, including committee chairman James Jeffords (Ind.-Vt.) and committee member Joe Lieberman (D.-Conn.). President Bush has already endorsed the U.S. signing on to the POPs Convention.

The evidence of DDT's effectiveness is dramatic. In South America, where malaria is endemic, malaria rates soared in countries that had stopped spraying houses with DDT after 1993: Guyana,

Bolivia, Paraguay, Peru, Brazil, Colombia, and Venezuela. In Ecuador, however, which increased its use of DDT after 1993, the malaria rate was rapidly reduced by 60 percent.

But DDT spraying is not a magic bullet cure-all. Eliminating mosquito-borne diseases here and around the world requires in-depth public health infrastructure and trained personnel—as were in place in the 1950s and 1960s, when DDT began to rid the world of malaria. And mosquito-borne illness is not the only scourge now threatening us. A growing AIDS pandemic, and the return of tuberculosis and other killer diseases, now also menace growing parts of the world's population, particularly in those areas where human immune systems are challenged by malnutrition and poorly developed (or non-existent) water and sanitation systems.

To solve this worsening problem as a whole—a disgrace in face of the scientific achievements the world has made—we must reverse the entire course of the past 30 years' policymaking and return to a society based on production, scientific progress, and rationality. The onrushing world depression crisis, demands a new FDR-style approach to economic reconstruction in the United States. The recognized spokesman for such a reform of our economic and monetary policies is the very electable candidate for the Democratic Presidential nomination, Lyndon H. LaRouche.

The United States should not ratify the POPs Convention with its phase-out of DDT and other valuable chemicals. On the contrary, this nation should bring back DDT *now*, under the provisions of existing U.S. law that allow the use of DDT in health emergencies. If the continuing mass murder of millions of people is not an emergency, what is?

—Marjorie Mazel Hecht

Notes

1. A summary of this work can be found in an article by Donald R. Roberts, et al., *Emerging Infectious Diseases*, Vol. 3, No. 3 (1997), pp. 295-302.
2. J. Gordon Edwards, "The Ugly Truth about Rachel Carson," *21st Century*, Summer 1992.

Edwards, a professor emeritus at San Jose State University in California, drank a spoonful of DDT in front of his entomology classes at the beginning of each school year, to make the point that DDT is not harmful to human beings. Now 83, and still fighting for the truth about DDT, Edwards is an avid mountain climber.

Letters



Pitcairn Island Revisited

To the Editor:

Recently I reread the very exciting and satisfactory interpretation of the Pitcairn Island petroglyphs by Ross Perfect, published in *21st Century*, Winter 2001-2002 ["Pitcairn Island Petroglyph Deciphered," p. 54].

I felt that the interpretation was not quite complete, and after some study I came to the conclusion that "the stick-like animal" glyph and the views of the Moon at two different stages of the eclipse revealed (I almost wrote "hid") within 5 minutes the exact time of the eclipse. This timing would enable the longitude of the island to be determined when compared with the observations of the same eclipse at their home location (Alexandria in Egypt?).

If the glyph of the "stick animal" represents the constellation at the zenith when the eclipse was in totality, it would fix the hour of the eclipse. A "Starfinder chart" for the Southern Hemisphere, adjusted for the equinox precession since 233 B.C., indicated that at midnight of December 14, Taurus would be at the zenith. There are enough stars in Taurus to be able to draw many simple diagrams, so I have no proof that the figure represented Taurus to the navigators at that time. Perhaps the figure is actually a script.



A copy of the Pitcairn Island petroglyph. The rock markings have been chalked in so that they can be seen in a photograph.

Taking the glyph to mean Taurus at the zenith, it tells us that the eclipse took place about midnight local time. So, one can deduce midnight December 13 or 14, 233 B.C. from the information on the glyph and knowledge of the Moon calendar which the navigators undoubtedly possessed.

I have interpreted the two strokes against each of the Moon segment glyphs to mean two 1/4-hour measures on the water clock. It seems clear that the first small segment shows what was visible one-half hour before the full hour point, just after the start of totality, and the second large segment shows how much of the Moon was visible one-half hour after the full hour point, just before totality ended.

Using the time equation for 233 B.C. (the time equation has moved 32 days since 233 B.C., and December 14 had the same variation as January 16 now) local noon would have been 9-1/2 minutes ahead of mean time. This means that the eclipse would have started at 23.41 local time. The view of the Moon would correspond very closely to that shown by the lefthand glyph (11/64 of Moon diameter).

Similarly, the end of the eclipse would have been about 1.03 local time, so that the amount of Moon visible at 1:30 a.m. December 14 corresponds closely to that shown in the righthand Moon glyph (27/64 of Moon diameter). There is a corollary that their water clock was very accurate.

The above shows that the navigators clearly defined the eclipse time within 5 minutes of actual, and if they had taken this information back "home," they would have been able to specify the

location of the island within 5 miles. This is much better than Pitcairn was located until very recently. Our 1962 *Encyclopedia Britannica* gives the longitude as 133 degrees West—but then I have found many other inaccuracies in that publication.

Incidentally, the star chart shown on page 58 of Ross Perfect's article cannot possibly be correct, since the Moon at the end of the month must have been near, or in, Sagittarius and not in Gemini, where it was during the eclipse. However, as it was that chart which led me to examine the glyph more closely, it was a serendipitous error.

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Evolution by Chance

To the Editor:

I was, frankly, appalled to read the comments of the Editor of this forward-looking science magazine on the certainty of a "perfection towards which all things in the universe are striving" as the basis for a rational science. This kind of utopian thinking was exactly the target of Darwin's evolutionary concept, which underlies essentially the entire field of current biology. Textbook after textbook goes to great lengths to explain just how the principles of chance evolution can, indeed, account for the whole of biological optimization.

The editorial error is to assume that, because fitness tends to improve, there must be a "striving" toward that improved state. The whole concept of the principle of natural selection was to show that things, such as life forms, tend to improve simply because the less fit ones die off. But every fitness selection is not necessarily an improvement. Is the evolution of nuclear arms toward greater megakill power an improvement? Many think that it is likely to lead the human race to complete self-annihilation. Would this "end" be governed by a principle of perfection?

What the editor seems to forget is that chance occurrences have their own laws of "perfection." It is a statistical fact that when chance distributions are combined, the result tends to be closer to the form of a Gaussian (or normal) distribu-

tion than the origins. This is the statistical law of convergence to the Gaussian form. It is not an "end" towards which events are "striving." It just happens to be a property of statistical distributions, and is one of the many statistical properties (or "laws") that govern the course of evolution. To attribute such properties the status of a 'final cause' is a kind of creeping mysticism that underlies many wild philosophical speculations in science. I had hoped that the 21st Century would have rung the death knell on such fantasies, but I see that this was too optimistic a prognosis.

Christopher W. Tyler
 San Francisco, Calif.
 cwt@ski.org

The Editor Replies

Apart from citing the authority of "textbook after textbook," you make no cogent argument for the law of chance evolution. The Gaussian normal distribution is an interesting phenomenon, but is hardly an argument for progressively higher ordering in nature. It seems to me that the actual progress in biological science should lead us more and more away from the Darwinian explanation. The more we learn of the complexity of biological organisms—the eye, the photosynthetic processes of a leaf, even the wavelength-sensitive switching capability of phytochromes described in this issue (p. 9)—the more difficult it is to explain all this by "chance" evolution, or survival of the fittest.

Since the alternative to Darwin is not Darby, I must conclude that something other than a fear of a return to religious fundamentalism is behind the unrelenting support for Darwin. Apart from the force of academic popular opinion, it seems to me that a confusion of scientific thinking with a crass empiricism or mechanism is at the root of the problem. Real, fundamental progress in science has always been accompanied by philosophical critique of the error of sense certainty. So the achievements of the Platonic Academy; of the Renaissance heirs of Nicholas of Cusa—Pacioli, Leonardo, Kepler; of the Huygens-Leibniz-Bernoulli collaboration; the breakthroughs of Ampère, Fresnel, et al. in the French school; and of the scientific heirs of the German classical renaissance—Gauss, Weber, Riemann, and Cantor.



These are some samples of how video game producers advertise their wares in Computer Gaming World.

A greater familiarity with Gauss's thinking would lead you to recognize in his concept of the complex domain, not a determination by statistical probability, but precisely the notion of determination of a lower by a higher-ordered domain, which is needed for a proper comprehension of evolution.

Video Game Addiction

Editor's Note: These two e-mail letters were received in response to *21st Century's* Fall 2000 article by Michele Steinberg, "Programmed to Kill: Video Games, Drugs and the 'New Violence,'" posted on our website at http://www.21stcenturysciencetech.com/articles/New_violence.html.

To the Editor:

This letter goes to the writer of "Programmed to Kill," Michele Steinberg.

In your article you clearly pointed the finger at video games (among other things) to be the reason(s) for teen violence and the cold-blooded murders at Columbine High School. Yet you had no evidence that supported these state-

ments. You claimed that these young men came from "well-to-do families" yet their own parents didn't know anything about the bombs they had made (in their own home) or the guns they had purchased.

The horrible tragedy at Columbine should not fall in the hands of video game distributors, screen writers or anyone for whom the blame does not belong. But should fall back on the parents, and their lack of awareness that their children had psychological issues that required attention. You blindly pointed your finger and found someone to place the blame on to make you sleep better at night. Children that do these acts of violence have problems far beyond their television screens, it is in their mind.

So to the writer of "Programmed to Kill," when you point your finger make sure it's in the right direction.

Concerned Gamer

To the Editor:

To Michele Steinberg and those who oppose violent videogames. Please read the following... [original spelling retained—ed.]

You people are jumping on a giant

bandwagon blaming videogames for violent acts. I'll just say this in a few lines. If videogames were never ever created, there would still be as much violence as there is today. We still (The spelling and grammar is just a teenager thing) have extremely violent gory movies and violent TV. So, are you going to take away all the good movies most people like to see, such as *Mortal Kombat* the Movie (which was not even that good). Hmm, nothing that good at the theaters now. And when I was in 7th grade I read a line about the battle of the Alamo saying that there was so many dead bodies the ground was about two through three inches deep in blood. Santa Anna lined (Have you even played a violent videogame before!?) up all the wounded and survivors up on a wall and shot them down. A few that were still alive were beaten to death with muskets or bayonets (or however you spell it). That's pretty violent and also picturing it. . . . Now what, are you going to take away our History textbooks too!?. . . .

"DOOM" only played a small part in the Cloumbine shooting. One of the gunmen had a sawed off shotgun just like in the game (which he copied from it), (It was kinda play fighting and kind of having fun running around) and he named it Arlene after a main character in the game.

I was taught right from wrong and I never ever let my value for human life (that was what we did in about 15% of our time) decrease. Just think about it. You can't protect your kids from finding out violence in reality for ever. You found out about how cruel and how nice (mostly we just played with building blocks or Legos) life can be. Cause one day, they are gonna go out thinking the world is *one big happy place* and then reality is gonna hit them in the back of the head and there gonna find out that the world is not *one big happy place* there gonna find out that the world is unfair, it's cruel, and that it sucks. And having to deal with it in one big blow is most likely gonna raise the expectancy of them committing suicide. The best you can do (parents) is keep them in a good well balanced family have a good religion, discipline them, tell and show them right from wrong, and tell them when they are right and correct them when they are wrong. And spend as much time with them and help them build

their character. That's what my family did and I am one of the nicest kids you can meet. I also play violent videogames a lot but I don't let it get in the way with my homework. I am 15 yrs. old. And videogames are not the SOURCE of violence, I can assure you.

Chris

P.S. If videogame guns improved gun handling, then I would spend countless hours playing *DOOM*, *Turok*, and *Bloody Roar*, so I become an expert rank in my marksmanship for my JROTC class. Cause I suck with a real gun. . . . Besides, videogame counsels [consoles—ed.] are 3D now well, they've been like that since late 1994 and early 1995. Games don't have little figures that pop up instantly and go down just as fast. Nor do they have a little gun to go with it. But the one I played with when I was in kindergarten had a little plastic gun and a game where pictures of men holding guns popped up slowly and stayed up for 3 seconds. I hardly call that *stimulus response like stated by Mr. Grossman*. Also, there were civilians that popped up even faster so that defeated the whole response thing cause you can't shoot innocent people. *The only thing violent games exercise are your need to play and have fun. . . .*

The Editor Replies

We refer readers and the two above correspondents to the commentary on this subject by Scientific Advisory Board Member Lyndon H. LaRouche, Jr. on page 12 of this issue. These two letters are clinically relevant evidence of the phenomenon LaRouche addresses.

Is Pluto a Kuiper Object?

To the Editor:

Since the discovery of the first Kuiper belt object some 10 years ago, there has been a pressure to "dethrone" Pluto from its status as a planet. Jeremy Batterson's article in the Summer 2001 issue ["How I Know Pluto Is a Kuiper Object," p. 80] argues that Pluto is just another object of the Belt.

However, I find Batterson's argument that invokes Bode's law somewhat misleading. From the traditional form of Bode's law, which still prevails in the textbooks, it does appear that even Neptune is way too close to fit in. The problem

here is that hundreds of alternative laws have been published in the 220-odd years intervening between Titius's invention of the empirical "Bode's" law and the discovery of the first Kuiper belt object. After the 1846 discovery of Neptune, the traditional Bode's law remained little more than a historic footnote, but searches for the regularities of the planetary distances continued. Indeed, before the discovery of Pluto several "laws" were published that predicted its distance to within 2 percent.

Moreover, as early as 1850, speculations appeared that the next Bode's "lane" out from Neptune would not be occupied by a single major planet, but, just as the fifth lane, by a swarm of smallish bodies. (Kuiper's hypothesis came a century later.)

How do we fit Pluto in Bode's law? There are many plausible answers. One is to divide the asteroid belt into two belts, and postulate another belt between Saturn and Uranus, where the so-called Centaurs (objects now known to have drifted down from the Kuiper belt) are located. This idea appeared to the Italian astronomer Giuseppe Armellini in 1917, though it still overestimated the distance of Pluto by some 14 percent.

A similar approach is graphically illustrated by Lothar Komp, but fits Pluto more closely.¹ The late Daniel R. Wells reinvented a law (previously very little known), which is an alternative to, rather than a variation of, Bode's law.²

As mentioned by Lothar Komp, there are also more complicated laws based on periodic corrections to the geometric series of Bode's law, which can be found from Fourier analyzing the planetary distances. However, the British planetologist G.H.A. Cole proposes a simplified form of this law . . . which gives 41.6 astronomical units for Pluto.³ Whatever formula we prefer, Pluto is no more difficult to fit in than, say, Venus or Uranus.

Another curious fact about Pluto is that many of the Kuiper belt objects have very similar orbits: They are locked in 3:2 or 4:3 resonances with Neptune, and hence called "plutinos." It seems that Pluto and its smaller sibling (as opposed to the bulk of Kuiper belt objects) form the next "lane," which originated somewhat farther than the present-day mean distance of Pluto.

This idea stops just short of reinstating Pluto as a planet. It is the dominant member of the family—more so than Ceres is in the asteroid belt. The problem is that the inner part of the Kuiper belt is unstable—objects from different regions intermingle—so the two initially separate areas may have become indistinguishable. Thus, we might never see a proper scientific proof of the idea.

Sinisha R. Ignjatovich
Montreal, Canada

Notes

1. Lothar Komp, "The Keplerian Harmony of Planets and their Moons," *21st Century*, Spring 1997, pp. 28-41.
2. Daniel R. Wells, "How the Solar System Was Formed," *21st Century*, July-August 1988, pp. 18-28.
3. G.H.A. Cole, *The Structure of Planets* (London: Wykeham, 1978), p. 25.

Jeremy Batterson Replies

The crux of the matter is not what word we use to describe Pluto, but, rather, that, like Ceres, it is characteristically different than all other bodies which we call planets. Ceres and Pluto each dominate in zones of countless planetoids of which they are a part. Any honest investigation reveals that Pluto is no more to the Kuiper objects, in rough order of magnitude, than Ceres is to the inner asteroids. It seems, thus, that our system creates two distinct phenomena, namely, planets and asteroid belts. The word we choose to describe them does not change the fact that they are distinct from one another.

More important is the question of methodology. You seem to have concluded that I took the failure of the Bode "law" at Pluto to be evidence that Pluto was not a planet, and note that similar exponential models do fit with Pluto. On the contrary, Titius-Bode is, most emphatically, not a "law," because it is not universal. It is simply a "shadow" of some ordering principle which is not yet fully understood, as are all other logarithmic projections which have yet been laid forth.

One of the things I always find amazing is when people say: "The Bode (or similar) law is valid, but over the years, the planets got pulled out of whack," or something like this. No, the universe came first, and these projections are simply conjectures of the truth. (Of course, many of these projections can account for Pluto—although I was not

aware that some one had predicted a second asteroid belt in 1850. This is very interesting indeed, and I hope you can provide some background.)

Jonathan Tennenbaum's methodology, discussed in my article, is superior to all mere logarithmic projections. First, he takes into account that the real universe, in all mediums, organizes itself into distinct "shifts." Take the case of water, which undergoes a sudden shift when it heats to the boiling point. This kind of sudden shift characterizes all mediums, in all circumstance wherein the medium is undergoing a continuous change of environment.

In our solar system, these shifts occur at the asteroid belts, while, in visible light, they divide the different colors. In the human singing voice, such changes occur at the vocal "register shifts." There is no regular, linear progression in the real world, without such shifts (which are called "singularities").

Second, Tennenbaum's hypothesis came from a desire to figure out the higher reason of the ordering. This is not the same as a simple mathematical law. The philosopher and scientist Lyndon LaRouche has pointed out that you cannot understand the motion of an orbiting body, for example, at any given moment, except from the standpoint of the entire completed orbit that it makes.

Thus, it is the higher ontology (which he calls "intent") which determines the orbital motion at each instant. This is exactly opposite to the way that most people think about this problem, who try to build up the higher ontology from the many moments of motion at each point of an orbit or similar phenomena. Thus, if we truly wish to find a universal law which will tell us precisely why planets take particular orbits, in relation to each other (assuming that there is such a principle), then we must seek a higher domain than simple logarithmic projections.

Ampère vs. Maxwell On Magnetism

To the Editor:

In one of your articles ["The Suppressed Electrodynamics of Ampère-Gauss-Weber," by Laurence Hecht, Spring 2001, p. 2], you criticized

Maxwell for separating the magnetic field from the electric (treating them as separate, while Gauss, Ampère, et al. considered magnetism to be an "epiphenomenon" of the electric.

A question: Gauss's Law says that the divergence of the magnetic field is zero. This means that there is no source of the magnetic field, no magneton as there is an electron. Does this not mean that the magnetic field is an epiphenomenon of the electric? Additionally, relativity shows that they are two aspects of the same phenomenon, as does modern particle physics. I was recently told that the electromagnetic field is a connection on a U1 bundle over space time.

So what was your point?

Marc Gordon
marcgo@msn.com

Laurence Hecht Replies

The point was stated in the title of the study I did on this subject in the Fall 1996 issue of *21st Century*, "The Atomic Science Textbooks Don't Teach." The origin of modern atomic science lies in Wilhelm Weber's validation of the Ampère atomic hypothesis.

The problem you are having derives from a defect in our educational system. You are not going to get any fundamental understanding of physics by collecting learned opinions on the subject. This is the method of textbook teaching, the principle of consumer fraud upon which our modern university system operates. You must read and work through for yourself the original experiments, which examine the fundamental physical paradoxes. Then you would learn, among other things, not to attempt to derive a truth about nature from a mathematical statement, as in "Gauss's Law says . . ." or "relativity shows. . ."

You are not alone. As the significance of Ampère and Weber's work in this field is either ignored or incompetently represented in all modern teaching on the subject, one must conclude what is otherwise obvious, that there is no modern physics worthy of the name. The most productive course is to address yourself to remedying this defect.

A New View of Geodynamics

by Sieghart Moser

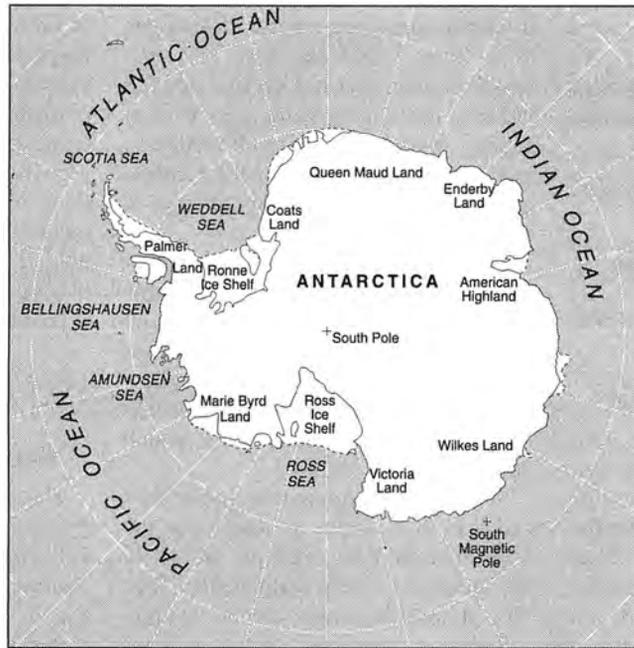
Professor Andreas Vogel of the Institute for Geography and Geophysics at the Free University in Berlin, published an article in the German edition of *Scientific American* (November 1994), in which he proposed to drop the idea of plate tectonics, that continents are situated on lithosphere plates.¹ Instead, he proposed continental blocks, reaching down to the asthenosphere. [The asthenosphere is the portion of the upper mantle beneath the rigid lithosphere, which extends from about 30-60 miles to 240 miles in depth. It is considered plastic enough for rock flow to occur—ed.] Concerning the motive power of geodynamics, however, he is still sticking to the theory of thermal forces from the Earth's core.

I have outlined a completely new view of geodynamics, based on angular velocity, while using Professor Vogel's new idea of continental blocks.

Antarctic Shape Explained

Looking at the map of the Antarctic continent,² one sees that the eastern part (East Antarctica) including its continental shelf of around 10° E to 170° W, has the shape of a semicircle. The semicircular coastline of this part of the continent, that is the coast of Queen Maud Land and Wilkes Land, is equidistant from the South Pole (that is, the rotation axis of the planet), and this is not an accident.

If we consider the effects on a continental block of the Earth's centrifugal forces which are operative in the vicinity of the South Pole, we understand that they must have a different character than they do at the Equator. A continental block, gliding over the Pole on the viscid asthenosphere, will seek to occupy a position in relation to the rotation axis in which the imbalance of the rotating continental block is a minimum.



The semicircular shape of the eastern part of Antarctica is explained in the new view of geodynamics proposed here.

The same behavior of mass particles in the vicinity of liquid rotation centers was experimentally detected by hydrologist Cornelius Lely (who designed and realized the drainage of the Zuiderzee in the Netherlands). The contrary case, the straying of mass particles from a liquid rotation center, was demonstrated in Lely's experiment.

The Antarctic continent represents the first case described: The predominant main mass of the visible continental block, consisting of the semicircular area of East Antarctica (whereat one must take notice of the underwater shelf of West Antarctica) occupies an almost concentric position in relation to the south polar rotation axis.

At the Pole, where the azimuthal component of the angular velocity reaches a maximum, the continental block takes up a position in which the center of gravity ultimately coincides with the rotation

axis. This sort of motion will occur in the high latitudes, in the case that the center of gravity of the continental block lies deeper than that of the dislodged magma.

These facts let us understand that the motion of the continents must be seen in relation to the rotation of the Earth.

Excluded by Plate Tectonics

The theory of plate tectonics would not allow such an explanation of the special position of the Antarctic continent at the South Pole. However, the model of continental blocks reaching down to the asthenosphere and a thin ocean floor, as developed by Prof. Andreas Vogel,¹ admits this explanation.

The question as to the motive power of global tectonics in the lower latitudes

is somewhat differently motivated. The reason for the prevailing view in geophysics—that motion in the asthenosphere is impelled solely by the conveyance of heat from the inner core of the Earth—seems to be that the heretofore accepted model of plate tectonics has not permitted another explanation for the origin of the motive power.

What facts argue for the angular velocity as the motive power for the convection cells of the asthenosphere in the lower latitudes? The angular velocity here conforms to the effect of its vertical component, and is deployed in the viscid medium of the asthenosphere. One must consider that the vertical component of the rotation is operating around an axis, which is parallel to the local geographic North-South direction, and, moreover, that at the Equator, the azimuthal component is zero and the vertical component is at its maximum. Accordingly, the formation of convection cells, whose motion is accomplished in the above-mentioned manner, are favored in Equatorial lati-

tudes. The effect of the vertical component can be observed in nature by the decline of the horizon in the East, and a rise in the West, corresponding to the West-East direction of the Earth's rotation.

Consequently, the resulting character of the dynamics of ocean floors and lithosphere blocks depends on the geographic latitude. The higher one proceeds in the northern and southern latitudes, the more the effect of the azimuthal component will increase, until the Poles, where it reaches its maximum. This explains the observation that the plates are subjected not only to slipping but also to rotation. How much force the azimuthal rotation can develop in the higher geographic latitudes is demonstrated by the semicircular

shearing of the east Antarctic continental block from the southern part of Gondwana, to which the south Australian coast still bears witness today.

It seems that the patterns of movement of the Earth's magma and crust are the result of the interaction of motive powers which originate in the angular velocity, the vertical component of which explains the dynamics in the convection cells of the lower latitudes, while its azimuthal component accounts for the dynamics of the magma and crust in higher latitudes. In the in-between zones, adjacent to the 45 ° southern and northern latitudes, the patterns of motion must obviously be characterized by the mutual interaction of both

dynamic components.

Born in 1928, Sieghart Moser (Sieghart.Moser@utanet.at) spent 10 years at the Technical University of Vienna studying technical chemistry and chemical technology. His professional career was spent as technical project manager for the design and construction of large-scale chemical industries, mainly in the French-speaking countries of North Africa and the Near East, for Voest-Alpine AG, Austria's largest steel producer.

Notes

1. Andreas Vogel, "Die Kern-Mantel Grenze: Schaltstelle der Geodynamik," *Scientific American* (German edition) Nov. 11, 1994, pp. 64-72.
2. I used the National Geographic Society's map of "Antarctica," scale 1:9,469,000, from 1987.

When Light Governs the Expression of Genes

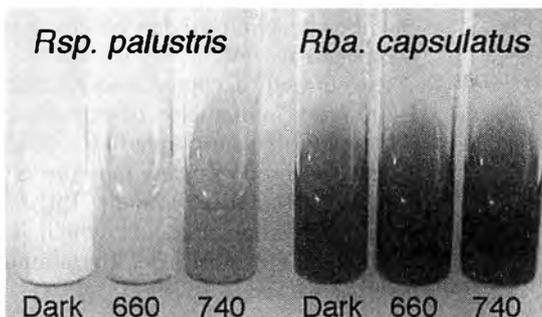
by Emmanuel Grenier

Researchers from the French national laboratories CEA, CRNS, and IRD¹ have just discovered a new type of phytochrome (a protein which acts as a light receptor) in photosynthetic bacteria, which is able to regulate the synthesis of proteins by giving off light.²

Phytochromes are plant pigments, which were discovered in the early 1960s. They are found in very small amounts in the plant cells, along with other pigments such as chlorophyll. They exist in two states, absorbing light either in the red, or the near-infrared band.

Five years ago, phytochromes were also discovered in bacteria. Depending on the illumination, the phytochrome passes from one state to the other, and sets off a chain of biochemical events provoking, for example, the germination or growth of a plant. The phytochrome thus plays the part of a switch for light, whose function in bacteria still remains mysterious.

The French researchers have been able to identify for the first time the phenomenon activated by this new phytochrome as well as the various molecules taking part in this regulation. In addition, they have discovered a new type of phytochrome in which the regulatory mechanism works by a simple protein-protein interaction (with a particular protein assigned to the expression of certain genes), without any



The pigmentation of the bacteria cultures reflects the photosynthetic activity of the sources. Light has no effect on *Rhodobacter capsulatus* (right). But it plays a key part in activating the photosynthetic apparatus of *Rhodospseudomonas palustris* (left). The three samples of each culture have been exposed to darkness, red light (660 nm), and infrared (740 nm).

chemical change. That differs from the phytochromes known until now, in which the activation mechanism is mediated by changes in the state of phosphorylation of certain amino acids.

The mechanism of this new type of phytochrome would seem to offer several promising applications. By simply applying light, it could be possible in the future, to activate or inhibit the synthesis of a particular gene. The majority of the present systems use a chemical inducing agent, but they are not flexible and are difficult to reverse. With this new type of photo-activated regulation one can imagine new

and much more forgiving forms of genetic therapy than those available at present.

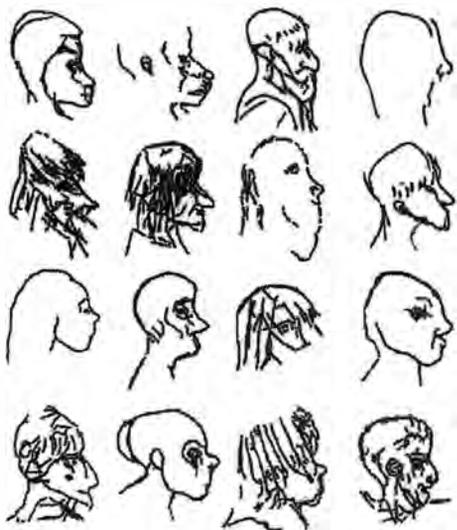
More fundamentally, the fact that light can exert an influence on the mechanisms of genetic expression opens a breach in the basic dogma of the theory of evolution, according to which the external environment cannot influence genetic heritage. His Majesty "Chance" is the only god whom the Darwinians will permit to govern evolution. Are we headed toward a rehabilitation of the ideas of Lamarck, in which, on the contrary, there is the possibility of direct environmental influence on biological evolution?

Emmanuel Grenier is the editor of the French-language *Fusion* magazine, and a *Scientific Advisory Board* member of 21st Century. This article appeared in the May-June 2002 issue of *Fusion* as the editorial.

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Notes

1. Biology of the exchanges between plants and rhizospheric bacteria (joint research team CEA-CNRS, Saint-Paul-les-Durance), Laboratoire Symbiose tropicale et méditerranéenne (joint research team IRD-CIRAD-INRA-ENSAM, Montpellier).
2. "Bacteriophytochrome Controls Photosystem Synthesis in Anoxygenic Bacteria," *Nature*, May 9, 2002.



News.bbc website

Some of the 155 human faces found carved in the rock on the floor of a cave in La Marche, France.

15,000-YEAR OLD PORTRAITS FOUND IN FRENCH CAVE

Lifelike drawings of human faces, thought to date back about 15,000 years, have been uncovered in a cave in southern France. At the time, Europe was in the grip of an Ice Age, with parts of northern and Alpine France covered by a glacier. Images of 155 human faces, as well as of lions, bears, antelope, and horses are carved on the floor of a cave in La Marche in the Lussac-les-Chateaux area of France. The carvings had been first identified in 1937 by French scientist Leon Pencard, who excavated the cave system for five years. Reports appeared in a few books, but were dismissed by so-called experts.

Dr. Michael Rappenglueck of Munich University is leading an effort to reassess the findings. The portraits were carved into limestone slabs that were then carefully placed on the floor. Rappenglueck believes that floor carvings may have been present in other excavated caves, but were destroyed in the excavations. Rappenglueck also noticed a series of pits in the floor of the cave, arranged in the shape of the Pleiades star cluster.

NUCLEAR CHEMIST SAYS EARTH'S CORE IS A FAST BREEDER REACTOR

The Earth's core is a natural nuclear reactor, according to the theory of nuclear chemist J. Marvin Herndon which appears as the cover story in the August issue of *Discover* magazine.

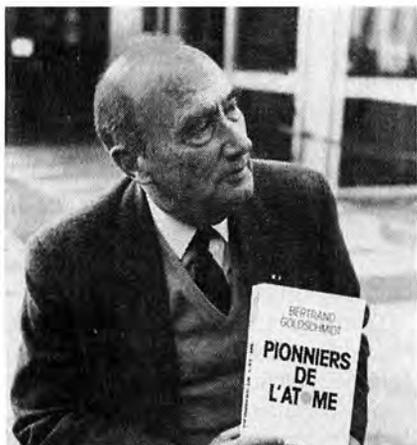
The currently accepted theory is that the Earth's core consists of a sphere, about 1,700-miles in diameter, of partially crystallized iron, or nickel-iron metal. This is thought to be surrounded by a fluid core of iron, nickel, and several light elements. In Herndon's view the core is a 5-mile diameter sphere of uranium-235, uranium-238, and plutonium. This is surrounded by a subshell of radioactive-decay and fission products, which is embedded in a larger inner core of fully crystallized nickel silicide. The uranium inner core functions like a fast-neutron breeder reactor.

One of the most important pieces of evidence for Herndon's theory, is the appearance of radioactive helium-3, a fission by-product, in Hawaiian basalts. In a simulation run at Oak Ridge National Laboratory, the ratio of helium-3 to helium-4 found in the rocks was found to precisely fit a model of fast-breeder reactors. Herndon is now working on the neon isotope ratio. He believes his theory explains the phenomenon of periodic weakening and reversal of the Earth's magnetic field. The heat produced by the reactor propels charged particles to the surface, which ultimately produce the magnetic field. But the natural process of the reactor creates neutron-absorbing by-products which "poison" and eventually halt the fission process. As these lighter by-products float out of the heavier core, the fission process starts again. "It's a very nonlinear process," says Herndon.

Herndon believes Jupiter, Saturn, and Neptune also have reactors at their core. This explains why Jupiter radiates twice as much heat as it receives from the Sun.

FRENCH NUCLEAR PIONEER, BERTRAND GOLDSCHMIDT, DEAD AT 89

Bertrand Goldschmidt, the last surviving pioneer of the French atomic energy effort, died June 14, 2002. Born in 1912, Goldschmidt began his career as a nuclear chemist, working with Marie Curie at the Institute of Radium. During World War II, he joined DeGaulle's Free French Forces in New York, and then became the only Frenchman to participate in the secret Manhattan Project to develop the atomic bomb. After the war, Goldschmidt directed the Chemistry Department of the French Atomic Energy Commission (CEA) where he was responsible for France achieving the full nuclear cycle, and producing the first milligrams of plutonium.



Georges M. Temmer

Dr. Bertrand Goldschmidt with a copy of his 1987 book, *Pioneers of the Atom, an inside story of nuclear development*. This book was translated into English as *Atomic Rivals: A Candid Memoir of Rivalries among the Allies over the Bomb* (Rutgers University Press, 1990).

BRAZIL BEGINS PRODUCTION OF ITS OWN ENRICHED URANIUM

Brazil has achieved commercial-scale production of enriched uranium, only the seventh country worldwide to have this capability. The production method employed, using advanced centrifuge technology, was developed by Brazil's naval research center.

The state company Nuclear Industries of Brazil will run the enrichment plant in Resende, Rio de Janeiro. Initially, the plant will supply 10 percent of the 120 tons a year needed to fuel Brazil's domestic nuclear plants, Angra I and II, with the goal of becoming self-sufficient in five years. Large-scale enrichment was the only part of the full nuclear fuel cycle which Brazil had not achieved. The technology is a spin-off of the Navy's ongoing work in building a nuclear submarine with national technology.

EXPERIMENT SHOWS GRAVITATIONAL CONSTANT VARIES WITH DIRECTION

A team of physicists working in Boston and Moscow have published experimental evidence that the gravitational constant varies with orientation. Two of the scientists, Mikhail L. and Lev I. Gershteyn, published the Attractive Universe Theory in 1988, predicting that the the gravitational force between two bodies would depend on the distribution of matter in the surrounding universe. Thus, the value of the gravitational constant, G , would depend on the direction in space, a dependency they call G anisotropy.

Using a dynamic torsion balance, O. V. Karagioz carried out experiments in Moscow which established a level of G anisotropy of not less than 0.054 percent. The experimental methods and results are reported in a paper appearing at www.arxiv.org/pdf/physics/0202058.

NEW YORK TIMES CAUGHT HYPING ALASKA WARMING DATA

Alaskan climate scientists charged that a *New York Times* story from June 2002 was hyping the story of an Alaskan warming. The *Times* story, "Alaska, No Longer So Frigid, Starts to Crack, Burn, and Sag," reported supposed widespread intense warming of up to 10 degrees F" in the state, and the alleged damage it has wrought.

But according to Gerd Wendler of the University of Alaska's Geophysical Institute, "In the last 20 years very little warming, for some stations even a slight cooling has been observed." Measured on a 30-year scale, Wendler said, there was some warming, but most of it occurred in the 1970s. The mean increase for all the stations representing a north-south cross section of Alaska, with an additional station in Alaska, for the 30-year period was 1.4 degrees C.

ICE AGE BISON CARVING FOUND NEAR MOSCOW

A beautiful bison figurine, carved from mammoth ivory, was found at the Upper Paleolithic site of Zaraysk, 100 miles southeast of Moscow. The carving is estimated to be 20,000 years old. According to a report by Hizri Amirkhanov and Sergey Lev on the www.archaeology.org website, the four-inch high figurine was found on a specially built podium at the bottom of a small storage pit. The site has been under excavation by the Institute of Archaeology of the Russian Academy of Sciences since 1995.

The figurine has a length-to-width ratio of 1.6:1, which perfectly coincides with that of an adult bison, and its beard and mane were carefully engraved, the scientists report. The bison's left legs had been broken off before it was put in the pit, and traces of red ocher and black pigment still remain on its surface.



NUCLEP

Accumulator tanks, built in Brazil, awaiting installation during construction of the Angra II nuclear power plant.



Hizri Amirkhanov and Sergey Lev (www.archaeology.org)

The 20,000-year old bison figurine from Zaraysk.

Schizophrenic-Like Video-Game Disorder

by Lyndon H. LaRouche, Jr.

EDITOR'S NOTE

In a May 1 webcast and other locations, 21st Century Scientific Advisory Board member Lyndon LaRouche, who is also a candidate for the Democratic Presidential nomination, asserted the connection between point-and-shoot video games and the drive by a utopian military faction to maintain a global condition of "perpetual war." The gist of that argument is summarized in the box on page 13.

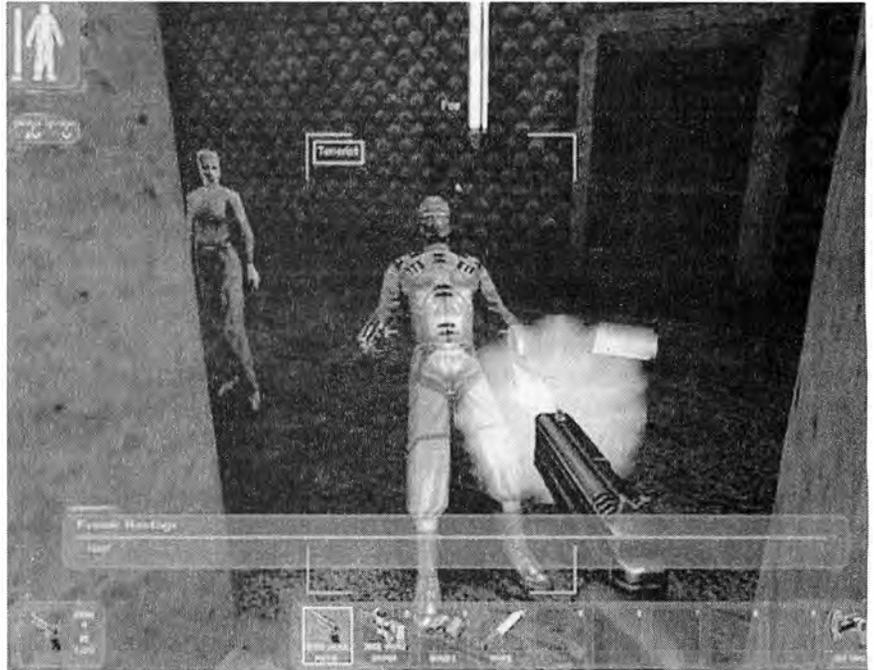
In response to his association of video games with violent behavior among youth, Mr. LaRouche received a passel of e-mails to his website from youthful addicts of the video games. As a service to citizens, parents, and the afflicted youth themselves, we reprint here his alarming analysis of this global problem, written on May 21, 2002.

This serves also as an answer to similar messages from youthful video game players appearing in our Letters column this issue. The messages, which came in response to our website posting of a Fall 2000 article on video games and the "new violence," are clinical evidence of the phenomenon LaRouche describes here.

I have recently conducted an experiment.

I have had the occasion to review a sizable sample of the highly agitated, panicked-squirrel-like e-mail chatter about me, among teenage and slightly older devotees of video-game behavior. While a minority among that sample show that they have retained skills suited to rational forms of communication, the majority exhibit common traits of acute functional damage, damage of a form akin to known forms of schizophrenia. Even the exceptional cases, where evidence of sanity peers out between the cracks in their resort to cult-like video-gamers' rhetoric, the argument, such as it is, is dominated by the same pathetic symptoms shared among every individual in this entire sample of those defending the video games.

Thus, although the number of individ-



Using a hostage rescue theme, this point-and-shoot video game trains youthful reflexes to shoot to kill.

uals included in the sample is not large, the consistency of certain pathological traits exhibited among all participants in the sample, is of a high degree of statistical significance.

This sample points toward the alarming conclusion, which is as relevant as other implications of the evidence from this sample, that most parents of these members of the "punk/no-future" generation, have little or no comprehension of what is fulminating within the minds of the addicts of this "Flagellant"-like horde of their children, these minors who have been virtually transmogrified into becoming video-game addicts.

Some of the broad characteristics of behavior consistently exhibited by the sample, are notable, on statistical premises stated above, as follows.

The sample shows every individual to be a participant in a cult formation, with marked similarities to the image provided by the fictional "The Lord of the Flies." Admittedly, such pathetic tenden-

cies are common among children and adolescents known from my personal experience of several successive generations. Admittedly, much group behavior among those age-groups would often be considered pathological if it were exhibited in an adult. However, while the comparison to the image of "The Lord of the Flies" is broadly relevant, the "group behavior" within the sample considered goes far beyond what is customary, except among members of gangs, or of the morally defective Ku Klux Klan lynch-mobs, prone to seemingly spontaneous outbursts of extreme collective violence.

One would not wish an army based on such recruits. They are as likely to erupt into orgies of killing one another, as their authorized targets.

Every case in the sample exhibited an intensely defiant quality of anti-truth group ethic, consistent with the "punk/no-future" ethic generally. but more highly honed than I have observed

in other types of cases. Although all members of the same deny fanatically any link between their video games and violence-proneness, all exhibited highly honed propensities for violence in the manner of the argument they employ. It would be fairly estimated that a proverbial "between 90-99 percent" of the sample have a highly honed propensity for violence, a propensity associated with their addiction to video games.

The specifically schizophrenic quality shown by most members of the sample, centers around their reliance on "rules of the game." Not only are "rules" adopted by them as a replacement for morality, but any real-life matter external to the internal practice of group-video-game behavior is regarded by them as belonging to a world outside that of their video-game fantasy-life. They are generally incapable of focussing on any reality existing outside the framework of the rules of that game which they are playing: It is for these mentally damaged persons, "Some bullshit," which they insist "does not exist." Dealing with them in their group-behavior mode is like dealing with a clinical psychotic.

The latter pattern reminded me of the account of the way in which the Erfurt [Germany school shooting] incident was, reportedly, concluded. According to the published account, the teacher who brought the student's rampage to a halt, did two things which I recognize as of

crucial clinical import. The teacher called to the student by name, and said, in effect, "Look into my eyes." The report indicated that the student was startled out of whatever state of mind he had been in at that moment, went into an adjoining room, and there took his own life. That report is consistent with the evidence I adduced from review of the sample, including my own exploratory exchanges with some among the members of that sample.

The Crucial Technical Point

In face of the syndrome which I observed from this sample, the popularity of various expressions of what are termed variously "radical empiricism," "logical positivism," and "existentialism," represent an important contributing source of national-security risk at this time. Victims of that type of philosophical world-outlook, will tend to be crippled in their ability to recognize certain crucial warning-signs of potentially extremely violent individual and group behavior from among the adolescent and younger victims of addictive forms of any type of video-game habituation.

The essential difference between man and beast, lies essentially in those qualities of cognitive behavior exhibited by the original or replicated act of discovery of an experimentally valid universal physical principle. This is in direct, explicit opposition to the false teaching central to Immanuel Kant's series of Critiques. Hence, just as a Classical

humanist mode of universal education, based on re-experiencing original discoveries of principle, humanizes a population of the young, so a radically mechanistic, learn-the-rules education ruins the moral sense of the young, whether in the family, the church, or the school.

However, as bad a method as Kant and his empiricist predecessors, and their positivist and existentialist kindred, may be philosophically, in other aspects of their behavior they exhibit human qualities contrary to their formal argument on this matter. What is to be feared, is the synthetic Kantian, for example, who "perfects" his philosophical aberration into an instrument of mechanical perfection. People who order their lives according to some more or less fanatical observance of a formal set of "ivory tower" rules, as is the implied effect of strong emotional attachment among minors to all forms of video-games, produces a potential for both individual and mass-psychotic outbursts akin to the state of mind of the madman holding a family hostage under the menacing muzzle of a sawed-off shotgun.

"You broke the rule I live by, and

LaRouche on War and Video Games

"But the key thing is Iraq. The key purpose behind this operation is to use this to get a wider war going, to get the Clash of Civilizations war that Sam Huntington, Brzezinski, and company want. So what you have here is a combination. The training and recruiting of large numbers of otherwise useless youth, psychotic youth or quasi-psychotic youth, by Nintendo games designed by the U.S. military, put into general circulation through the military, with cooperation of Japan's production of Nintendo games, and so forth.

"We are now taking from our population, our youth, our adolescent

and other youth, we're turning a large portion of them into potential Nintendo killers, who are trained killers, trained on their videogames, who then simply have to go out and get trained with actual weapons and do what they've been trained to do on videogames. Recruit them as soldiers and send them in various parts of the world, as part of a Clash of Civilizations war. Put the two things together, and you have the new Roman Legions, the new Waffen-SS, to send around the world."

Lyndon H. LaRouche, Jr., International Webcast, May 1, 2002, "The Middle East Blow-Back Effect"

COMING IN 21st CENTURY SCIENCE & TECHNOLOGY

- Dr. J. Gordon Edwards on DDT, Mosquitoes, and Human Health
- A.K.T. Assis, K. Reich, and K.H. Wiederkehr on The Absolute System of Units of Gauss and Weber
- Dr. Robert Stevenson on the Development of Plate Tectonics

therefore I must kill you!" is the gist of the matter. As a soldier, they would kill a member, or members of their unit, on impulse for no different motive than that. All of the members of the sample, when taken as an interacting group, exhibit precisely that quality of mental disorder. The image of the attributable "emotion" of the fabled robot programmed to kill, is there. The sense of what human is, that the person on the receiving end of their action, is human, does not exist for the moment. They are "enforcing the rules of the game." They are, to all practical purposes, psychotic when in that frame of mind.

The cure: Get them out of the games, and back into the real world. Some members of the Congress are clearly candidates for similar therapy.



Stuart Lewis/EIRNS

LaRouche in dialogue with youth at a recent Schiller Institute educational event.

LaRouche Tells Video Gamer How to Break the Habit

In response to a youthful defender of violent video games, during his Memorial Day webcast on May 28, 2002, Democratic Presidential pre-candidate Lyndon LaRouche identified the creation of the "punk generation" as the crucial precondition for the video-game psychosis which is producing "stone killers" among today's youth.

It is the sense of hate sitting in your gut, that turns youth to video-game playing, LaRouche argued, and leads them to try to block out reality. In effect, the child becomes schizophrenic, and prone to acting out the evils of the video.

LaRouche's concluding summary captures his crucial point:

"The point is, as I said, you can not explain the games by the game itself. Yes, the people, who develop these games, who market the games, they know *exactly* what they're doing. The intention behind the production and marketing of these games, is to create mass-killers in the United States, through video games. One who accepts the games is going to play that role, because that's what they're programmed to do. And, that's the intention behind the people who make the

money out of peddling, selling these games. But, the problem is, the reason why the person becomes a victim, is because *we*, with our consumer society, with our post-1966 society, the *unreal society*, in which what is real, is what you *get*, not what you produce.

"Before 1966, what was real, was the opportunity to produce something, yourself. The right to produce, the right to have a job; the right to be productive; the right to be respected, because you're useful. After 1966, the shift came: It's not what you *are* or what you produce, or what you do, that's important. It's what you can *get*. Like, on a credit card. And we got a big credit card for the United States: It's called the current-account deficit—big credit card. You can buy anything from any part of the world, but you don't have to pay for it—until the day you have to, and then it becomes painful.

"So, that's the problem. So, the point is, we have *destroyed* our children! Our children are bodies of rage, and somebody comes along, like a prostitute, a pimp—comes along to the children, and pimps to them, and says, 'You want to get your kicks? I can give you pleasure. Play the game!'

"It's an ugly, evil story. But, what you have to do, to understand this thing, if you've been a video-game player, you have to see exactly what I just told you. You have to see why, what the load of hate is, in your belly, your sense of estrangement, of alienation from society, in your belly, which causes you to flee from reality, into the magic of electronic games. And, there, you release this load of hatred, of frustration, which comes from what is called 'anomie,' in your belly; and it controls you. Therefore, you become two people: On the one hand, you're potentially a human being. That's your real self. But, on the other hand, you have a socially induced form of mass psychotic schizophrenia, which is inducing you, by conditioning, through the game.

This is Pavlovian brainwashing, pure and simple; which produces a person, who's a real person on the one side, but has an artificial personality—a *game-like* personality—on the other side. And they flip back and forth between the two states."

(LaRouche's full answer is available both in audio and text version on his campaign's website, www.larouchein2004.com.)

THOR HEYERDAHL (1914-2002)

A 20th Century Pioneer of Ancient Navigation

by Rick Sanders

On April 18, 2002, Thor Heyerdahl breathed his last, after 87 years of life well spent. Before World War II, Heyerdahl had already abandoned an "island paradise" in the Pacific, because he had an idea, and could not rest without testing it. When the war broke out, he was soon recruited to carrying out irregular war against Nazi Germany in his native Norway. After the war, he became famous—and feared by academia—for building ships to test hypotheses about ancient navigation, and sailing them himself.

He had an idea, a concept, that man's history stretched back much further than most people think, that man was traveling the oceans long before the present. Heyerdahl was not arrogant and blind like so many people today: He took seriously the stories, the "myths" that he heard on his early travels in the South Seas. The Peruvian "myths" told of red-bearded men, whom some called "gods," who had shown up in Peru a long time ago, and then sailed away westward along with their "Sun-king," Kon-Tiki, never to return. These are the South Sea "myths" which led to Captain Cook's being thought of by the Pacific islanders as a modern reappearance of Kon-Tiki.

Heyerdahl looked at the Humboldt Current, which flows counterclockwise between Peru and certain Pacific islands, and calculated that under the most optimistic conditions—given a steady wind and current—it would take about 90 days to make landfall after leaving Peru. To test his idea, he needed a raft and a crew. He wrote a telegram to Torstein Raaby, a radio operator who had crossed his path in World War II, when they were both fighting behind Nazi lines in Scandinavia: "Am going to cross Pacific on a wooden raft to support a theory that the South Sea islands were peopled



*Thor Heyerdahl
(Oct. 6, 1914-April 18, 2002)*

from Peru. Will you come? I guarantee nothing but a free trip to Peru and the South Sea Islands and back, but you will find good use for your technical abilities on the voyage. Reply at once."

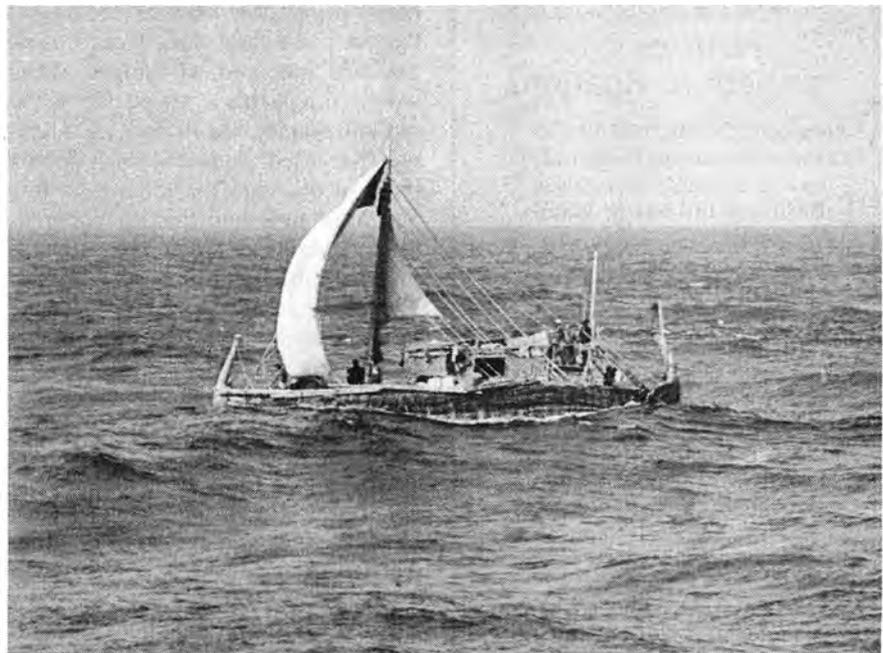
The next day the following telegram arrived: "Coming. Torstein." They found four other crew members, built a 40-foot-long balsa raft, organized support

for it among military and diplomatic circles, and, in 1947, travelled 4,300 miles in 101 days, from Peru to the island of Raroia. The feat showed that, in principle, this same trip could have been made many thousands of years ago, so that South America could have been in contact with the Pacific Islands, at least from east to west.

And They Did Not Sink!

Was it a fluke? Was it something any old gang of rambunctious young folk could have done? Neither. Heyerdahl was both humble and proud; he knew when to listen, and when not. For example, common sense would have said to use bone-dry logs, to provide greater buoyancy; common sense would have said, that the ropes used to lash the logs together would chafe through very quickly, and that chains or wire rope should be used instead.

But Thor believed in human history:



The Ra in mid-Atlantic, photographed from a passing commercial ship.



Heyerdahl examining models of the oldest reed boats, in the Cairo Museum.

"I knew all the time in my heart that a prehistoric civilization had been spread from Peru and across to the islands at a time when rafts like ours were the only vessels on that coast. And I drew the general conclusion

that, if balsa wood had floated and lashings held for *Kon-Tiki* in 500 A.D., they would do the same for us now if we blindly made our raft an exact copy of his."

A couple of storms proved him right: "After two storms the *Kon-Tiki* had become a good deal weaker in the joints. The strain of working over the steep wave-backs had stretched all the ropes, and the continuously working logs had made the ropes eat into the balsa wood. We thanked Providence that we had followed the Incas' custom and had not used wire ropes, which would simply have sawed the whole raft into matchwood in the gale. And, if we had used bone-dry, high-floating balsa at the start, the raft would long ago have sunk into the sea under us, saturated with sea water. It was the sap in the fresh logs which served as an impregnation and prevented the water from filtering in through the porous balsa wood."

Following the explosive success of the *Kon-Tiki* Expedition, Heyerdahl organized and led the Norwegian Archaeological Expedition to the Galapagos Islands (1952); and a major archaeological expedition to the Pacific's most isolated island: Easter Island (1955-1956).

The 'Ra' Expeditions

Heyerdahl continued his research on ancient navigation and turned his attention to the ancient reed-boats

made of papyrus. Academia believed that these boats would become waterlogged after less than two weeks on open water; but Heyerdahl talked to the people who still today build and use these reed boats: in Peru, on Lake Chad in Africa, and the Marsh Arabs in Iraq. Their boats look the same still today as those found depicted on the pyramids in Egypt.

Heyerdahl gleaned from them, and from his own experience with the balsa logs, that the most important problems to solve to keep the reeds from becoming waterlogged, are what kind of reed is used, and *when it is cut*. The first boat, launched as *Ra I* from the old Phoenician port of Safi, Morocco, in 1969, sailed 5,000 kilometers (2,700 nautical miles) in 56 days, until storms and deficiencies in the construction caused the team to abandon its target only one week short of Barbados. Ten months later, in 1970, Heyerdahl—using another reed ship, *Ra II*—succeeded in crossing the widest part of the Atlantic, 6,100 km (3,270 nautical miles), in 57 days, from Safi to Barbados.

The assertion, dignified as a "theory," that no one could have crossed the Atlantic much before Columbus because they did not have the ships, etc., was thrown on its head. But more than that, Heyerdahl used a ship modelled on those that were being built 4,000 years, or even much longer, before Columbus. Now the academic fairy tale, that North and South America were uninhabited until the forerunners of the Indians and Eskimos crossed the Bering Strait, about 12,000 B.C., was in jeopardy.

Heyerdahl continued to organize expeditions, and write books about them, all of which are worth reading: to the Tigris River (1977), the Maldives Islands (1982, 1983, and 1984), and the Canary Islands. Thor Heyerdahl will be sorely missed by all those who delight in pointing out that the Emperor (that is, those who persist in promoting historical frauds), basking in the adoring gaze of his courtiers, was not wearing any clothes.

Photographs are taken from Heyerdahl's 1971 book *The Ra Expeditions*, about his voyages by reed raft to America (Garden City, N.Y.: Doubleday & Company).

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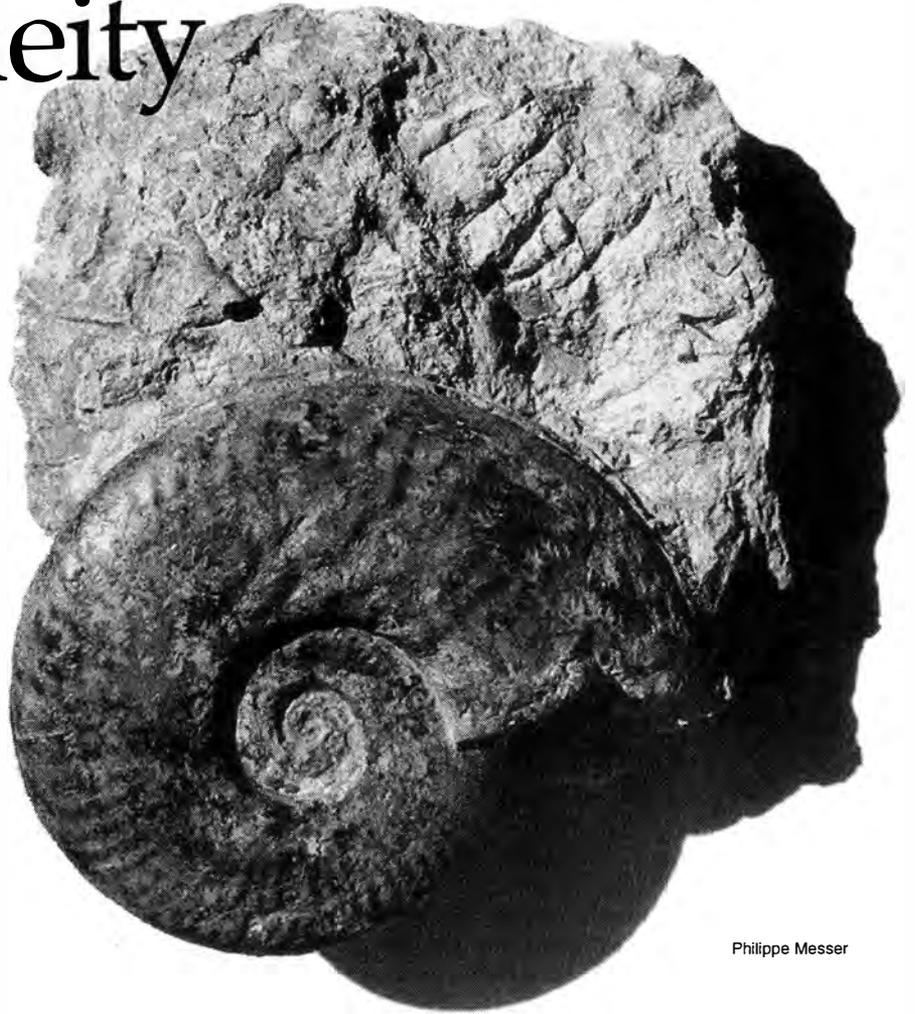
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Leonardo da Vinci's Geology and the Simultaneity Of Time

by Dino De Paoli

On the occasion of Leonardo's 550th anniversary, a look at some of the lesser known ideas of this universal genius: his revolutionary views of geology in a time when literal Biblical interpretations and Aristotelian materialism (such as "spontaneous generation") prevailed.



Philippe Messer

"And you, O man, who will discern in this work of mine the wonderful works of nature, if you think it would be a criminal thing to destroy it, reflect how much more criminal it is to take the life of a man, and if this, his external form, appears to thee marvelously constructed, remember that it is nothing as compared with the soul that dwells in that structure; for that indeed, be it what it may, is a thing divine"

Anatomy Folios, A

I have long wondered about Leonardo's fascination with rocks and mountains. Why in all of his paintings did he use such incredible forms of rocks, hills, or mountains for a background? I am no painter, although I like to look at paintings (especially those on cave rocks dating to 20,000 B.C.); therefore, I will not try to look for an answer in terms of painting techniques. But I like mountains, and I thought, therefore, that I would be able to understand Leonardo's fascination with them.

Leonardo had climbed the Monte Rosa in Italy, and many other mountains, but that alone is not enough to explain the mountains in his paintings. Further, his rocks are very strange, both precise and unreal at the same time. I have tried, therefore, to look back into Leonardo's notebooks, specifically to an area where I have a bit more familiarity than I have with painting: his scientific discoveries. The results are interesting, and are worth being presented to those who know Leonardo only through his paintings.

I knew, and had written about, some of the innovative scientific results and the scientific method which Leonardo introduced during our recent history.¹ Nevertheless, once I started looking anew into his notebooks, and became more and more familiar with his astounding results in the field of geology, I re-experienced the usual astonishment typical for one who confronts Leonardo for the first time. Again, I had to fight with doubts and desires.

Pierre Duhem, a famous French scholar, described Leonardo's work on geology as "perhaps his most complete and lasting invention." In a sense, I fully agree with that judgment; but the truth is even greater, for geology was only one of Leonardo's many "incomplete but lasting inventions." (We shall come back to the meaning of the word "incomplete.") Nevertheless, geology is indeed a crucial area of his many discoveries, and also a probable key to explain the backgrounds of his paintings. But if this be so, then the question comes up immediately: How did Leonardo look at mountains? With the cool eyes of a geologist, or the colorful one of an artist?—or both, and are the two combined? Another personage comes immediately to my mind, Johann Goethe—geologist, mountain lover, and artist—but such analogies are always tricky, and the answers not always obvious.

Confronted with Leonardo, one knows that there is always the obvious danger of trying to bring him down to a reachable, personal level of thinking, an error that occurs in most of the books and articles I have read about him; but it is an error which is difficult, if not impossible, to avoid. His mind is so complex and multifaceted, that a new dimension constantly appears, so that Leonardo himself, like most of his paintings, produces that uneasy sense which one has in looking at something which appears, at the same time, to be incomplete and perfect. It is this feeling that brings the reader or viewer, if honest, into doubts, turmoil, and expectation. Fear and desire suddenly melt together, as if one is on the verge of uncovering a "big secret," as if Leonardo were sent from another world with an unclear message about the Truth, like an ancient prophet, or Leonardo's beloved personage, St. John the Baptist.

We know other great artists who were interested in science, Goethe among others. We know great philosophers who were

also great inventors, among them, Leibniz. And we know great scientists who loved and performed art, among others, Georg Cantor and Albert Einstein. But, even risking the appearance of repeating a banality, Leonardo is a unique experience. To go from his scientific notes back to his paintings—unfortunately I do not know records of his music—and back again to his notes, creates a unique effect. Images, motions, insights, and discoveries turn up here and there, but all within a sense, if not a grasp, of the oneness of his creative mind.

This is a sense which is impossible to fully replicate, because most of us simply cannot reach Leonardo's mind. Consequently, instead of accepting the "chiaroscuro" picture, which he himself liked, we become frightened and want to rush back to the full light, to the Cartesian "clear and distinct." People start looking for axioms and theorems, for deductions and inductions, for clear formulations and formulas. Instead, Leonardo has written only notes or made sketches, and he can jump from one idea to a completely new one in a matter of five lines. He has left unfinished drawings and enigmatic pictures, "Because the painter will do infinite things, which cannot be expressed with words, because the appropriate vocabulary is lacking" (CU 6v, TP 15a). Nevertheless, Leonardo is the most rigorous producer of precise results.

We become frightened by the apparent emotions that he arouses in our own mind, the vorticity that can be induced by his *Adoration of the Magi*, or his *Battle of Anghiari*, the *St. Anne* or *The Last Supper*. We recognize that we do not need to turn Romantic, to be submerged by the fluxes, or vortices of nature or by enigmas; because that is the attractiveness of Leonardo, which, at the same time induces the calming effect caused by the presence of the intelligible. This is something so powerfully described by Schiller: "Und ob alles in ewigem Wechsel kreist / Er beharret im Wechsel ein ruhiger Geist" (And though all's e'er-changing in spirit and scene / Within that change rests a spirit serene).²

Where is such "Geist" or spirit located? If one considers such a question to be useless, then at, least, one should have reflected upon why Leonardo's *St. John* or *St. Anne* (in the London drawing) point to the "outside" of their space-time frame. The answer is not so obvious, as if Leonardo were just using symbolism. The moment we make the mistake of looking for symbols, at that precise moment we are left only with the troubling ambiguity of the smile of the *St. John* or with the seductive ambiguity of the smile of the *Mona Lisa*, or probably, in both cases, only with the ironic smile of Leonardo himself:

[M]ake your work carry out your purpose and meaning. That is, when you draw a figure, consider well who it is and what you wish it to be doing [CA 341 r. R. 599].

Fear and desire: This is a typical mixture, when we are faced with Leonardo's works, because we sense the incoming confrontation with something "unclear" and "unknown." Indeed, a relatively young Leonardo wrote:

And drawn by my ardent desire, impatient to see the great abundance of strange forms made by that creative

nature, having wandered for some time among the shadow rocks, I came to the mouth of a huge cavern, before which I stood for a moment, stupefied by such an unknown thing. I arched my back, rested my left hand on my knee, and with my right, shaded my lowered eyes. Several times I leaned to one side, the other, to see if I could distinguish anything, but the great darkness within made this impossible. Immediately, both fear and desire arose in me: fear of the dark and menacing cavern; desire to see whether it contained any marvelous thing within it. . . [Ar. 155r, R. 1339].

The above metaphor of the cavern, throws us back to our actual subject, mountains and geology. What are the secrets contained in the dark cavern? But before exploring it, let me present Leonardo's life.

Leonardo's Life

Europe in general, and Italy specifically, was the momentary and passing center of an upsurge of creativity in science, politics, economy, and art. The Republic of Florence was one of the main centers of this upsurge. In the midst of that process, reflecting its achievement and shortcomings, Leonardo was born on April 15, 1452, in Vinci, a small town near Florence. The future master of "ambiguity" was himself the product of one; he was the illegitimate son of a local notary and a peasant girl. At about the age of 15, he was sent as an apprentice to the most renowned sculptor in Florence, Andrea del Verrocchio. There he learned about painting, sculpture, metal casting, perspective, architecture, anatomy, and more general studies of nature.

He showed himself immediately to be attracted by bold ideas, such as the construction of a navigable canal from Pisa to Florence. According to the 16th Century Florentine sculptor Georgio Vasari, Leonardo made designs for mills and engines powered by water. In 1472, he had already surpassed his master, when he painted the kneeling angel on the left landscape in Verrocchio's *Baptism of Christ*. Soon after, he designed an Arno Valley landscape. In both of the above works, Leonardo already revealed a fascination for mountains, and specifically for rocks, echoing a bit the Flemish painter Jan Van Eyck's *Receiving the Stigmata*. From that point on, all of Leonardo's paintings were to use mountains as background.



www.arttoday.com

A detail from Leonardo's *St. John the Baptist*, at the Louvre in Paris.



www.arttoday.com

A detail from Leonardo's drawing of *St. Anne*, at the National Gallery in London.

In Florence, Leonardo composed part of *The Annunciation*, the *Ginevra de' Benci*, and the two madonnas, today respectively in Munich and the Benois in Leningrad (the background of the latter is repainted). The rocks fully dominate the unfinished *St. Jerome*.

Apparently, it is also at this stage that he read Ovid's *Metamorphoses*, whose relevance we will explain later, and whose influence is felt in the unfinished masterwork, *The Adoration of the Magi*, in which Leonardo, who has already used geometric perspective, surpasses it, creating a "natural" space, where ideas and life shape motions, emotions, and events in a complex harmony.

In 1482, Leonardo, already renowned as painter, musician, and military and civilian engineer, left Florence for Milan to work for Duke Ludovico Sforza. Here, with the famous *Madonna of the Rocks*, he brought the dialogue between historical and geological time to the forefront: Any good reproduction shows that the "grotto," the cavern, is not a simple architectonic symbolism, but a living part of the whole. Naturally, Leonardo being Leonardo, he could not resist showing the details of what was becoming his center of interest and of his polemic: the horizontally and vertically stratified sedimentary rocks.

In Milan, Leonardo painted some portraits, whose attribution is disputed, and which later were repainted; these are the only works where there is no sign of rocks: *The Musician*, *The*

Lady with an Ermine, and *La Belle Ferronniere*. His other Milanese masterwork, *The Last Supper*, although dominated by the drama of the "great betrayal," with its explosive effects, nevertheless places the sovereignty of Jesus Christ over the slow motion of hills and mountains.

Leonardo dedicated most of his time in Milan, however, to science: architecture, mechanics, anatomy, and military projects, although he defined war as a "bestial madness." He concentrated a lot of effort on problems concerning water management and the related hydrology, botany, and geology—efforts he later expanded to include themes like meteorology, fluid dynamics, and human flight.

In this context, in 1496, he began a close collaboration with Luca Pacioli, the famous geometer and follower of Cusa. From Pacioli, Leonardo was pushed to work out geometrical problems and also probably to work on astronomy, so that one finds scattered notes indicating a hint of heliocentrism: "The

Sun does not move" (W 12669, R. 886), and "The Earth is not the center of the circuit of the Sun, nor the center of the universe" (F 41b, R. 858). Did he elaborate such insights? We do not know, but we do know that 75 percent of his notes were lost.³

In 1499, Milan was conquered by the French King, Louis XII. This put an end to Leonardo's efforts to cast the monument to Francesco Sforza, Ludovico's father, and forced him, and Pacioli, to escape to Mantua, where he started a portrait of Isabella d'Este. After a brief visit to Venice, he returned, finally, to Florence in 1500.

There, from 1502 to 1503, he worked for Cesare Borgia and Niccolo Machiavelli as a "military engineer." In this role he inspected many fortifications in Cesena (where he developed projects for a navigable canal), Imola (of which Leonardo's famous map still exists), Perugia, Rome, Senigallia, and so on.

In Florence, in 1503, he was at the apex of his influence; he became involved in many water projects, worked on the Piombino marsh, the possible diversion of the Arno canal, the design of a bridge over the Bosphorus for the Turkish sultan Bajazet II, and many others. In the midst of all this activity, he tried to produce the later-destroyed *Battle of Anghiari*, and realized his immortal *Mona Lisa* (1503-1516), whose rocky landscape appears unreal, but alive. The mountains of *The Battle of Anghiari* show the effects of transformation caused by weather, time, life, and man, and clearly they are located in a space-time and perspective distinctly different from that of the *Mona Lisa*, as if they were two different, superimposed layers. It is in this period that Leonardo also started a manuscript called "About Transformations from One Body to Another without Loss or Increase of Matter" (Fo I 3v; R. 1374).

In 1506, Leonardo returned to Milan, marking his coming with a project whose idea is anticipated in the masterful drawing of *St. Anne* (now at the National Gallery in London) and in some "geological" landscapes in the Windsor collection (W. 12394-97, 12409, 12414). This project was to be finalized with the unfinished painting of *St. Anne* (at the Louvre in Paris). Here the landscape, as in the *Mona Lisa*, is fully integrated with the event; but, here, too, the mountains show their own space and history, as if on the verge of being formed in a very distant time. After one has admired the totality of the painting, it is worth having a closer look at the rocks on which the feet of *St. Anne* and the *Virgin* are posed. The details of such sedimentary rocks reveal to us, once more, the deep knowledge and the implicit polemic that Leonardo is launching through his geological discoveries, as we will soon describe.

It is during this period that he also notes, "The knowledge of



Leonardo's drawing of the valley of the Arno.

past epochs and of the position of the Earth is both ornament and instrument to the human mind" (CA 373v, in J.R. p. 12), and he planned a book "about the sky and the Earth," regrouping astronomy and geology. Today we are left only with notes of this, collected in the "Codex Leicester" and in the "Codex F."

In 1512, Leonardo left Milan for Rome, hoping for support from the new Medici Pope, Leo X (Giovanni de Medici). There he worked on anatomy, made studies of flight, realized projects for the draining of the Pontine Marshes, and probably made his two testamentary works, the drawing called *Self-Portrait* and the unfinished and later retouched, reworked, and repainted *St. John the Baptist*. What the original "Angel" or "St. John" looked like we do not know, and, therefore, we are left only with guesses as to Leonardo's reflections about man's "fears and desires."

In 1516, with an increasingly hostile environment in Rome, Leonardo accepted the offer from his great admirer, the king of France, Francis I, to move to Amboise in France, where he worked until the end, helping to find solutions to the water management of the Loire and Cher. There he died, reportedly in the arms of the King, in 1519.

Leonardo and the Geosphere

As we have indicated, most, if not all of Leonardo's drawings and paintings, use specific forms of mountains as background and contour. Therefore, it would be useful for the reader to have a fresh look at examples such as *The Virgin of the Rocks*, the *Mona Lisa*, and *St. Anne*, in details, and also some of the Windsor drawings.

It is a general difficulty in geology, to conceptualize the idea of change on a scale which, as we now know, reaches into the millions of years and which therefore appears practically as "no change" during the lifetime of an observer. (Thus, we have the popular saying, "solid as a rock.") Among the different ways to form rocks, we have what is called metamorphosis,

that is, the transformation of organic and inorganic solid matter through pressure, heat, and so on, in such a way that the original appearances can no longer be detected.

There are also other instances, where there is a better conservation of past events, of the interrelationship between life and the inorganic world. For example, we have the presence of fossils (remains of once living beings) in stone, occurring inside parallel layers of sedimentary rocks (rocks resulting from the consolidation of sediment accumulated in layers, transported by river, and deposited at the bottom of lakes and seas). Such rocks are the ones most often present in Leonardo paintings, in particular, in the *St. Anne, The Virgin of the Rocks*, and the Windsor collection's drawings.

The fossils encapsulated within the sediments, and the story they tell of geological time, will now become the focus of our search among Leonardo's notes.

Fossils

Many people have found or bought fossilized animals and plants. The paradox that an investigative mind must immediately solve, is to explain how petrified shells of marine animals are to be found far away from shores, on top of some mountains. How did these marine animals end up on top of the mountains and become rock-like?

Or, as Leonardo put it, "Why do we find the bones of great fishes and oysters and corals and various other shells and sea-snails on the high summits of maritime mountains, just as we find them in low seas?" (Leic. 20r, R. 992).

We know that from ancient times, others posed the same question; for example, Anaximander (610-547 B.C.), Xenophanes (560 B.C.), Herodotus (484-420 B.C.), and Eratosthenes (276-194 B.C.) all had noticed the presence of shells in mountainous areas, and thought that part of the Earth must have been under seawater in the past.

Ovid (43 B.C.-17 A.D.), in a text which Leonardo read, quotes Pythagoras as saying:

I have seen what once was solid Earth now changed into sea, and lands created out of what once was ocean. Sea-shells lie far away from ocean's waves, and ancient anchors have been found on mountain tops. What was at one time a level plain has become a valley; thanks to the water flowing down over it, mountains have been washed away by floods, and levelled into plains [*Metam.* XV 233-271].

But, how might we explain the presence of such ancient seas on top of the mountains? Or, how do we explain that plains eventually become mountains?

The fact that mountains are consumed, eroded by water is observable, but what of the formation of mountains? Today, we know that such a process spans millions of years.

That the seawater moved into and out from the present European continent, according to Eratosthenes, was the result of the "opening" of the Strait of Gibraltar. For others, such large motion of the seawater was caused by some kind of deluge. For the cultures using the

Bible, the motion was the result of Noah's Flood.

Christian and Islamic thinkers were less bound to the orthodox Biblical story than it is often believed; and, therefore, although Ibn-Sina (980-1037), Albertus Magnus (1200-1280), Roger Bacon (1220-1292), and Jean Buridan (1300-1358) each developed some interesting insight on the matter, they were unable, nevertheless, to discover a coherent alternative to the story of the Great Deluge. Only when we come to Leonardo's work, do we see how the combination of free thinking, rigor in hypothesis, and crucial experiments can lead to some correct answers.

In the period prior to Leonardo, the "anti-clerical" current had developed an alternative explanation to Noah's Flood, derived from Aristotle's *Meteorology*. According to them, the fossils found in the mountains are not the remains of animals once living in the sea, but are the product of a kind of "spontaneous generation," a *vis generativa* (creative force) present in the rocks themselves and activated by the influence of the stars! Such an explanation was used even to explain the presence of minerals inside the rocks. Still in the 18th Century, the anti-clerical Voltaire writes:

I do not deny that one can find at 100 miles from the sea some oysters, shells, etc.—products which resemble perfectly the ones produced in the sea, but are we really sure that the rocks themselves cannot produce such fossils?" (Ch. XIII of "Des singularites de la nature").

Leonardo made fun of such Aristotelian "spontaneous generation," but did so in his usual rigorous way, and it is worth examining Leonardo's method. He argued that if such *vis generativa* were forming fossils, then one could not find in the same place both old and young exemplars, whose age it was possible to determine by the number of the growth lines on the shell (a discovery made by Leonardo himself). Moreover, he



John G. Johnson Collection, Philadelphia Museum of Art

Jan Van Eyck's painting, St. Francis of Assisi Receiving the Stigmata.

said, one could not find in the same place entire and broken shells.

As for those who say that those shells are found to exist over a wide area, having been created at far from the sea by the nature of the locality and the disposition of the heavens, which moves and influences the place to such a creation of animal life, to these it may be answered: Such an influence could not place the animals all on one line, except those of the same species and age; and not the old with the young . . . nor some broken and others whole . . . nor the claws of crabs without the rest of their bodies . . . nor would there be found among them bones and fishes' teeth. . . . Where the valleys have never been covered by the salt waters of the sea, shells are never found [Leic. 9r, R 988].

And in another passage, Leonardo again insists:

And, if you were to say that these shells were created, and are still being constantly created in such places by the nature of the spot and of the heavens which might have some influence there, such an opinion cannot exist in a brain of much reason; because the years of their growth are numbered on their shells, and both small and large ones may be seen, which could not have grown without food or fed without motion, and here they could not move! [Leic. 9v, R 989].

Finally, Leonardo says:

. . . [I]f you wish to say that the shells are produced by nature in these mountains by means of the influence of the stars, in what way will you show that this influence produces in the very same place shells of various sizes and varying in age, and of different kinds? And how will you explain to me the fact that shingles are all stuck together and lying in layers at different altitudes upon the high mountains. . . . This shingle is nothing but pieces of stones which have lost their sharp edges. . . . And how will you account for the very great number of different kinds of leaves embedded in the high rocks of these mountains, and all kinds of petrified things, togeth-

er with ocean crabs, broken in pieces and separated and mixed with their shells [F 80 v, MC p. 313].

What is relevant in these foregoing notes from Leonardo's writings, is that Leonardo's arguments are all supported by his own discoveries in the field of morphology of animals, plants, and forth. But, let us now turn to the other side, the proponents of Noah's Flood. Leonardo had earlier expressed general doubts about the universality and timing of such an event:

Here a doubt arises, whether the Flood which came at the time of Noah was universal or not, and this would seem not to have been the case, for the reason which will now be given. We have in the Bible that the flood was caused by 40 days and 40 nights of continuous and universal rain, and that this rain rose 10 cubits above the highest mountain in the world. . . . In this case, the water would have formed a perfect globe and would not be able to move. . . . Therefore, how then did the water . . . depart? If it departed, how did it move, unless it went upwards? At this point natural causes fail us, and therefore, in order to resolve such doubt, we need invoke a miracle, or else say that all this water evaporated by the heat of the Sun [CA 155 r, R. 986].

But even if a flood occurred, this could not be responsible for the type of fossils we find, because, he writes:

[Y]ou have first to prove how the shells at the height of a thousand meters were not carried there by the Deluge, because they are seen at one and the same level, and mountains are seen which considerably exceed this level. . . . and then you must show that neither rain . . . nor the swelling of the sea, could enable the shells, which are heavy things, to be driven by the sea up the mountains, or be thrown there by rivers flowing contrary to the course of their waters [Leic. 3r, R.985].

These foregoing arguments, resulting from Leonardo's own observations and experiments, can be made more explicit:

If the flood, according to the Bible, covered even the highest mountain, then one should find shells on top of the highest mountains, and not in layers at the middle level. The sea-waves could not carry living shells because they are too heavy. (You will be told later, how to prove that such shells were once alive.) Leonardo had intensively studied the way waves function hydraulically, both in nature and in experimental apparatus which he constructed.⁴ The rivers, obviously, could not carry objects contrary to their normal direction, from the mountains down to the sea.

Later, in a full-page note titled "Of the deluge and of marine shells," Leonardo detailed the above arguments with pointed irony against "those who meas-



The Granger Collection

Detail from Leonardo's *St. Anne, the Virgin, and Child*, at the Louvre in Paris.

ured the height of the water and took account of the time”:

If you were to say that the shells, which are to be seen within the confines of Italy, far from the sea and at such heights, had been brought there by the Deluge, I should reply that if you believe that this Deluge rose seven cubits above the highest mountains, as he who measured it has written, these shells, which always live near the seashore, should have been left on the mountains; and not such a little way from the foot of the mountains; not all at one level, nor layers upon layers. And if you were to say that these shells are desirous of remaining near to the edge of the sea, and that as the sea rose in height, the shells left their first home, and followed the rising waters up to its highest level,— to this I answer, that the cockle is very slow moving . . . and therefore it would not have travelled from the Adriatic Sea as far as Monferrato . . . a distance of 250 miles, in 40 days—which he has said who calculated the time. And if you say the waves carried them there, the waves would not have been able to move them, because of their weight, except at the bottom. And if you do not grant me this, confess at least that they would have to stay at the summit of the highest mountains. . . .

And if you should say that the shells were carried by the waves, empty and dead, I say again that where the dead ones went, the living were not far distant, and in these mountains one finds all living ones, for they are recognizable by the shells being intact; and they are in a layer where there are no dead ones. A little higher up, one finds all the dead ones, where they were thrown by the waves, with their shells broken. . . .

And if the shells had been carried by the muddy Deluge, they would be mixed up and separated from each other amidst the mud, and not in regular rows in layers as we see them in our times [Leic. 8v, R 987].

It is made clear, again, above, why the ordered layers of fossils could neither have been brought there by the waves, nor have travelled alone there in 40 days! That these shells were alive, and therefore heavy, is proved by the fact that the shells are still intact, while on a higher layer, one can recognize dead shells. The fact that the shells are in ordered layers shows the lack of the violence of a Deluge, which would have broken and mixed them and not deposited them in regular layers. Leonardo insists on bringing more proofs to show that the fossils were once alive:

If the Deluge had to carry shells 300 to 400 miles from the sea, it would have carried them heaped together with various other natural objects; but, even at this



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Leonardo's *The Virgin of the Rocks*, at the Louvre in Paris.

distance from the sea, we see the oysters together . . . all dead . . . indicating that they had been left here by the sea, still living, when the Strait of Gibraltar was cut through [Leic. 9 v, R 989].⁵

And again, he presents even a stronger argument concerning corals still sticking to rocks:

How are we to account for the corals which are found every day . . . with wormholes in them, sticking to rocks left bare by the currents of rivers? These rocks are all covered with stocks and families of oysters, which as we know, are unable to move [Leic. 10 v, R. 991].

He sums up the attacks against both sides—the Biblical interpreters and the Aristotelians—and hints at his own theory

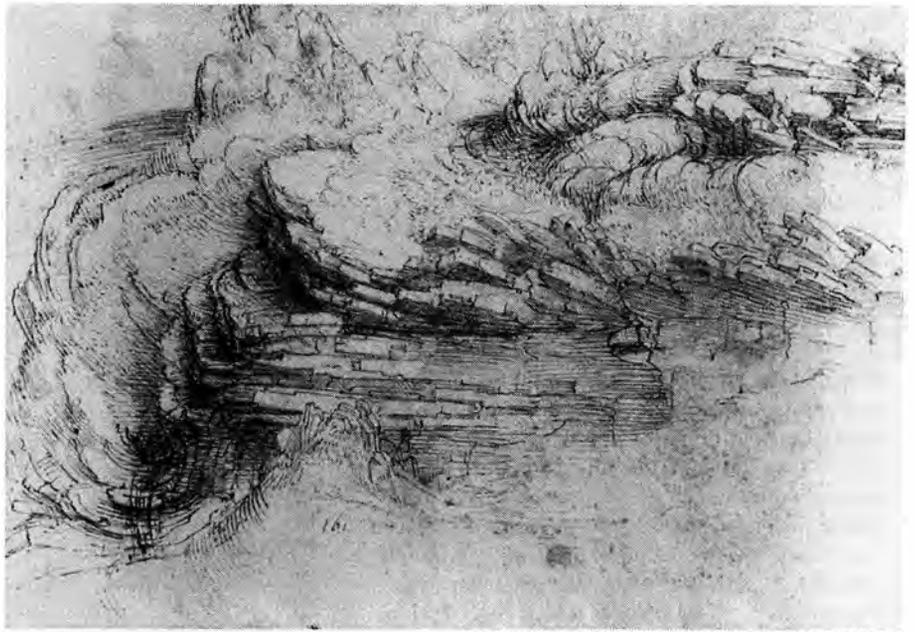
about fossils, introducing the formation of layer upon layer of sediments at the bottom of the sea, sediments carried by rivers and later petrified so as to become what we can observe as sedimentary rocks—the rocks of Leonardo’s paintings! Thus:

Of the stupidity and ignorance of those who imagine that these creatures were carried to such places distant from the sea by the Deluge. How another group of ignorant persons maintains that Nature or the Heavens created them in these places by celestial influences; as if in these places one did not also find the bones of fishes, which have taken a long time to grow; and as if one could not count on the shells of cockles and snails the months and years of their lives, as one does in the horns of bulls . . . and in the branching of plants. . . Why do we find so many fragments and whole shells between the different layers of stone unless they had not formerly been covered on the shore by a layer of earth thrown up by the sea, and which was afterwards petrified? And, if the above-mentioned Deluge had carried them to these places from the sea, you would find the shells at the boundary of one single layer of rock only, not at the boundary between many layers from where may be counted the winters of the years during which the sea multiplied layers of sand and mud brought down by the neighboring rivers, and spread them over its shores. If you choose to say that there were several deluges to produce these layers, cockles and fossils, you would also have to affirm that such a deluge took place every year. . . [Leic. 10 r , R 990].

Sediments and Stratification

Leonardo has achieved the breakthrough that allows him to count the passage of time, the ages, through the growth of layers in shells, in plants, and in sedimentary rocks! Therefore, he had reached conclusions that are still valid today: Fossils were once living organisms, not produced by rocks. They were not transported by water but: “Where there is now land, there once was ocean.” They were buried at the bottom of the sea, obviously for longer than 40 days, inside sediments deposited by rivers. Therefore the Earth’s crust and the planet were in a continuous process of transformation over an immense period of time. The mountains themselves were subject to modifications by the eroding power of water, Sun, ice, and organic material:

“The water wears away the mountains and fills up the valley, and if it had the power, it would reduce the earth to a perfect sphere,” Leonardo writes (CA 185 v, MC p. 317). And



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Study of an outcrop of rock by Leonardo da Vinci, RL 12394

“mountains are made flat by the activity of water . . . stones are transformed in sand by heat and ice” (Leic. 17v).

Even if Leonardo initially adopted the wrong theory of Pliny, about the system of water circulation from the oceans to the mountaintops to re-descend into the sea as rivers, later he realized that: “The water of rivers comes not from the sea but from the clouds,” (Codex Hammer Catalogue, p. 13) and “how water rises in the air by means of the heat of the Sun, and then falls again in rain” (E, 12a; R. 930).

In the depths of the sea, the transported mud, composed mostly of materials resulting from an interplay between inorganic and living matter (bacteria, algae, shelled mollusks, brachiopods, corals, and so on), forms strata of different heights and inclinations: a process of stratification. With time, such sediments, left without water under low pressure and low temperature are transformed into sedimentary rocks, preserving some of the once living organisms as fossils.

Here Leonardo’s notes, first on the shellfish:

Of creatures that have their bones on the outside. . . . When the floods of the rivers which were turbid with fine mud deposited this upon the creatures which dwelt beneath the waters near the ocean shores, these creatures became embedded in this mud, and finding themselves entirely covered under a great weight of mud, they perished. . . . In the course of time, the sea level became lower, and as the salt water flowed away, this mud became changed into stone; and those shells that had lost their inhabitants became filled up with mud; and during the process of change of all the surrounding mud into stone, that mud which was inside the half-opened shells . . . also became changed into stone. . . [F 79 r, MC p. 311].

And on fish, Leonardo writes:

All the creatures that have their bones inside their skin, upon being covered over by the mud from the inundations of rivers . . . are immediately enclosed in a mold by this mud. So, in course of time, as the channels of the rivers become lower, these creatures being embedded and imprisoned in the mud . . . have fallen down into the base of the mold which had been formed by their impress; and as the mud becomes lifted above the level of the stream, the mud dries and forms first a sticky paste and then changes into stone, enclosing everything it contains. . . [F 79v, MC p. 312].

And finally, Leonardo says,

When nature is on the point of creating stones it produces a kind of sticky paste, which as it dries, forms itself into a solid mass together with whatever it has enclosed there, which, however, it does not change into stone, but preserves within itself the form in which it has found them. This is why leaves are found whole within the rocks which are formed at the base of the mountains . . . just as they have been left there by the floods from the rivers . . . and there the mud caused by the successive inundations has covered them over, and then this mud grows into a mass together with the aforesaid paste, and becomes changed into successive layers of stone which correspond with the layers of the mud [F 80 r, MC p. 313].

The invisible process of the formation of successive layers of transported mud is nothing but what we observe as strata in certain mountains, he says:

In every concavity at the summit of the mountains we shall always find the divisions of strata in the rocks [Ar. 30b, R. 982]. . . .

How the stratified rocks of the mountains are all in layers of mud deposited one above another by the floods of the rivers. That the different size of the strata is caused by the difference in the floods of the rivers: that is to say greater or lesser floods. . . . How between the various layers of the stone are still to be found the tracks of the worms which crawled about them when it was not yet dry [Leic. 10 r, R. 980 / 90].

Leonardo explains again, more clearly:

The stratified rocks are created in the vast depths of the seas because the mud which the storms detach from the seacoasts is carried out to the deep sea by the rebound of the waves; and after these storms, it is deposited upon the bottom of the sea, and as no storm can penetrate the sea on account of the great depths extending below the surface, the mud lies there motionless and becomes petrified . . . and thus with blocks set at different angles, it is made up of layers of as many different thicknesses, as the differences in the storms, more or less violent [Leic. 35r].

The results indicated above, allow Leonardo to look differently at the real history of the Earth. He next elaborates how the sedimentation of the rocks is uncovered in the mountains by the work of the same rivers that formed them in the first instance:

The shells . . . which are born in the mud of the sea testify to us of the change of the Earth. . . . The mighty rivers always flow turbid, being colored by the Earth, which is stirred up by the friction of their waters at the bottom and against the banks; and this wearing uncovers the face of the strata formed by the layers of shells, which lie on the surface of the mud of the sea where they were born . . . and these same strata were, from time to time, covered over by varying thickness of mud which had been brought down to the sea by the rivers in floods of varying magnitude; and thus, these layers of mud became raised to such a height that the bed of the sea emerged into the air. And now these beds are so great a height that they have become hills or lofty mountains, and the rivers which wear away the sides of these mountains uncover the strata of these shells . . . and the ancient beds of the sea have become chains of mountains [E 4v, R. 935].

Leonardo has shown how the layers of deposits under the water correspond to sedimentary rocks, with their layers incorporating organic material and telling the successive history of the Earth's changes. But how did such layers of deposits on the bottom of the sea become certain types of mountains? Here and there we find Leonardo's notes on this question:

The mud was deposited in which the shells lived, and which rose in layers according to the levels at which the turbid Arno flowed into the sea. And from time to time the bottom of the sea was raised, depositing these shells in layers, as may be seen. . . [Leic. 8v, R 987].

Or, in another location:

The marine shells and oysters that are seen in the high mountains, which have formerly been beneath the salt waters, are now found at so great a height, together with the stratified rocks, once formed of layers of mud carried by the rivers in the lakes, swamps, and seas; and in this process there is nothing that is contrary to reason [Leic. 36.r, Mc. p. 356].

He found one possibly correct answer, in any case:

If the Earth . . . which sustains the ocean, rose up and stood uncovered, being almost flat, how in process of time could mountains, valleys, and rocks with their different strata be created? The mud or sand from which the water drains off when they are left uncovered after the floods of the rivers supplies an answer to this question . . . and after the water has thus been drained away, these hills begin to dry and to form stones in layers corresponding in thickness to the depth of the mud which

the rivers deposited in the sea in their floods [F 11v, Mc p. 310].

This is true in some cases—it seems true for Colorado, for example—but not in all cases, not for the Alps. Leonardo did not fully consider the endogenous phenomena; he could not make crucial experiments inside the Earth, and take into consideration volcanism or other mechanical transformations (or at least we do not know that he did). Nevertheless, he indicated something interesting, although in a strange language:

The great elevations of the peaks of the mountains above the sphere of the water may have resulted from this: . . . [A] vast cavern inside the Earth may have fallen in a vast part of its vault towards the center of the Earth . . . and it removed itself immediately from the center of the world and rose to the height, for so one sees the layers of the rocks. at the summit of the high mountains. . . [Leic. 36 r, Mc pg 355].

Whatever the completeness of his theory, Leonardo was, in any case, in a situation to notice that the distinct layers of rocks clearly indicate the passing and the measure of time:

You have now to prove how the shells are not produced except in salt waters . . . and how the shells in Lombardy are found at four levels. And so it is with all which are made at different periods of time; and these are found in all valleys that open out into the seas [Leic. 36 r, R 993].

The implications were obvious: The history of the Earth was older than 4000 B.C. and older than the historical period covered by man, and Leonardo knew how to read the language of the stones:

Since things are much more ancient than letters, it is no marvel if, in our day, no records exist of these seas having covered so many countries. . . . But sufficient for us is the testimony of things created in the salt waters, and found again in high mountains, far from the seas [Leic. 31 r, MC 345].

Now, after those statements, one can have a fresh look at *St. Anne*, the *Mona Lisa*, and others of his paintings.

Leonardo had clearly arrived at the point of conceiving of the Earth as an "organization," not using the word organism: a global interplay between the geosphere and the biosphere. A totality, but not resting in a state of equilibrium. On the contrary, life was pushing towards dynamical growth:

Nothing originates in a spot where there is no sentient, vegetable, and rational life. . . . So that we might say that the Earth is animated by a spirit of growth [Leic. 34 r, R. 1000].

As usual, Leonardo meant not only the obvious process of life, but also the growth of the Earth as a whole. He would not

be Leonardo, if he had not experimented on how the Earth increases in size as a result of the activity of life. Leonardo made precise experiments in a container on the accumulation of organic material and bio-inert matter (humus) caused by bioorganic migration during the life and death of plants. He measured it and then extrapolated the results for the whole Earth, commenting:

[I]f you let 10 years elapse and then measure the increase in the soil, you will be able to discover how much the earth in general has increased, and then, by multiplying, you will see how great has been the increase of the earth in the world during thousands of years. . . . For do you not perceive how, among the high mountains, the increase of the earth covers and conceals the walls of ancient and ruined cities? [CA 265 r, Mc p. 318]

The Earth as a biosphere—this is Leonardo's view, although for the word "biosphere," we have to wait until the work of Eduard Suess (1831-1895) and his friend Vladimir Vernadsky (1863-1945). Therefore, before deriving some further conclusions, from the material seen above, I want to make a brief remark about the transmission of Leonardo's geological ideas.

Unfortunately, Leonardo's notes, in general, and on geology, in specific, disappeared for a long time. The *Codex Leicester*, with most of the geological notes, reappeared officially only in 1717, bought by the Earl of Leicester, with a copy of this Codex ending up in Weimar, Germany, and probably in the hands of Goethe.

Parts of the scientific notes were finally recollected in Paris, and in 1797, Giovanni Battista Venturi published an official report to the Academy of Science, which made them known to the full scientific elite in Europe. Charles Lyell (1797-1875), the Scottish geologist, considered the founder of modern geology, acknowledged in the later editions of his *Principles* (p. 31, in the 1867 edition), that his attention was called to Venturi's geological extract from da Vinci's manuscript by Mr. Hallman. Lyell uses quotations from Leonardo's geological notes. We have to realize, as we saw with Voltaire, that the wrong ideas about geology lasted deep into the middle of the 19th Century. Suess himself had still to fight against the arguments based on the role of Noah's flood.

But in this case, we know that Leonardo's ideas on geology, spread like a stream, while Europe was falling back into a little Dark Age. We know (as reported by Lyell), that in 1517, a certain Fracastoro used Leonardo's material against "the Aristotelian theory of spontaneous generation, then taught in all the schools" (Lyell, p. 26) and against the concept of the Biblical deluge. Lyell adds "it must be conceded that they [the Italian ecclesiastics in 1517] displayed less polemical bitterness than certain writers who followed them beyond the Alps, two centuries and a half later."

It seems certain that Jerome Cardano (1501-1576) accessed and made use of Leonardo's notebooks in his *De subtilitate libri* (1550) and *De rerum varietate* (1557). It is known that a strong echo of Leonardo's ideas, in general, is to be found in Huyghens (1629-1695) and in the Dane, Nicolas Sténon (1638-1686), who showed conclusively that the layered rocks

of Tuscany exhibit sequential change, and, therefore, both the fossils and the strata themselves are the “archive” of the history of the Earth, because the layers of rock are arranged in a time sequence, with the oldest on the bottom, and contain memories of past geological events.

But Sténon, under the threatening atmosphere prevailing in that new Dark Age of modern Europe, did not dare to attack the theory of the Deluge and its fossils. Gottfried Leibniz (1646-1716), who met with Sténon around 1670, expressed his own interesting thought in the *Protogaea*. Leibniz, like Leonardo, attacked the idea that fossils would be the products of the influence of stars and spontaneous generation, and interestingly enough, he adds that “a large number of forms were transformed during the great changes to which the Earth was subjected.” It would be interesting to follow also the track of the German school of Freiberg, and of Goethe himself, but this goes beyond our present scope.

Therefore, let us go back to Leonardo himself, to try to see how he locates himself, as a human being, in relation to the biosphere.

The Search for Truth

We are now in a position to try to re-evaluate our reflection on Leonardo’s work, to see if the interplay between geology and painting, which I tried to illuminate, goes even deeper and is subsumed under other philosophical or methodological concerns.

Many describe Leonardo as a “naturalist,” confusing him with a Schelling, with the Epicureans, the Stoics, the pre-Socratics, and so on. In my opinion, scholars have greatly underestimated the role that “ideas,” in Plato’s sense of that term, play in Leonardo’s relation to Nature, even though convention has it that Leonardo seems not to have had access directly to Plato’s work.

Concerning his “method,” Leonardo definitely had some kind of explicit set of rules, but it seems to me that he did not really follow them! We have his so-called “Treatise on Painting,” actually patched together faithfully from scattered notes after Leonardo’s death, but it is very difficult from such formalities to imagine the realization of a *Mona Lisa*. Rules can improve the way to make an idea more visible, but they will not reveal the generation of the idea itself.

It is known that Leonardo was proud to call himself an “Omo senza lettere,” an “illiterate”; that is, someone who had



Another study of rock formations from the Windsor collection.

not been trained in Latin, in theological or philosophical disputes. Therefore, the worst offense one could commit to Leonardo, would be to try to fit him into some fixed school or methodology, be it Platonist, Neo-platonist, Aristotelian, Nominalist, Realist, Naturalist, or so on.

It is my conviction that Leonardo did not blindly follow any school or sect; he avoided following the “Platonic theology” of the Florentine Neo-platonics, as he avoided following the orthodox theologies. He simply hated empty formalism, magic, and mysticism, which were killing the Italian Renaissance and would soon bring Europe to disaster:

They go about puffed up and pompous, dressed and decorated with [the fruits], not of their own labors, but of those of others. And they will not allow me my own. They will scorn me as an inventor; but how much more might they be blamed—they who

are not inventors but boasters and declaimers of the works of others [CA 117 r, R. 11].

Leonardo calls himself an “inventor,” and he correctly values this quality for what it is. He is not a technician, but neither is his genius to be reduced to that of a magician. As for his “illiteracy,” one has to see what that really meant. Surely, he was less illiterate than the majority of our university students today! He had been raised in a culture which valued the “Socratic method,” and, therefore, he will proudly call himself “autodidact”—self-taught; but if he was not a “declaimer of the work of others,” he surely confronted the past masters.

We have a list of the books he possessed in about 1504; they numbered 116, quite a large library for an illiterate! And these were not “light” books! Among others we find: The *Bible*, Ovid, Aesop, Pliny, Diogenes Laertius, Albertus Magnus, Petrarch, Cecco d’Ascoli, Saint Ambrose, Saint Augustine, Saint Bernard of Siena, Aristotle’s *Meteorologica*, Euclid, Alberti, Pacioli, Regiomontanus, Archimedes. Others, which we know he read, are not mentioned in that list: Dante and Nicholas of Cusa, for example.

Nevertheless, it is clear that Leonardo rarely started from a book, and never from some academic dispute. He started from a confrontation with Nature, from the need to resolve the difficulties encountered. It is around the formation of hypothesis, we would say, or of inventions, in his own words, that then his mind would become an unstoppable engine. He would not

rest, and this is visible from the notes and sketches, until he had tested all the possible variations, by constructing experimental setups. In that context, he would also read whoever had something to say on the issue, be it a saint or a heretic (for example, Cecco d'Ascoli):

Although I may not, like them, be able to quote other authors, I shall rely on that which is much greater and more worthy: on experience, the mistress of their Masters [CA 117 rb, R. 11].

We have seen, in his works on geology how the force of his argument was always given by the results he had obtained directly, or out of rigorously prepared experiments.⁶

In his general explanations, sometimes Leonardo falls in traps; he falls back into old theories and uses expressions of this or that school, but, once he returns to his crucial experiments, then, as we saw, there is no sacred author or text anymore: He goes boldly and uncompromisingly ahead, sensing, knowing that he is on the path of the Truth. And in my opinion, his own paintings progressively reveal this awareness that the issue of Nature is the issue of Truth. Therefore, when he make appeals to be "truthful to Nature," this has a very specific meaning.

The Incompleteness of Man's Truth

Leonardo knew, probably from the tradition of the masters of perspective, and probably from his own self, with the help of Saints Augustine and Ambrose, and Nicholas of Cusa, that truth, and therefore the oneness of Nature, can be apprehended, but that this can be done neither in the form of a finite, completed statement nor as an infinite series of such statements.

As a oneness, truth must have closure, but such closure, like the point at infinity in perspective, must transcend the space of the representation. Therefore, Cusa describes Truth as being an "actual infinity," because in the contrary case of a "simple infinity," one would always be searching in an endless motion, but would never acquire a certainty of its existence. (This is a point that Giordano Bruno missed in reading Cusa.) The concept of "actual infinity" like Schiller's "ruhiger Geist" (inner calmness) means that an idea must always appear in the midst of motion.⁷

Leonardo is fully aware of the problems connected with infinity:

Water struck by water forms concentric circles extending out a great distance from the point of impact. The voice in the air moves a greater distance, and still longer goes fire. The mind reaches even further into the universe, but, being finite, cannot reach infinity [H 67 r].

Or, he writes elsewhere: "Nature is full of infinite causes which were never set forth in experience" (I 18 v, Mc 61).

Often, people have misinterpreted such statements, as they later misrepresented similar statements by Pascal.⁸ The tendency is to think in terms of "spatial infinity," while here, something else is at stake, and it is this something else that we now discuss.

Leonardo confronted himself relatively early with the problem of locating "ideas" in the relationship between man and nature, especially if nature is conceived alive, changing, and destroying any frozen and rigid totality or oneness. His reading of Ovid tells us about his early awareness of the role played by time and change:

With time, everything changes [Ar. 57 r]. . . .

O Time! Consumer of all things; O envious age! Thou dost destroy all things and devour all things with the relentless teeth of years. . . . Helen, [weeps] too when she sees herself in the glass, wrinkled with age. . . [CA 71 v; R. 1163].

Leonardo copied and slightly changed the above sentences, from Ovid's *Metamorphoses* (XV 232), from the same section in which the famous speech attributed to Pythagoras appears:

All things change, but nothing dies. . . . Nothing is constant in the whole world. Everything is in a state of flux, and comes into being as a transient appearance. Time itself flows . . . like a river . . . what was before is left behind, that which was not comes to be [Ovid, XV, 148-190].

There are other notes, from the same period, where Leonardo amplifies this idea; addressing a fossil fish, he writes:

O mighty and once living instrument of formative nature. Incapable of availing thyself of thy vast strength, thou hast to abandon a life of stillness and to obey the law which God and time gave to procreative nature. . . . O Time, swift robber of all created things, how many nations hast thou undone, and how many changes of states have happened, since the wondrous forms of this fish perished here in this cavernous and winding recess? Now destroyed by time thou liest . . . with bones stripped and bare; serving as support and prop for the superimposed mountain [Ar. 156 r, R. 1217].

Leonardo also relates Truth to such a directional generative process: "Truth was the only daughter of Time," he writes (M 58v, R. 1152).

Time and Mathematics

It is well known, that, since he was in his 20s, Leonardo was involved in many projects concerning the construction of machines and instruments to render the forces of nature useful to mankind, and that he very much valued such work: "Instrumental or mechanical science is of all the noblest and the most useful," he writes (R. 1154). It was clear to him, as to us today, that "Mechanics is the paradise of mathematical science" (E 8v, R. 1155).

Therefore, in this context, and in many other notes, he emphasizes that "There is no certainty in sciences where one of the mathematical sciences cannot be applied" (G 95 v, R. 1158).

Certainty, at least one form of certainty, seems to be linked to mathematics. But how does this fit with the changing power of Time? Truth, as far as it is linked to the process of change, will consume all fixed structures, making them mortal moments, and will destroy all fixed certainties.

Today, we can better understand how Leonardo, as soon as he amplified his researches in areas such as fluid dynamics, anatomy, biology, geology, and so forth, must have realized that, in the quest for certainty, mathematics either was playing a reduced role, or no role at all. He seems to have been explicitly conscious of the limit of geometrical representation when confronted with living nature. He writes, "Although time could be included among the continuous magnitudes, given that it is indivisible and without body, it does not fully fall under the power of geometry" (Ar. 173 v, BR 605). And also, "Describe the quality of Time as distinct from the Geometrical definition" (Ar. 176 r, R. 917).

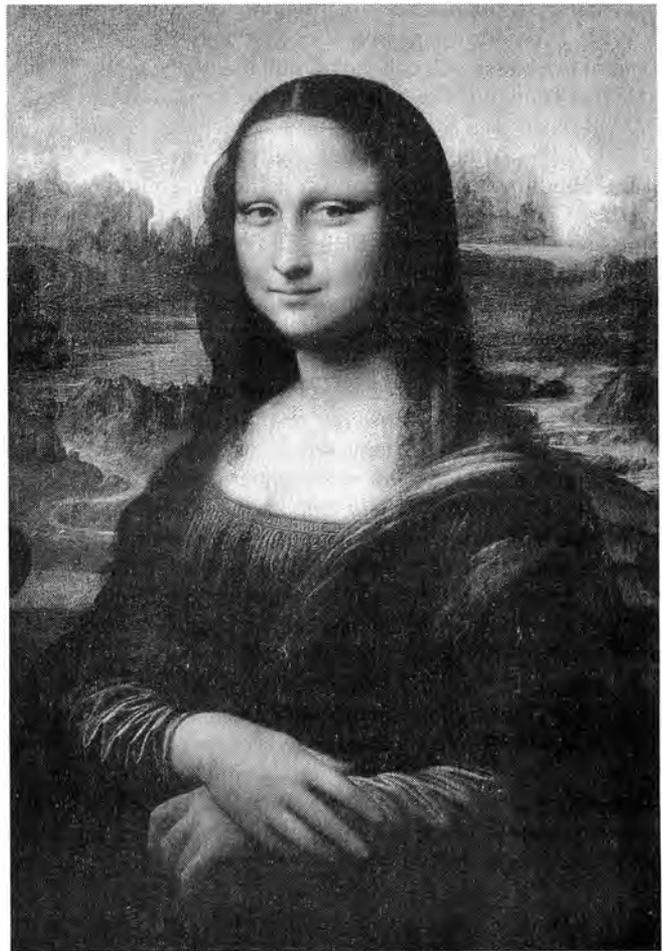
As we see from the scattered notes cited above, and as we know from his more extended notes on the limits of linear perspective, for Leonardo, the contrast between the useful certainty of mathematics and the disruptive or constructive power of the forces of nature and of life must have been very clear. The fact that useful formal realizations or descriptions of the forces of nature will be "consumed by time" will be a theme that in different forms will keep the minds of scientists and artists busy for a long time, until it will be definitely solved by Kurt Gödel in 1931, with his famous theorem on the "incompleteness" of formal representations.⁹

The awareness of the limits of the certainty of formalism and the need to shift to "truth in time," have pushed many cultures to fall into relativism, skepticism, romanticism, or pure irrationalism, as happened, for example, in Germany after Kant, or today, with the "New Age." Leonardo, on the contrary, never dropped the certainty of the existence of truth, of intelligible lawfulness:

O! Marvellous, O stupendous Necessity, by thy laws thou dost compel every effect to be the direct result of its cause, by the shortest path. These indeed are miracles. . . . Who would believe that so small a space could contain the images of the entire universe? O mighty process! What talent can avail to penetrate a nature such as these? What a tongue will it be that can unfold so great a wonder? Verily, none! This it is that guides the human discourse to the considering of divine things [CA 345v, Mc p. 238].

For Leonardo, Nature is not chaotic: "In Nature, there is no effect without a cause; understand the cause, and you will have no need of the experiment" (CA 147 v, Mc p. 64). And, "Who negates the reason of things, reveals his own ignorance" (M 1, Ma p. 65).

The existence of a "necessary reason"—as Leibniz will redefine the above expressions of Leonardo—and the possibility for man to grasp it through his mind, imply that man is not subject in the same way to the river of time, as are stones or even animals, at least, not all the time. Human societies are not passively waiting to be consumed by time, at least not



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Leonardo's Mona Lisa, at the Louvre.

all societies. Therefore, we can state that Leonardo does not fall in the mistake of a Prigogine.¹⁰

Here, for example, are some notes in which Leonardo hints at something very interesting:

Men are in error when they lament the flight of time . . . not perceiving that it is a simple transition, but good memory, with which nature has endowed us, causes things long past to seem present [CA 76 r, R. 1170].

Avoid studies of which the result dies with the worker [Fo III 55r, R. 1169].

Poor is the pupil who does not surpass his master [Fo III 66v, R. 498].

Man can confront geological time as if "from outside"; he can transcend it if he rediscovers "what was already written in his heart," and willfully reaches for the melting of the past history into a better future. We reconstruct and transform our historical, our geological, our cosmological time, and make our present into the future each time that we improve the work of

our masters through actions that will not die with the worker.

What Leonardo expresses above, is very similar to what Lyndon LaRouche will call the "simultaneity of eternity"¹¹—an idea that Leonardo expands on his reflections about art.

Art and the 'Simultaneity of Time'

Everybody will agree that Leonardo's paintings are not "frozen," but, I ask myself, how is Leonardo's awareness of time and change expressed? He will never try to express this symbolically or try to "mimic" time, so to speak. On the contrary, we get an impression of a "suspended time." But let me try to elaborate.

We know that Leonardo, during his first stay in Milan, was involved inside his "Academy," with debates about various art forms, he himself being a master of all of them. Some parts of this debate, have been delivered to us through notes, later patched together by a student of Leonardo, and today called "The Paragon of Arts." There, Leonardo argues that painting and music were superior to all the other art forms.

If one disregards the polemical overtones of the dispute, and focusses on the core and essence of the arguments, the crucial aspect of his reasoning immediately appears: Painting and music are superior, because they are able to express time as "simultaneity of time." This, and only this, transmits the awareness of the real harmonic unity, the existence of an oneness: "Because from very many voices, represented at the same time, results the harmonic proportion" (CU 10 r, TP 21).

He proceeded further, insisting that harmony has a true meaning only if it can be "instantaneous" or "at the same time," and finally, he criticizes poetry because:

The poet in describing an [entire] body, will present it piece by piece, and in different times, while the painter can show it all at the same time . . . [and] the poet cannot describe the harmony of the music because he has not the power to say different things at the same time [Cu 18r-v, TP 32].

Leonardo looks at the "time flow" from the point of view of the eternal, the simultaneous, and the domain of the living Idea.¹²

It is only the possibility of expressing this paradox of temporal simultaneity, which allows artistic activity to help societies to maintain an assurance about Truth, despite and above the lack of formal types of certainties. The artist can express intelligibly and evoke that unique new element that can solve the paradox: the willful use of our creative (divine) power. Therefore, Leonardo can say, "The divinity which is the science of painting transmutes the painter's mind into a resemblance of the divine mind. . ." (CU 36 r, TP 68).

Such awareness transforms the artist, the painter, into a "philosophical painter" or a "scientific painter," giving him a moral responsibility in expressing the invisible nature of the truth through visual means. Therefore, Leonardo, conscious of the limit of formalism, will push the visual space to its limits without breaking it, with the risk of falling into symbolism and subjectivism. He wants to maintain the intelligibility of Truth, of that power which allows the continuous "re-creation" of the world—a power that is located in all human beings and, there-

fore, can be recognized by the viewer, listener, or reader of a work of true art.

The possession of a "divine mind" locates the artist in a different dimension which no longer allows him to simply "imitate physical nature." On the contrary, says Leonardo: "The painter contends with, and rivals, nature" (Fo. III 44v, R. 3).

Leonardo "loved" nature; he is even known for his sentimentalism: He bought birds in the market to then set them free. Everybody can admire his delicate paintings of cats, flowers, and rocks, or the attention he paid even to insignificant details in our environment. But Leonardo was not a Romantic; he knew that physical nature is animated, moved, and evolved by majestic forces able to make and unmake even mountains. He knew how destructive "time" can be. Leonardo described how civilizations disappeared, and their remnants were covered by the growth of the Earth. Consequently, he was fully aware of the implication of his idea that the painter "contends with, and rivals, nature."

As a philosophical painter cannot simply "imitate," so human societies cannot simply "adapt to" physical nature, because Nature is a contender, although not an enemy, of man. We should contend with nature itself, not with other species, and even less with other human beings. The painter, the man, has a unique role, that of being a creator inside a generative nature! He is not playing virtual games and does not construct arbitrary artificialities, but from inside, he helps that generative process to go "over itself." Man becomes the small but "immutable spirit" of the *Metamorphoses*; he can willfully steer the forces of nature through ideas and, therefore, transcends each of its moments by participating in a higher process and Truth.

Hence, *Mona Lisa*, in her own space-time, dominates over the majestic geology of the mountains, the whole forming an intense, moving unity.

Man's scientific-artistic quality of being a creator inside a creative nature, is actually revealed in activities that are today despised as "anti-natural," but which Leonardo called "the noblest of all sciences"; that is, the instrumental and mechanical sciences.

The 'Natural' Economy

Leonardo's machines, have been widely reproduced and admired, but very often they are presented as the fantastic output of someone sitting under a tree and dreaming about all kind of objects: bicycles, submarines, autos, and airplanes.

The reality is slightly different. Leonardo was fully involved in the realization of "great projects": the construction of infrastructure in Florence, Milan, Rome, Amboise (France), and other places. His sketches for roads, for draining marshes, for canals, for "ecological cities," and so on, were part of specific and coherent projects to improve the economic conditions of the period. In the context of such projects he elaborated, copied, or invented hundreds of new machines or instruments with the main aim of aiding physical work or eliminating human muscle as the main motive-power.

The consciousness of the role of technology, resulting from human mental creativity, in improving the condition of laborers, transformed the notion of work from the feudalistic "God punished men to work," into the Christian humanist view that "human work is a participation in the creative activity of God in the process of transformation of the created."¹³

The notion of participation in the transformation of the created, implies first, that transformation in and of nature is a necessary, lawful event; second, that the existence of human society is located in the willful continuation of such evolution, but sustained through ideas; and third, that the essence of such evolution is expressed by specific temporal changes.

Time 'the Devourer,' or the Issue of Entropy

All of this converges in rendering clear the parallel between the illusion of a society based on "no growth," and the illusion of trying to render temporal Truth through formal structures. In the relationship of society to nature, time plays the same role as it played in the relationship of man to Truth.

During the period in which Leonardo worked, the idea was widespread that it was possible to obtain a machine able to generate "perpetual motion," especially because of the use of water-powered pumps. There was the illusion that one could exist without the need to improve technology.

Leonardo recognized clearly the absurdity of such an idea: "Descending water will never raise from its resting place an amount of water equal to its weight," he said (CA 147va, Re 84). He therefore attacked "the engineers who think to make dead water stir itself into life with perpetual motion" (W. 19070 v, Re 83). In a note written around 1494, he explodes: "Oh! Speculators about perpetual motion, how many vain

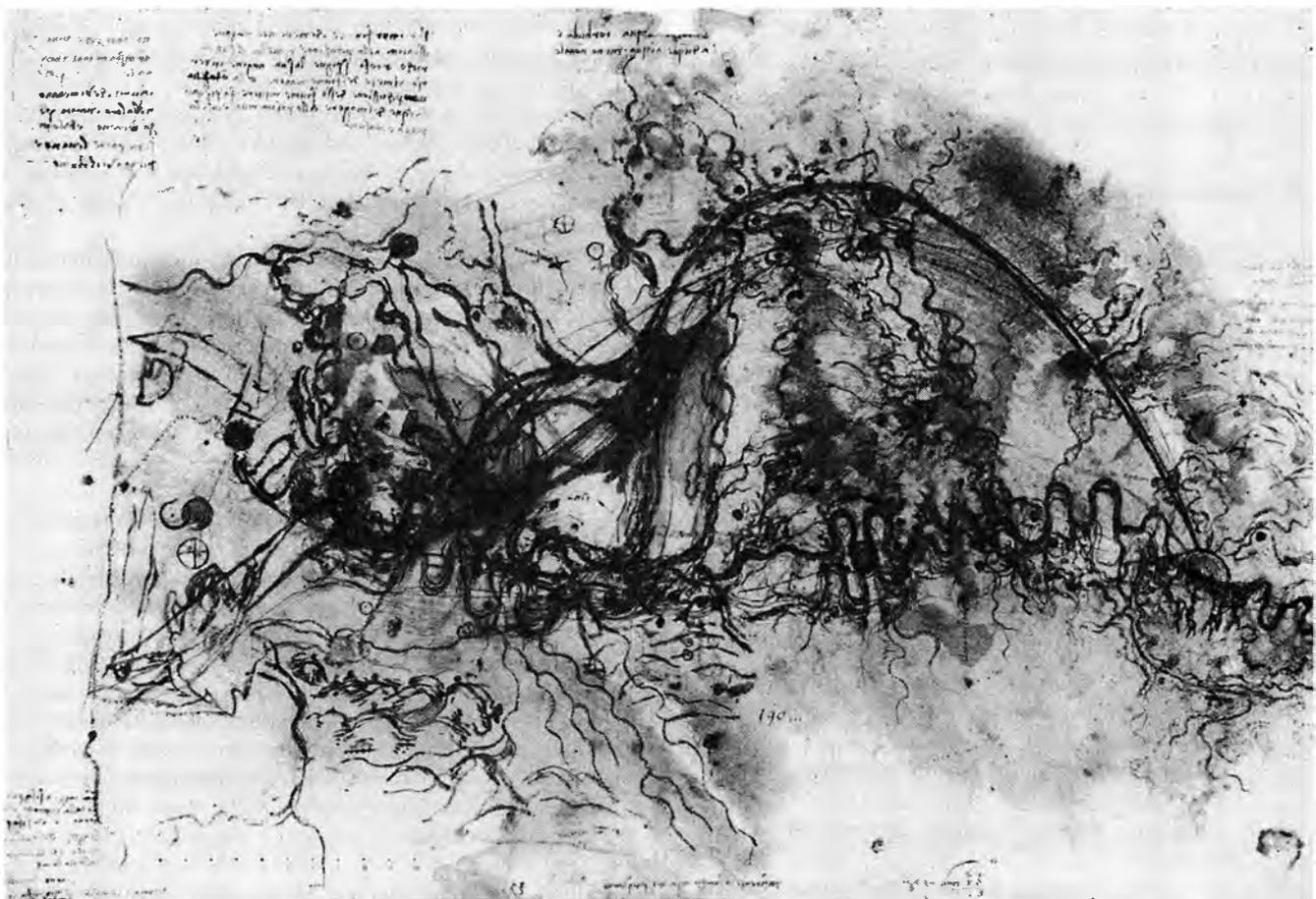
chimeras have you created in the like quest. Go and take your place with the seekers after gold" (Fo. II 92v, R. 1206).

For us today, the idea of a perpetual motion machine has become nonsensical, although many still have illusions about a social perpetual motion machine. But it was Leonardo who first discovered the reasons for the impossibility of such nonsense. He clearly specified friction as the reason for loss of power, over time, in a machine:¹⁴ "Falling water will raise as much more weight as its own, adding the weight equivalent to its percussion," but you have to deduct from the power of the instrument "what is lost by friction in the bearings. . ." (CA 151r-a, Re 84).

All engineers try to ease transport by increasing the numbers of wheels, but Leonardo realized also that,

the more wheels you will have in your instrument . . . the greater will be the friction of the wheels. . . . And the greater the friction, the more power that will be lost by the motor, and consequently, force is lacking for the orderly motion of the entire system [CA 207v-b].

As usual, he expanded the results, from solids to liquids and gases, discovering liquid viscosity with the consequent vortices and turbulences. He proved also that wind, through friction, causes the evaporation of water, writing: "The rain,



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Map of the Arno with the proposed route of a canal, by Leonardo da Vinci, RL 12279

A Note on Sources for Leonardo's Writings

When citing Leonardo, I have listed the original codex. The translations, in some cases, are my own, or another source is cited from the list here.

Collections:

CA = Codex Atlanticus (1487-1518)

W = Windsor (1478-1518)

BM = Arundel Mss (1478-1518)

CU = Urbinas (1480-1492)

TP = Treatise on Painting

Notebooks

Fo I, II, III = Forster I, II, III, (London)

1480-95 = S.K.M. in Richter

A, B, C, D, E, F, G, H, I, J, K, L, M = Mss. A, B, C, and so on (Paris) 1484-1514

Tr. = Codex Trivulziano (Milan), 1492

M I, II = Codex Madrid I, II (Madrid) 1491-1493 and 1503-1505

Tu = Codex on flight (Turin) 1505

Qa = *Quaderni di anatomia*, Windsor 1504-1506

Leic. = Codex Leicester (Gate) 1508-1510

Ash. I, II = Ashburnham (Paris), complement of codices A and B

An. = Anatomy folios A, B, 1490-1510

Transcripts of Leonardo's Notes

R = Richter, *The Notebooks of Leonardo*, 2 Vols., (New York: Dover 1883, 1970)

Mc = E. MacCurdy, *The Notebooks of Leonardo*, New York: Braziller, 1939

JR = J. Roberts, C. Pedretti, *The Codex Hammer Catalogue*, 1982

Co = *The Codex Leicester-Gate in CD-ROM*. (Corbis, 1996)

Pe = C. Pedretti, *The Codex Leicester-Gate*, Powerhouse, 2000

P = C. Pedretti, K. Clark, *Leonardo, Studi di Natura* (Studies of Nature) B.R. Windsor, 1982

Uc = Arturo Uccelli, *I libri di meccanica di Leonardo* (Books on Mechanics), (Milan: Hoepli, 1940)

Br = A.M. Brizio, *Scritti scelti di Leonardo* (Selected writings of Leonardo), (UTET 1952-1996)

Ma = Augusto Marinoni, *Leonardo scritti letterari*, (Leonardo's selected literary writings), (Rizzoli 1980)

DeT = Nando de Toni, (L'idraulica in Leonardo, Selezione di passi (Hydraulics in Leonardo, selections), (Brescia: Morcelliana, 1934)

Re = Ladislao Reti in *Leonardo Technologist* (Burndy Library, 1969)

HL = H. Ludwig, *Leonardo da Vinci's Buch von der Malerei* (Ital./Deut.), Zeller (1882) 1970

which descends from a cloud, does not descend in its entirety, but vaporizes in large quantity and diffuses in the air because of friction with the air" (Leic. 14r).

Today, the different forms of friction fall under the more general notion of entropy; that is, the indicator of the tendency of physical and chemical processes to "die down," or for structures to "become old," and nowadays this concept is associated with the "arrow of time." Leonardo, following Ovid, had expressed the same idea with his poetic: "Time! Consumer of all things."

The reappearing of time, as change in the form of mechanical entropy, definitely makes it clear that there is a link between the two "impossibilities" that we have encountered up to now: the impossibility of equating Truth with formal or completed certainty, and the impossibility of equating Existence with a "completed perpetual machine." In both cases, the solution is based not in ignoring change, but in subsuming and mastering temporal changes.

Again, the Simultaneity of Time

Leonardo, as any good engineer, reduced the effect of friction and therefore increased efficiency by the use of curves of least action—cycloids, for example.¹⁵ But he realized that, although efficiency could momentarily be improved, the main problem was located in the intrinsic limit inherent in any given "motive force," a crucial principle that Leibniz and Lazare Carnot rediscovered much later.¹⁶ Once the type of motive power is given, then its maximum output is also given, and there is no way to increase it. Leonardo says: "It is impossible to increase the power of instruments . . . once the quantity of force and motion is given" (M. I, 175v). And: "It is impossible that the power of any motive force should be able at the same time and with the same movement to create a power greater than itself" (E 66 r, MC 534).

Not only can a motive-power not be increased above its intrinsic limit, but, in reality, it will continuously decrease in power because of the effects of friction, as we saw before. therefore, to survive, we must continue the process of generative nature at the social level, and we must discover higher forms of motive-powers, where "higher" is a measurable indicator of the direction of the inventions. Lazare Carnot beautifully described this process:

The discovery of a new motive power in Nature is always a precious thing . . . especially when used to help the action of man. . . . The ancients knew only a few such motive powers: water, wind, animals, and so on. . . . But machines can only transmit energy; they cannot increase it. The key is [in] the motive powers. We have discovered new motive powers, or better, we have created them, because although the elements are already pre-existing in nature their low density makes them not useful to man. Only artificially do they acquire the quality of motive powers, as in the steam engine, black powder.¹⁷

Indeed, we know that Leonardo started looking for new motive powers, including steam engines.¹⁸

Therefore, to be able to exist, a society has to solve two



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impossibilities: That no given formalism can express truth, and that no single technology can express the existential power of nature.

Truth and existence have to incorporate time and change in the form of creative changes, in the form of "the simultaneity of time," and, consequently, we participate in the transformation of nature with ideas so that, to paraphrase Leonardo, "any human mind can be transmuted into a resemblance of the divine mind."

But the road of temporal truth, the making of history, is not an easy road: Traps, errors, and betrayal are present all along the way. Leonardo painted in *The Last Supper* the betrayal of Jesus Christ by a man, and he pointed to the danger that humanity could be betrayed by some evil part of itself. For example, by those who hope to keep their privileges perpetually, and who, through "zero growth" will lead the entire society into the "bestial madness" of wars, in search of new "living spaces" on a planet, which, by their own policies, has been rendered smaller and smaller. This faction will render all humanity to be an easy prey of Time, the devourer of all fixed things. Leonardo, with a vision of what was happening in Italy, and would happen soon in Europe wrote:

Creatures shall be seen upon the Earth who will always be fighting one with another, with very great losses. . . . These shall set no bounds to their malice. . . . O Earth! What delays thee from opening and hurling them headlong into the deep fissures of thy huge abysses and caverns, no longer to display in the sight of heaven so savage and ruthless a monster [CA 362, R. 1296].

We came out of the "Little Dark Age" of the mid-16th to 17th Century and hopefully, we can avoid other, onrushing ones, so to carry further what Leonardo could have written on his tomb:

"I was not consumed by time; therefore, mankind can be."

Dino De Paoli, based in Hannover, Germany, has written widely on the history of science. Sponsored by the Schiller Institute, he has also presented a series of lectures to university audiences in Europe on the ideas in this article.

Notes

1. Dino De Paoli, 1985, 1986; LaRouche, 1989.
2. Friedrich Schiller, *Die Worte des Glaubens* (TRANS.)
3. Leonardo also explained why we see the whole lunar disc even when the Moon is illuminated only a bit by the Sun at the crescent. He explains that this is the result of the Sun's rays being reflected by the Earth's into the Moon. Kepler in 1610, still credited his teacher M. Mästlin with discovering this.
4. Dino De Paoli, 1986. Also (Leic. 9v), where he describes the construction of a transparent box to make visible the motion of water and currents. And in (Leic. 10v), he constructs a wind tunnel to see the effects of wind and water.
5. The idea that the Mediterranean Sea flowed out through the Strait of Gibraltar was already noted by Eratosthenes in the 3rd Century B.C.
6. Leonardo could not directly see the sedimentation at the bottom of a deep sea, but he constructed models with transparent boxes to visualize water currents, turbulence, mud deposits, and so on.
7. D. De Paoli, 1997, 1999
8. D. De Paoli, 1999
9. D. De Paoli, 1999
10. D. De Paoli, 2000
11. Lyndon H. LaRouche, Jr., 1996, 1997, 1999
12. From what is said here, it is clear that Leonardo's criticism of the concept of harmony produced by linear perspective, whose space (projective space), better than the Euclidean one, enlarges the notion of invariance to situations where lengths changes with position. Nevertheless, Leonardo more and more searches for the invariance (that is, the simultaneity, the divine) neither in lengths nor in simple proportions, but in creativity.
13. Pope John Paul II, Speech at Camerino, March, 19, 1991.
14. He discovered that friction is independent of area, but linked to smoothness and load. This was rediscovered by Lazare Carnot and Charles Coulomb in 1783.
15. Not only did he introduce or rediscover the use of cycloids in transmission, but also he made explicit experiments to prove that a ball in an arch descends more quickly than on a line (in TU 1v).
16. D. De Paoli, 1999
17. D. De Paoli, 1999
18. The models used later by Huyghens and Papin are very similar to those of Leonardo. See De Paoli 1985.

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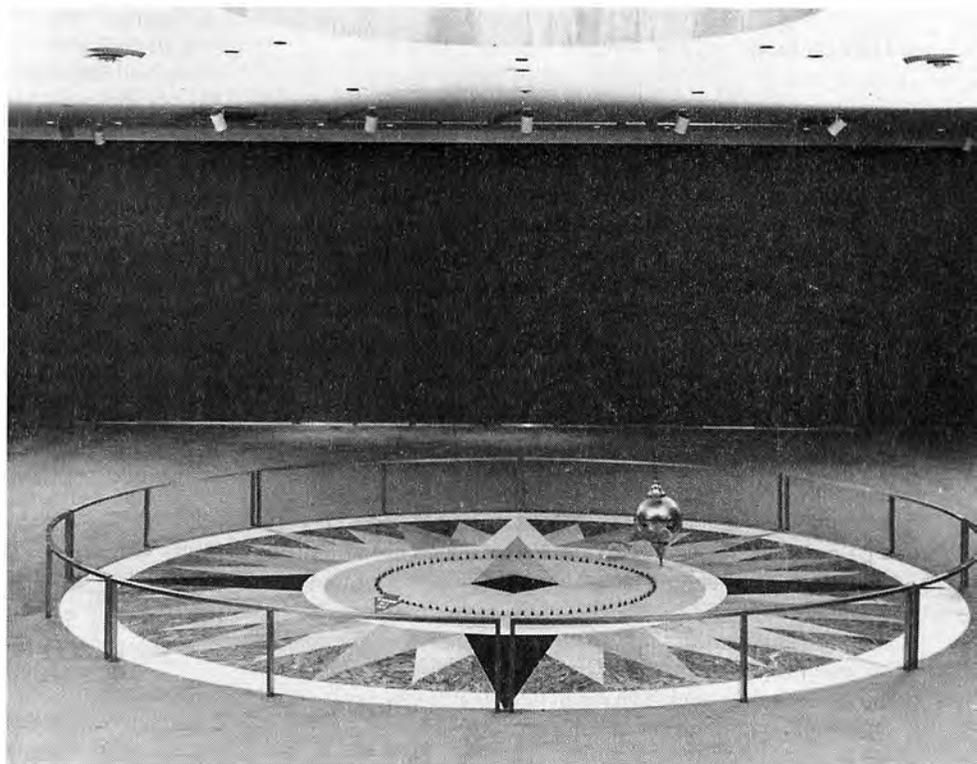
ON A CONNECTION BETWEEN ELECTROMAGNETISM AND GRAVITATION

The Action of a Magnetic Field on the Motion of a Pendulum

by Maurice Allais

A glass pendulum oscillating inside a solenoid changes direction in response to changes in the direction of the electrical current. These experiments, carried out in 1953, led the Nobel Prize-winning author to suspect a connection between electromagnetism and gravity.

Here, a Foucault pendulum in a Smithsonian museum display in Washington, D.C. The Foucault effect (which demonstrates the rotation of the Earth) is one of several effects that must be taken into account in determining the action of a magnetic field on the motion of a pendulum.



Courtesy of Smithsonian Institution

“The periods when one is led to formulate a single principle behind phenomena, which had previously been seen as due to absolutely distinct causes, have almost always been accompanied by the discovery of a great number of new facts, because a new manner of conceiving the causes suggests a multitude of experiments to try, and explanations to verify.”

—A.M. Ampère
*Théorie mathématique des phénomènes
electromagnétiques, 1825*

The belief that a magnetic field corresponds to a local rotation of the ether¹ led me to carry out some very important experiments in 1953, which showed the action of a magnetic field on the motion of a pendulum oscillating inside a solenoid.²

I. The Experiments

1. General Conditions of the 1953 Experiments

- The experiments took place in April-May 1953 in a location especially set up for this within the Etablissements Cléménçon, 34 rue Milton in Paris, put at my disposal from April 15 on, by André Martin, president of the Cléménçon company. The pendulum and the solenoid were built by Mr. Coupry, an in-house engineer at the Etablissements Cléménçon. The experiments were done under my direction, with the very active and effective collaboration of Mr. Coupry, and with the help of Miss Bouteloup, my assistant. The experiments could generally be carried out only at night, because the Etablissements Cléménçon was in use during working hours.

- The pendulum consisted of a glass sphere, 11.3 cm in diameter, weighing 2,270 grams, suspended by a 0.8 mm diameter nylon string. The pendulum was 224 cm long, and its oscillation period was 3 seconds.

The azimuth of the plane of oscillation was established by means of a graduated circular sector placed above the solenoid, and capable of being moved relative to a fixed sector, graduated in degrees. The distance between the movable sector and the two long immovable strips between which the pendulum oscillated, could be varied from 2 to 4 cm.

- The suspension mechanism consisted of two nickel-plated rings, 4 cm in diameter, the one *A*, clamped between two slabs of wood attached rigidly to the ceiling, and the other *B*, supporting the pendulum. The suspension was thus dissymmetric (Figure 1). The plane of ring *A* was oriented close to magnetic north.

The pendulum is held in its initial plane of oscillation, *A*, by a string which is burned when the pendulum is judged to be sufficiently still. The initial amplitude (the semi-major axis of the ellipse) was 10 cm. This pendulum is hereinafter called a Cléménçon pendulum.

The displacement of the plane of oscillation was taken to be positive in the counterclockwise direction.

The initial oscillation seemed to be in a plane, but soon an ellipse was manifested. The ellipse was considered positive or negative, respectively, depending on whether it was formed in a counterclockwise or a clockwise direction, the latter the same as the Foucault pendulum.

- The magnetic field *H*, was created by a solenoid consisting of two coils of 5-mm diameter copper wire, each of 112 turns. The coils were wound in parallel around a cylinder 58 cm high and 50 cm in diameter, made out of an asbestos-composite. Each coil was made up of 8 concentric windings. A 100-amp continuous current was passed through the solenoids. The strength of the magnet-

ic field *H*, at the center of the solenoid, was about 400 gauss.³

The current was considered as positive, when, by the customary convention, it ran counterclockwise through the windings.

2. Preliminary Experiments

- Preliminary experiments were carried out with and without current, using the same apparatus, on Saturday, April 25, 1953, from 11 a.m. to 12 midnight, and Thursday, May 7, 1953, from 10 p.m. to midnight. These experiments brought me gradually to two conclusions:

(a) When there was no current, the plane of oscillation of the pendulum tended towards a limiting plane around which it oscillated, and this limiting plane was different, depending upon the time of day.

(b) When the elliptical trajectory of the pendulum did not differ much from a plane trajectory, a *negative current* tended to create a positive ellipse and to displace the plane of

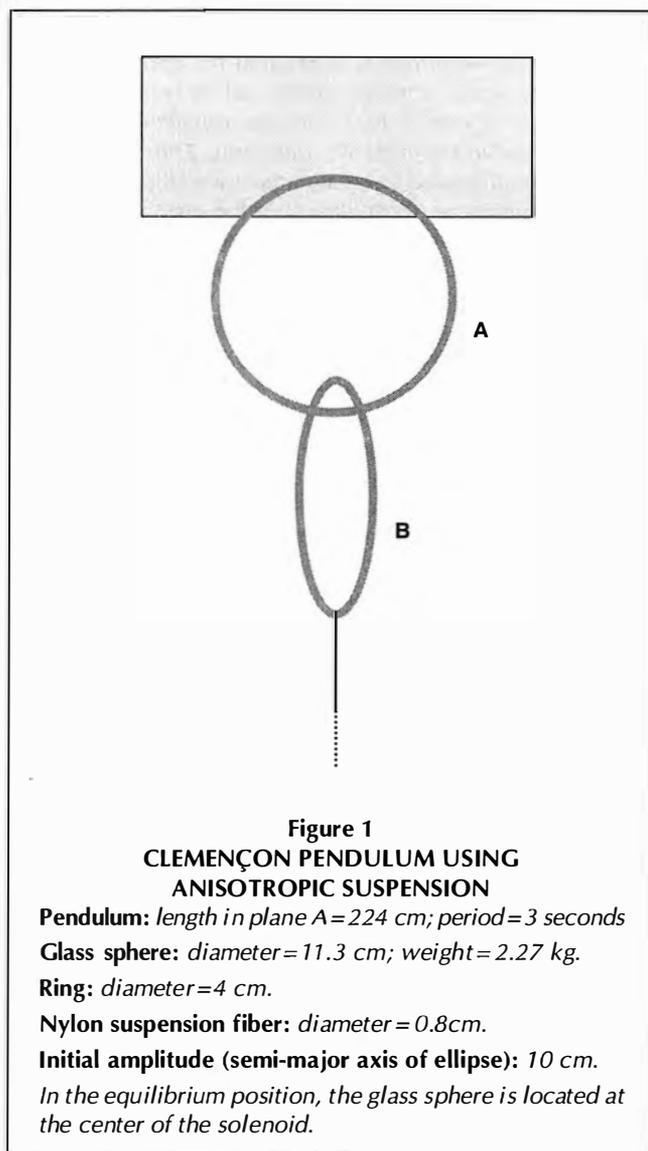


Figure 1
CLEMENÇON PENDULUM USING
ANISOTROPIC SUSPENSION

Pendulum: length in plane *A* = 224 cm; period = 3 seconds

Glass sphere: diameter = 11.3 cm; weight = 2.27 kg.

Ring: diameter = 4 cm.

Nylon suspension fiber: diameter = 0.8 cm.

Initial amplitude (semi-major axis of ellipse): 10 cm.

In the equilibrium position, the glass sphere is located at the center of the solenoid.

oscillation in the *positive* sense (counterclockwise), and a *positive current* tended to create a negative ellipse and to displace the plane of oscillation in the negative direction (clockwise).

- It was these findings which led me to the experimental procedure of Friday, May 8, 1953.

3. Experiments Carried Out May 8, 1953

- The experimental procedure of May 8, 1953, from midnight to 2 a.m., were essentially as follows:

Without the application of a current, the pendulum was released in plane *A* with a 10-cm amplitude of oscillation, and an ellipse appeared. This ellipse was *negative*.⁴

When it was clear that a negative ellipse was taking shape, a negative (according to the normal conventions) current was switched on. After a short delay, the current produced a change in the direction of description of the ellipse. From thence, once the change was manifested, the direction of the current was reversed, and the result once again was a reversal of the direction of description of the ellipse.

In fact, these experiments confirmed my earlier observations, namely, that a positive current, all by itself, tended to create a negative ellipse; that is to say, to make the plane of oscillation turn in the negative direction. And, also, that a negative current tended to create a positive ellipse; that is to say, to turn the plane of oscillation in the positive direction. To make these effects manifest, the dimension of the minor axis of the ellipse had to be kept very small, on the order of 1 mm.

- Three series of observations were carried out:

Series I

(1) Starting with *no current*: The pendulum was released in azimuth *A*; a negative ellipse appeared.

(2) A negative current was turned on: The negative ellipse disappeared, and then became positive.

(3) Current was reversed: The positive ellipse disappeared, then became negative.

(4) Current reversed again: The negative ellipse disappeared, then became positive.

(5) Current reversed: The positive ellipse disappeared, then became negative.

(6) Current reversed: The negative ellipse did not become positive; it remained negative.

Result: four significant effects. (A significant effect is considered to be one where each time that the current is reversed, it changes the description of the ellipse.)

Series II and III

Phases (1), (2), and (3) of Series II and III are *identical* to those of Series I, except that in phase (4), the negative ellipse maintains itself and remains negative. In each of the series II and III, there are thus only *two significant effects*.

- *These three series of observations show that there is a connection between the existence of a magnetic field, and the motion of a pendulum; and that (using the normal conventions of direction and sign), a current of a given sign tends to generate an ellipse of the opposite direction.*



Maurice Allais, physicist and Nobel Prize-winning economist at his desk.

II.

Physical Interpretation

1. A Complete Similarity

- It is appropriate, first of all, to emphasize a *very remarkable analogy*.

I recall to mind here, that the mutual action of two continuous electrical currents is such that they tend to orient themselves so that the direction of the currents will be the same.⁵ Similarly, if one considers a dissymmetric pendulum which is made out of a disc, the disc tends to orient itself to the plane of oscillation of the pendulum, so that all the velocities of the elements of the disc, tend to approach the velocity of the center of gravity.⁶

As a result, the currents and the trajectories of the elements of a pendulum behave in the same manner. Two parallel currents attract each other and tend to line up with each other. Similarly, the velocities of the elements of a dissymmetrical pendulum's disc tend to approach the velocity of the center of gravity.

- This analogy leads one to formulate a *perfectly natural hypothesis*.

If, in fact, one assumes the hypothesis that the motion of the electricity in the windings of the solenoid and the motion of the ether inside the solenoid, are both in a direction opposite to that of the current, according to the normal conventions of direction and sign—conventions which are totally arbitrary⁷—then the three series of experiments described above, signify that a positive current of the ether, tends to induce a positive elliptical trajectory to the pendulum, and that a negative current of the ether, tends to generate a negative trajectory to the pendulum.

In other words, *the direction of displacement of a pendulum on its trajectory, tends to identify itself with the effective direction of displacement of the ether and of the current.*

• Out of of this analogy and this hypothesis, there follows a complete similarity between the motions of matter and the motions of electricity, and between their interdependence.

2. Factors Determining the Motion of the Clémençon Pendulum

• In the light of the analyses of the motion of the *paraconical pendulum* (a pendulum suspended from a ball-bearing), which I undertook from 1953 to 1960, and which are presented in my 1997 book, *L'Anisotropie de l'Espace*,⁸ the determining elements, F_i , of the motion of a pendulum when there is no magnetic field present, other than the Earth's magnetic field, are the following:

F_1 —*Foucault effect*: $\phi'_f = -\omega \sin\lambda$, where ω represents the rotational velocity of the Earth, λ the latitude of the place in question, and ϕ'_f the rotational velocity of the major axis of the pendulum's trajectory in a clockwise direction.

F_2 —*Effect of the Airy Precession*: $\phi'_a = (3/8)\rho\alpha\beta$, where $\rho = 2\pi/T = \sqrt{g/l}$; $\alpha = a/l$; $\beta = b/l$, where l , T , g , a , and b represent, respectively, the length of the pendulum, the period, the acceleration of gravity, the major and minor axes of the elliptical trajectory. The minor axis of the ellipse is counted positively or negatively, respectively, according as the ellipse is formed in a counterclockwise or clockwise direction.⁹

F_3 —*Effect of the Anisotropy of the Support*: In fact, the elasticity of the suspension analyzed above, is greater in the direction B than in the direction A . This anisotropy tends to cause the formation of ellipses and to cause the plane of oscillation to oscillate around a plane perpendicular to direction A .¹⁰

F_4 —*Lissajoux Effect*: Because of the suspension by a ring, the length, l , corresponding to the oscillating pendulum, is not the same in both directions A and B . The result of this is that the trajectory of the pendulum tends to reproduce Lissajoux curves.¹¹ This in turn proves that the Lissajoux effect tends to generate elliptical trajectories.

F_5 —*Lunar-solar Influence*: The influence of the Sun and Moon is essentially expressed by the generation of ellipses.¹²

F_6 —*Anisotropy of Space*: The plane of oscillation of a pendulum with *isotropic suspension* tends to change at each instant to an oscillation around a direction of the anisotropy of space, which varies with time, and this anisotropy generates the formation of ellipses.¹³ The more isotropic the suspension, the more this effect is affirmed.¹⁴

3. The Influence of a Magnetic Field

• When one adds to these six factors, the influence of a magnetic field, the analysis of the motion of a Clémençon pendulum becomes extremely complex.

However, in the *Series of Observations I, II, and III*, here above, the Foucault effect is manifested from the beginning, when there is no current, and the ellipses are very flattened.¹⁵ Indeed, after the launching of the pendulum, the factors F_3 and following,¹⁶ elicit, little by little, the formation of ellipses. Note

that in the three *Series of Observations I, II and III*, the initial ellipses are negative.

If, right from the beginning, one turns on a negative current (according to the usual conventions), which corresponds to a positive rotation of the ether, (following the hypothesis of Section II, 1, above), there is a tendency towards the establishment of a positive ellipse, and in fact, one sees that what should have become a negative ellipse at the beginning, becomes positive. If one then *immediately reverses* the current, the positive ellipse once again becomes negative.

This phenomenon does not occur except when the minor axis of the ellipse is very small, the plane of oscillation is close to direction A , and the effect of the magnetic field H , predominates over the other effects.

When, at the end of each of the *Series of Observations I, II, and III*, the ellipse does not return again, this is because the plane of oscillation has finally departed from the initial direction, A , and the effects F_3 and following, predominate over the effect of the magnetic field H . This is also the explanation for the fact that the inversion of the direction of the elliptical trajectory does not occur again.

• It is essential to note that during the three *Series of Observations I, II, and III*, it was possible, by applying the above principles, to cause the plane of oscillation to remain stationary for a very long time, the which had never yet been observed during previous experiments carried out. Rather, in the situation (3) of *Series III*, even though the ellipse did not return, it remained noticeably immobile for about 20 minutes.

• If on the other hand, *continuous* experiments are carried out, without any current reversal, factors F_3 and following end up dominating over the influence of the current, whose influence is nullified. The influence of the current may even become relatively negligible, and might thus no longer be visible.¹⁷

4. Meaning of the Results

• The results of the *Series of Observations I, II, and III* are only qualitative, but, in the light of the indications above, they are very significant when it comes to the influence of a magnetic field on the motion of the pendulum. In fact, one might consider that this influence predominates over the factors F_i , and that the order of magnitude of the influence of a magnetic field H of 400 gauss on the motion of a Clémençon pendulum, is of the same order of magnitude as that of the Foucault effect.

If the results were merely the result of chance, the return of the four ellipses in *Series I*, would have a probability of $1/2^4 = 1/16$. Taken together, the return of eight ellipses would have a probability of $1/2^8 = 1/256$, the which is a very low probability, much lower than that of the threshold of general significance considered to be 1/100.

Indeed, in light of the long experience I acquired during the observation of the motions of various pendulums from 1953 to 1960, I consider today that the effects manifested of the influence of a magnetic field are practically certain.^{18,19}

• The experiments carried out on Friday, May 8, 1953, put into evidence a very remarkable connection between mechanics and electromagnetism.

This connection cannot be explained by currently accepted theories. In fact, the interpretation which has been given

here above, may be able to contribute to the reciprocal understanding of mechanical and electromagnetic phenomena.^{20,21}

III. New Experiments 1. My Analysis of 1953

My observations of May 1953 led me to make two decisions:²²

- To observe the motion of a Foucault pendulum in a magnetic field, H ;
- To analyze the motion of a pendulum in the absence of any magnetic field other than that of the Earth, H_T .

The first decision derived from the fact that when the oscillation was practically in a plane, and the motion of the pendulum reduced itself to the Foucault effect, one did not observe an effective influence of the magnetic field.

The second decision resulted from the fact that the anomalies which cropped up, notably, the tendency of the pendulum to oscillate around a privileged direction, variable with time, was among all other findings, of exceptional interest.

The construction of a Foucault pendulum, some meters in length,²³ had proven very difficult, and in fact, observing this new suspension both continuously, and in alternating periods, with and without current, I never succeeded in establishing the influence of a magnetic field in an incontestable way, such as had been the case on May 8, 1953, when the direction of the current had been immediately changed each time in response to the sign of the observed ellipses.

The reason for this is essentially that because this pendulum is some meters long, the effects of factors F_3 and following finally came to dominate over the Foucault effect and to partially, or even totally, mask the effect of the magnetic field.²⁴

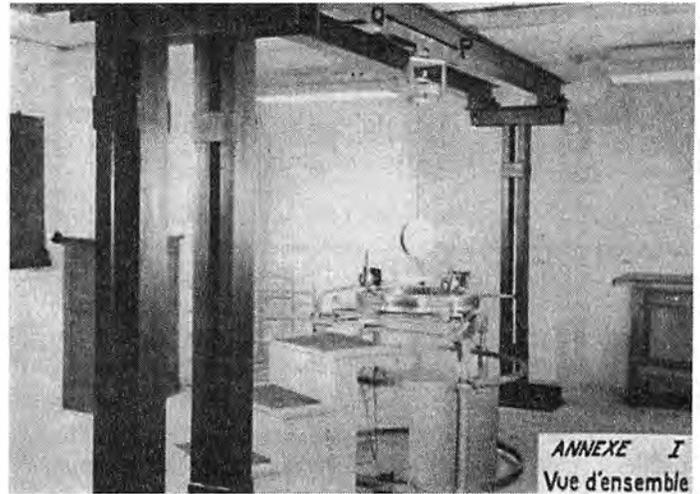
In fact, it was only after an in-depth study of the motion of the paraconical pendulum from 1953 to 1960, that I was able to achieve a complete analysis of factors F_2 to F_6 . In 1955, I decided to devote myself entirely to the analysis of the anomalies of motion of a paraconical pendulum in the absence of any magnetic field H other than that of the Earth, postponing until later an in-depth analysis of the influence of a magnetic field.

• I realize fully today, that I would have been better advised to limit myself in 1954, to the simple repetition of the experiments of May 8, 1953, which would have rapidly led to absolute certitude regarding the existence of the sought-for effect of a magnetic field on the motion of a pendulum, and the determination of its order of magnitude.

2. My Analysis Today

• The consideration of various experimental data, which it is beyond the scope of this article to report in exhaustive detail, but which I plan on publishing in subsequent articles in the near future, has led me to consider today that the order of magnitude of the force corresponding to the action of a magnetic field on a mass in motion is given by the expression²⁵

$$(1) F_h = M\gamma_h = K_h \frac{HMv}{c\sqrt{\mu}}$$



No photographs are available of the Clémençon pendulum experiment. In a later series of experiments (1953-1960), Allais studied the motions of a paraconical pendulum, shown here, in the presence only of the earth's magnetic field.

where M , v , and ϕ_h represent, respectively, the mass, the velocity, and the acceleration of the pendulum; H is the magnetic field, c and μ are the velocity of light and the universal gravitational constant, and K_h is a constant whose order of magnitude is unity, with

$$(2) 1/5 \leq K_h \leq 5$$

The expression of F_h can be usefully related to the Foucault effect, whose expression is

$$(3) F_f = M\gamma_f = Mv\omega \sin \lambda$$

where ω represents the velocity of rotation of the Earth and λ the latitude of the place of observation.

Thus, we have

$$(4) r = \frac{F_h}{F_f} = \frac{K_h H}{(c\sqrt{\mu}) (\omega \sin \lambda)}$$

where r represents the ratio between the two effects.

One would have in CGS (centimeter-gram-second) units

$$(5) H = 400 \\ c = 3 \times 10^{10} \quad \mu = 6.67 \times 10^{-8} \\ c\sqrt{\mu} = 7.75 \times 10^6 \\ \omega \sin \lambda = 0.55 \times 10^{-4}$$

Thus, we have

$$(6) r = K_h \frac{400}{(7.75 \times 10^6)(0.55 \times 10^{-4})} \\ = K_h 0.96$$

Taking into account condition (2), the relationship r is thus on the order of unity, and the calculation has confirmed the results of the experiments of May 8, 1953, because the coefficient K_h has a value clearly greater than unity. In fact, this confirmation is very remarkable.

• With regard to the analysis presented in Section II, 3 above, I am today totally convinced of the existence of an effect of a magnetic field on the motion of a pendulum,²⁶ and I believe that for the reasons given in Section II, 2

above, this effect was partially or totally masked in some of the experiments which I carried out in 1954 at the Iron and Steel Research Institute, with a Foucault pendulum about 3 meters long and a magnetic field on the order of 400 gauss.

Clearly, the confirmation of this effect and its order of magnitude remains to be established by new experiments.²⁷

3. New Experiments

The above results have led me to propose new experiments of the following sort:

(a) *A magnetic field of 1,000 gauss or more.*

- To use a solenoid with a magnetic field H of 1,000 gauss or more, instead of the 400 gauss used in 1953.²⁸

- To use a pendulum *identical* to the one of 1953, with the same type of suspension.

(b) *Repetition of the experiments of May 8, 1953.*

Repetition of the experiments of May 8, 1953, carrying out *ten series of consecutive observations*, instead of three.

(c) *Carrying out of three series of continuous, linked observations.*

Carrying out of three series of continuous linked observations, four days in a row, following the principle I utilized in 1957 with the paraconical pendulum (which were in the absence of any magnetic field H^{29}): the first without current, the second with a positive current, the third with a negative current.

Taking into account the long and invaluable experience on the motion of the pendulum which I acquired from 1953 to 1960, I believe today, that this is the best technique for *quantitative* analysis of the influence of a magnetic field on the motion of a pendulum.³⁰

The comparison of three linked series of observations might permit a quantitative determination of the effect of the magnetic field on the pendulum, because on average the factors F_1 to F_6 analyzed above (Section III, 3) remain approximately the same for the three series.³¹

4. The Purpose of the Present Article

The essential purpose of the present article is to make known *the new experimental facts* which I found in 1953 to all those interested in elaborating a unified theory of physics. These new facts, whose analysis I have been unable to pursue until now for various reasons, *establish a significant connection between electromagnetism and gravitation*.³² It is also to inspire, when it becomes possible, the absolutely necessary repetition of my experiments of May 8, 1953.³³

Maurice Allais is an Honorary General Engineer of the Corps of Mines of France and former professor of the National School of Mines in Paris; since 1945, he has been Director of the Center for Economic Analysis (CNRS) of the National School of Mines in Paris. A former professor at the University of Paris X, Nanterre, he is the winner of the 1978 gold medal of the CNRS and of numerous distinctions, French and foreign, for a considerable body of work.

Allais is a member of the Institute of France, and he received the Nobel Prize for Economics in 1988. For more about Allais and his works, see the website <http://allais.maurice.free.fr>

This article was translated from the French by Richard Sanders, and originally appeared under the title "L'action d'un

champ magnétique sur le mouvement d'un pendule" in Fusion, No. 87, Sept.-Oct. 2001, pp. 47-53.

Notes

1. On the existence of the ether, see Maurice Allais, 1997, *L'Anisotropie de l'Espace*, (Paris: Editions Clement Juglar) pp. 536-546.
2. These experiments were the subject of a communication by sealed letter to the Academy of Sciences, during the week of May 11 to 16, 1953, under the title: "Mouvement d'un pendule conique dans un champ magnétique" (Motion of a conical pendulum in a magnetic field) (six pages with an appended three-page Note). This communication is dated May 9, 1953. The quotation from Ampère at the start of the present article, was used as an epigraph following the title of this Note.
3. The maximal absolute value of the magnetic field of the Earth, attained at the two poles, north and south, is 0.66 gauss. Under continuous operating conditions, the temperature of the solenoid ranges from 35 degrees at the coldest point (lower exterior part) to 110 degrees at the hottest part (interior, upper part).
4. To the six factors that correspond to the paraconical pendulum *suspended from a ball-bearing*, it is fitting to add, in the case of a pendulum *suspended by a string (Clémençon pendulum)*, a *seventh factor* which corresponds to the torsion of this string. On the seventh factor, F_7 , see most particularly A.C. Longden, 1919, "On the Irregularities of Motion of the Foucault Pendulum," *The Physical Review*, Vol. xiii, No. 4, (April 1919) pp. 241-258. According to Longden, the torsion of the wire might result in the ellipses being negative, or positive (see especially, p. 249).
5. This is shown by the spectacular experiment of two identical electrical circuits, the one fixed, the other mobile. If initially, they are placed side by side, carrying continuous currents of opposite direction, the mobile circuit moves immediately so as to cause the currents to become parallel. See also, C. Goudet, *Electricité*, (Masson, 1953), pp. 334-342.
6. Maurice Allais, *L'Anisotropie de l'Espace*, p. 93.
7. The conventions accepted today are purely arbitrary. On the *totally arbitrary* definition of the sign of electrostatic charges (*resinous and vitreous*), see, notably, A. Lafay, *Cours de Physique*, (Gauthier-Villars, 1930) Vol. I, p. 133. See also Edmund Whittaker, *History of the Theories of Aether and Electricity*, Vol. I, (Thomas Nelson, 1951) pp. 44, 47, 175-176, and 362-363; and Jean Perrin, *Electricité*, (Hermann, 1941) pp. 22, 29. *By convention*, one assigns the + sign to vitreous charges, and the - sign to resinous charges.
8. Allais, *op. cit.*, pp. 171-196.
9. *Ibid.*, p. 173.
10. *Ibid.*, pp. 184-187 and 193-195.
11. Jules Lissajoux, "Memoire sur l'étude optique des mouvements vibratoires," *Annales de Chimie*, Vol. 51, (1857) pp. 147-231.
12. Allais, *op. cit.*, pp. 184-187.
13. *Ibid.*, pp. 193-195.
14. See Note 4, above.
15. See Allais, *op. cit.*, pp. 93-95. At the beginning of each series of observations of 14 minutes, one notices the Foucault effect.
16. Included in it is *Factor F_7* , (see note 4 above).
17. That is what brought me, in the month that followed, to concentrate my activity on the analysis of a pendulum's motion *in the absence of any magnetic field, H*, other than that of the Earth, H_T (see also note 32 below).
18. These effects gave rise to a detailed commentary in my communication by sealed letter to the Academie des Sciences (note 2 above).
19. It is appropriate here to emphasize that the effects observed cannot be explained as the result of the formation of warm air currents inside the solenoid, because were such rotation due to warm air currents, the reversal of the current would not have had any effect.
20. In particular, the charge of the electron, considered today as negative, *would have to be considered as positive*.
21. In fact, I concluded thus in my Note of May 9, 1953 (Note 2 above), p. 6: "Without wishing in any way to exaggerate the importance of the preceding results, we think that the present experiment will mark an important day in the history of physics, because for the first time to our knowledge, it establishes in an incontrovertible manner, a spectacular connection between two domains of physics, separate until now, mechanics (gravitation and inertia) on the one hand, and electromagnetism on the other. "Since this connection does not seem to be explicable by any of the currently accepted theories, it becomes the basis for a physical representation of electromagnetism which might be capable of throwing much light on the comprehension of electromagnetic phenomena."
22. See my communication by sealed letter to the Academie des Sciences

- (note 2 above), appended Note, p. 9.
23. I had chosen a suspension analogous to the one finally used by Longden (note 14 above), pp. 255-257 of his 1919 article.
 24. Section II,2 above.
 25. I did not arrive at this expression until relatively recently, after the 1997 publication of my work, *L'Anisotropie de l'Espace*.
 26. When I edited my 1997 work, *L'Anisotropie de l'Espace*, I had not yet found my Note of 1953 (Note 2 above) which was not very accessible in my archives. To tell the truth, after almost a half century, I had forgotten all about this note, and I was able to write (p. 45):
 "From the ensemble of observations of a very limited number done in 1953, then in 1954, and 1955 at the I'RSID, of the motion of a ball of glass oscillating in a magnetic field on the order of some hundreds of gauss, I was not able at the time to draw any definitive conclusions. However, today I think that the effects to be foreseen are too small to be measured when using the magnetic fields we are able to produce today."
 In fact, the publication of this text seems to be completely unjustified, in light of the results of my May 8, 1953 observations, analyzed above. Those observations showed very clearly the existence of the sought-for effect, that is, the effect of a magnetic field on the motion of a pendulum; its order of magnitude not differing much from the Foucault effect.
 27. It is only too evident that the experiments of May 8, 1953, from 0 hours to 2 hours of the morning, almost 50 years ago, would not be enough to be completely convincing today.
 28. With a magnetic field, 2.5 times larger than in 1953, the effect of this field must have a clear influence on the effects of factors F_3 and F_6 .
 29. See *L'Anisotropie de l'Espace*, p. 103, and Chart VI on p. 104. Each elementary series of observations took 14 minutes. For each successive experiment in the linked series, we began, at the moment t , from the azimuth obtained in the previous experiment, which had started at $t - 60$ minutes.
 For each of the three triply linked series, the observations $3n + 3$ were linked with observations $3n$, observations $3n + 4$ with observations $3n + 1$, and observations $3n + 5$ with observations $3n + 2$.
 30. This linked series lasting four days, will be executed as follows.
 In the *first series without current*, the pendulum will be launched at the beginning of each hour, h , and its motion will be observed for 14 minutes. At hour $h + 1$, the pendulum is relaunched from the final azimuth observed at the end of the experiment of hour h , and again the pendulum will be observed for 14 minutes; and so on. The azimuth of the very first launching will be the azimuth of A .
 In the *second series with a positive current*, the pendulum will be launched at time $h + 20$ minutes, from the final azimuth reached in the experiment beginning at time $h - 1 + 20$ minutes. At time = $0 + 20$ minutes, the initial direction of the series is that of azimuth A .
 In the *third series with a negative current*, the pendulum will be launched at time $h + 40$ min in the azimuth at which one arrived beginning at time $h - 1 + 40$ minutes. At time = $0 + 40$ minutes, the initial direction of the series is that of azimuth A .
 For each series, we will obtain 96 observations of 14 minutes duration.
 31. See Graphic VI of *L'Anisotropie de l'Espace* and its commentary, *op. cit.* pp. 103-104.
 32. Beginning in 1953, I was concerned with the setting up of my laboratory at the Iron and Steel Research Institute at Saint Germain, and I gave priority to the analysis of the motion (in the absence of current) of a paraconical pendulum. This analysis absorbed most of my activity from 1954 to 1960 (see my work of 1997, *L'Anisotropie de l'Espace*, p. 64).
 Alongside my work in physics, in 1953 and 1954, I wrote four very important memoirs, on monetary dynamics and on the application of risk theory to mining research:
 - "Illustration de la Théorie des Cycles Economiques par un Modèle Monétaire non Linéaire" (1953).
 - "Explication des Cycles Economiques par un Modèle non Linéaire à Regulation retardée" (1954).
 - "Les Fondements Comptables de la Macroéconomie. Les Equations Comptables entre Quantités Globales et leur Applications" (1954).
 - "Evaluations des Perspectives Economiques sur de Grands Espaces. Application au Sahara Algérien" (1954).
 These circumstances help to explain why I did not immediately resume my experiments of May 8, 1953.
 33. As is indicated in Section III, 3 above.

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SPACE FARMING ON MARS

Greenhouse Aboard Mir Shows Plants Can Thrive In Space



The author studying samples of onion plants, during an Earth experiment in the SVET Space Greenhouse.



Astronauts living in space could be eating fresh vegetables and “space bread,” milled and harvested from an onboard greenhouse. The seeds from these plants will grow the first food crops on Mars.

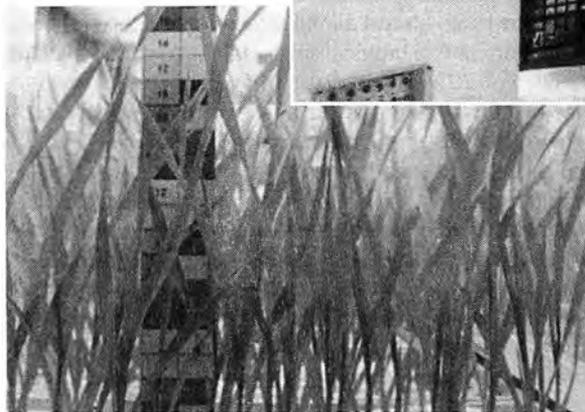
by Dr. Tania Ivanova

make fresh bread as on the Earth—will be grown there. At the time when trips to Mars become a reality, and the habitable bases on the Moon begin to look like settlements with their gardens and parks, the history of astronautics will record that some of the first space greenhouses were developed and produced in Bulgaria.

The SVET (“light”) greenhouse, automated plant growth facility, developed as a Bulgarian-Russian Project in the 1980s, was launched in the Mir Orbital Station on June 10, 1990. The goal of the investigation was to study plant growth under microgravity, in order to include plants in future Biological Life Support Systems for long-term manned space missions.

An American-developed Gas Exchange Measurement System (GEMS) was added to the Bulgarian-developed SVET equipment in 1995, to monitor additional environmental and physiological parameters. Many long-duration plant space experiments were carried out in the SVET-GEMS complex right up to the end of the 20th Century.

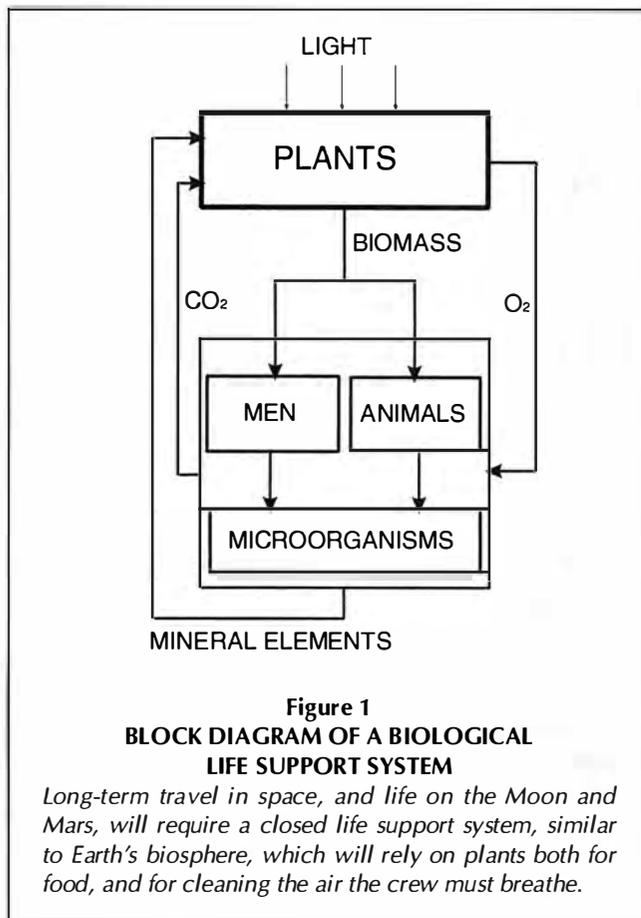
Significant results in the field of fundamental gravitational biology were achieved, as second-generation wheat seeds were produced under microgravity. The new International Space Station provides a perfect opportunity for conducting



Space Research Institute/Bulgarian Academy of Sciences

After discovering huge deposits of frozen water on the Moon, the researchers breathed more easily: Nature itself had paved the way for future scientific stations on Earth’s satellite. Future lunar stations could now be supported by an artificial, closed biological system, like the Earth’s biosphere, with all the necessary plant and animal species—enough for food, and for air recycling. Settled on the Moon, the Earth inhabitants could launch spacecraft to other planets (initially to Mars), more easily and much more cheaply: Six times less power is needed to escape the Moon’s gravity than to escape that of Earth.

When flight to Mars becomes a reality in the near future, a considerable part of the interplanetary spacecraft’s interior will be occupied by a space greenhouse. Vegetable crops and even wheat—whose grains the astronauts will use to mill flour and to



long-term, full life-cycle plant experiments in microgravity during the 21st Century.

The team of scientists that created the first-generation SVET Space Greenhouse has developed a concept for a new generation Space Greenhouse with adaptive environmental control for optimal results during plant microgravity experiments, based on Bulgarian "know-how" and experience. Future long-duration manned flights to Mars and the scientific laboratories on the Moon and Mars, based on plant bioregenerative systems, will be a reality.

Plants and Biological Life Support Systems

The creation of a Biological Life Support System based on the recycling of chemical elements, as in the Earth's biosphere, is a fundamental and very complicated scientific task for our civilization, and is a prerequisite for future long-term manned space missions. A system that includes higher plants and animals theoretically ensures up to 90 to 95 percent of the needed substances for the crew. The effect of microgravity on growing plants is an important area of research, because plants could be a major contributor to Biological Life Support Systems.

Plants will produce food and oxygen for the space crews while eliminating carbon dioxide and excess humidity from the closed cabin environment. The functional diagram of Biological Life Support Systems by analogy with natural ecosystems includes organisms of the principal trophic levels (Figure 1).¹ The first level is the energy "gates" of the system,

through which energy enters from outside. This energy (light) is the basis of the system's existence. This level is produced by photoautotrophic organisms—plants.

The next trophic levels are occupied by heterotrophic organisms, including men and animals, for which the organic matter produced on the first level (biomass) is a source of life. The last link of the trophic chain is presented by different soil microorganisms (fungi, bacteria, and so on) which complete the decomposition of organic matter and turn it into mineral elements utilized by plants.

A great quantity of energy is lost in the process of passing from one trophic level to another. Plants are a fundamental link of bio-regenerative Biological Life Support Systems for future use on space stations and in spacecraft making long journeys to other planets. By achieving maximum yields of edible plant products, the investigators can supplement the food, now carried from Earth, with fresh food grown onboard in space. This would save weight, which is especially important in such long space journeys.

Plants can also regenerate the atmosphere onboard by expelling oxygen through their photosynthesis, and scrubbing the carbon dioxide produced by the crew's breathing. At the same time, having in mind the complexities of living and working on long-duration flights in closed volumes, we should not underestimate the uplifting psychological effect of taking care of a garden far away from the Earth, which will contribute to mission success.

The question of the possibility of growing plants in weightlessness has excited scientists from the very beginning of space research. Since 1962, almost all the scientific programs for both piloted and automatic biological spacecraft have included plant experiments. For 20 years, biologists have almost managed to prove that the critical conditions in space were not a show stopper for growing plants through a complete life cycle.

Limited success in a seed-to-seed cycle was achieved in 1982, when *Arabidopsis thaliana* plants were grown from seed to maturity. But growth was quite retarded and generally poor.² The plants were grown in a Russian Phytion-3 device on the Salyut-7 Orbital Station for 69 days. About 200 seeds were formed, half of them immature, after return to Earth laboratories. Further, the plant growth was considerably less vigorous and healthy than that achieved with ground controls in the same plant-growth devices, and many of the seeds produced were empty.

After this success, which eliminated weightlessness as an obstacle, in principle, for plant development, an international team of investigators under the direction of the Institute of Biomedical Problems (now the State Scientific Center) in Moscow, took up the task of developing every single link of the space Biological Life Support Systems separately.

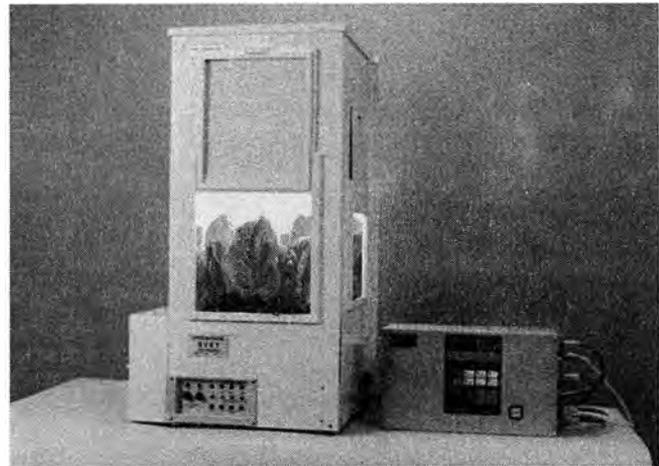
A new scientific program, "Study of the ways and means for use of higher plants, algae, and animals in biological systems for life support of space crews" was set up within the framework of the "Intercosmos" Program in 1983. This was coordinated by G.I. Meleshko and Ye. Ya. Shepelev from the Institute for Biomedical Problems in Moscow, with scientific teams from other countries joining their efforts to design and develop instrumentation and new biotechnology. The goal was to develop the main links of a future closed biological system, including plants and animals.

A team of researchers from the Space Biotechnology Department of the Space Research Institute of the Bulgarian Academy of Sciences developed the first Space Greenhouse, named SVET, for plant experiments. These researchers were included in this scientific task because their 15 years of experience in developing equipment for space physics investigations was well known. The development and production of the SVET Space Greenhouse modules was funded by the Bulgarian side (a patent has been issued), while the Russian side ensured the launch and crew training, and led the flight experiment. Another scientific team, from the Institute of Animal Biochemistry and Genetics of the Slovak Academy of Sciences developed the Incubator-2 system, created for long-term experiments with animal eggs (Japanese quail).³

Both pieces of equipment, for plant and animal research, were launched to the Mir Orbital Station in 1990, and the first successful experiments in microgravity were carried out. The Bulgarian research activities on the SVET Space Greenhouse project can be divided into two main periods. From 1983 to 1991, Russian-Bulgarian collaboration took place within the framework of the "Intercosmos" program, which included the launch of the SVET equipment and the first experiments. The second phase of activities, from 1994 to 2000, centered on the American-Russian-Bulgarian collaboration, characterized by the launch of the second-generation, modified SVET-2 Space Greenhouse, and many long-term experiments.

In the 1980s, the aim was to improve and optimize the equipment and biotechnology for plant growth, with the purpose of providing additional vitamins to the space crew's food. But in the 1990s, the research was directed to those experiments that would also clear the air, and even provide food for future long-term space voyages. It was of great importance to solve the problem of providing the crew with "bread" by growing a crop of wheat—a very good prospective grain crop for the future Biological Life Support Systems in weightlessness.

Some wheat experiments were being conducted in various Russian facilities onboard Mir, but again, plants were less healthy than those grown in control groups on the ground. Super-Dwarf wheat was grown in the Russian Svetoblock-M equipment for 167 days during 1991.⁴ When plants were harvested at the "boot" stage (each surrounded by a leaf, the head not yet visible),



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The SVET Space Greenhouse, with lettuce growing in the plant chamber and the control box at right.

they were only 13-cm high and had only one tiller. There were no seeds gathered (nor were there any in the control experiment on Earth), because of the poor light conditions. Some space plants matured under somewhat higher light, after return to Earth laboratories (28 seeds produced). However, the only head formed during the spaceflight turned out to be sterile.

First 'Space' Vegetables Grown in the SVET

The first SVET Space Greenhouse was created in order to grow plants under the long-term spaceflight conditions of the Mir environment (see photo, this page). The equipment was mounted inside the Krystal module, docked to the Mir, on June 10, 1990. In the same year, the first successful two-month vegetable plant space experiment was conducted. SVET was the only automated facility for such experiments onboard the Mir, and was used until Mir's plunge into the Pacific Ocean in March 2001. It was used to accommodate a series of plant space experiments (a total of 680 days) named "Greenhouse" during different scientific programs in the period 1990-2000 (see table, this page).

The SVET Space Greenhouse has a 1,000 square-centimeter growing area, and can accommodate mature plants up to 40 cm.⁵ The plant chamber is well lit by fluorescent lamps and has two wide windows (the front one is transparent) for seed sowing, observation, and sample taking by the crew. The root module is divided into two equal sections and is filled with the substrate baltanine, which is a natural zeolite that is enriched with mineral salts in order to sustain several consecutive crop cycles. (This is an original Bulgarian technology.) This module is changeable, mounted on rails like a drawer. The substrate moisture is controlled precise-

MAIN PLANT EXPERIMENTS CARRIED OUT IN THE SVET SPACE GREENHOUSE ONBOARD THE MIR ORBITAL STATION (1990-2000)

Experiment	Year	Start-End	Days	Plant variety
1. GH 1	1990	June 16 - Aug.8	54	Radishes, chinese cabbage
2. GH 2a	1995	Aug. 10 - Nov. 9	90	Wheat, super dwarf
3. GH 2b-I	1996	Aug. 5 - Dec. 6	123	Wheat, super dwarf
4. GH 2b-II	1996-1997	Dec. 6 - Jan. 17	42	Wheat, super dwarf
5. GH 3	1997	May 31 - Sept. 30	115	Mustard (<i>Brassica rapa</i>) (3 experiments)
6. GH 4	1998-1999	Nov. 18 - Feb. 26	100	Wheat, <i>Apogee</i>
7. GH 5	1999	March 9 - Aug. 17	130	Wheat, <i>Apogee</i> (2nd generation)
8. GH 6	2000	May 15 - June 26	4	Lettuce crops (<i>genus Brassica</i>)

Total days: 680



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Radish plant sampling in the SVET Space Greenhouse.

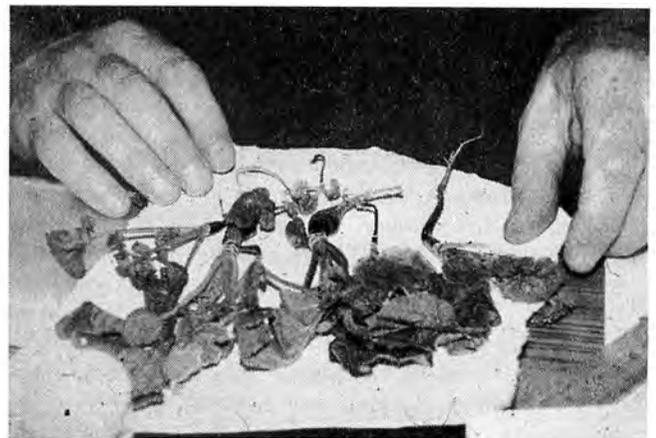
ly at a desirable level by sensors, valves, and a water pump, and the necessary oxygen is supplied to the root area.

The controller collects the environmental data from both the shoot and root zone and provides automatic control using actuators (lamps, ventilator, pump, and compressor). On June 16, 1990, Russian cosmonauts Alexander Balandin and Anatoli Solovyov, started the first long-term, 54-day plant experiments called "Greenhouse 1" with vegetables—white-topped red radishes and chinese cabbage (*Khibinskaya*). They were carried out in the SVET Space Greenhouse during the Russian-Bulgarian biological program, June-August 1990.

When fresh plant samples were returned to Earth for investigation, they were normally developed, although small sized. For the first time, we had grown a radish root crop under microgravity, but they were three times smaller than the control group grown on the ground. The considerably large difference (4 to 8 times) in biomass for plants grown under space and Earth conditions showed that the space plants were exposed to significant moisture and nutrient stress. The balance between the optimal air and water content in the plant root media was disturbed; obviously, it was necessary to work on this problem for future experiments.

In any case, this first experiment was an indisputable success and proved the efficiency of the Bulgarian research equipment and biotechnology in space. Unfortunately, after this hopeful experiment, experiments in the SVET Space Greenhouse came to a standstill for almost five years. It turned out that Russia did not have enough funds to use all of the capacity of its orbital laboratory, and a number of important programs were simply given up.

In this critical situation, the question was whether this space



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Freshly gathered radish plant samples, wrapped in wet filter paper, were delivered to Earth by the crew in August 1990.

station itself would be given up as well. NASA's interest in this long-standing, habitable space object saved the Mir Orbital Station. The Americans did not have their own space station, in which to conduct long-term experiments. After U.S. Presidents George Bush and Bill Clinton reduced the budget for space research and for the Freedom Space Station, the American scientists directed their attention to the Russian capabilities.

In 1993, Vice President Al Gore and Russian Premier Viktor Chernomyrdin signed an agreement to conduct joint space research using the hardware complex available onboard the Mir. An American-Russian-Bulgarian agreement was signed in Moscow in April 1994 to carry out long-term experiments within the framework of the Mir-NASA program in the SVET Space Greenhouse during 1995-1997. The fundamental biological task was to grow wheat through a complete seed-to-seed life cycle onboard the Mir, with the participation of American astronauts and by the good offices of the repeated flights and capabilities of the Space Shuttle and the Russian cargo missions.

The Struggle for 'Space'-Produced Seeds

According to the agreements, an American Gas Exchange Measurement System (GEMS) was developed for additional environment monitoring, at the Space Dynamic Laboratory of Utah State University, under the leadership of Gail Bingham. GEMS was added to the existing SVET Space Greenhouse in 1995.⁶

Two separate transparent bags were placed above the plants, one over each of the two root module sections, enclosing the plant chamber volume, so as to allow local gas exchange and leaf environment measurement. GEMS provided four infrared, high-precision gas analyzers measuring the absolute and differential carbon dioxide and water vapor levels in the air entering and exiting each bag, as well as the absolute and differential pressures of the measured gases. These were necessary to evaluate the photosynthesis, respiration, and transpiration of the plants. Cabin pressure and oxygen levels were also measured. A laptop computer collected all the environment data on a disk, and brought these data to Earth at the end of the mission.

The SVET system provides one substrate moisture sensor per each root module section, which is enough for the measurement and control of the substrate moisture levels. GEMS sup-

plements these with 16 additional substrate moisture level sensors (8 per module), to monitor the water distribution in the whole substrate volume. The additional sensors were designed to be integrated in the existing Bulgarian root module in flight.

A series of long-duration plant experiments was conducted in the SVET-GEMS complex during 1995-1997. The first attempt to grow Super Dwarf wheat in this complex was made in 1995 as a part of the Mir-Shuttle program. The Principal Investigator was Frank Salisbury, from Utah State University.⁷

In the 90-day experiment "Greenhouse 2a," low light intensity and other technical problems strongly disturbed the ontogenetic cycle of the wheat plants; they stayed alive but were mostly vegetative.⁸ A new, modified piece of equipment—SVET-2, with optimized units, developed by Bulgarian scientists, was launched to Mir in 1996, (supported by NASA). The new light unit with 2.5 times higher lamp intensity, and all the other units, functioned well, and no hardware problems were encountered until 2000.

The Super Dwarf wheat experiment "Greenhouse 2b" was repeated by the same investigators in the new SVET-2-GEMS complex in 1996.⁹ The "Greenhouse 2b" experiment was conducted in two stages, of 123 days and 42 days. During the first stage, the aim was to grow wheat during a full seed-to-seed life cycle. Although 297 perfect looking wheat heads developed in the growing area, all the heads were sterile, with development stopped at the pollen development stage. Ground studies proved that ethylene, which was measured as 1 to 2 ppm in Mir's cabin atmosphere, induced male sterility in the wheat plants.¹⁰

New wheat seeds were planted during the second experiment stage. The leaf bags were installed and for the first time, successful transpiration and photosynthesis measurements were carried out for 12 days using the GEMS equipment.¹¹ GEMS demonstrated that open gas exchange measurements are possible in space. The green plants were frozen and returned to Earth for biochemical analysis.



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A discussion of the American-Russian-Bulgarian agreement for utilization of the SVET Space Greenhouse in April 1993, in Moscow. From left: the author; Dr. G. Meleshko, from the Institute for Biomedical Problems in Moscow; and Dr. Gail Bingham, from the Space Dynamics Lab of Utah State University.

A mustard plant species, *Brassica rapa*, with a very short life cycle, was used in the next seed-to-seed experiment, Greenhouse 3, carried out in SVET-2-GEMS equipment in 1997. The Principle Investigator was Mary Musgrave, from Louisiana State University.¹²

The collision of Mir with the Progress supply ship on June 25, 1997, caused a loss of power to the SVET-2 Space Greenhouse, as well as a lowering of the temperatures and changing of the atmospheric pressure and composition on Mir. American astronaut Michael Foale saved the experiments, by supplying them with power from the main core module of Mir to SVET by a cord. The first successful seed-to-seed full plant cycle in space was completed. For the first time, "space" seeds (produced in space), were planted again, germinated, and one normal plant was developed. A series of three experiments was completed during the 122-day opportunity on the Mir.

But the struggle of the scientists was to grow wheat seeds, and they knew that only one step was left for success. American scientist Bruce Bugbee, also from Utah State University, proposed using another wheat variety, called Apogee, because it is resistant to high ethylene concentrations.

The wheat plant experiments continued in 1998-1999. The "Greenhouse 4 and 5" experiments were carried out by Russian cosmonauts (mostly by Sergei Avdeev), in the Russian Scientific Program. In the "Greenhouse 4" experiment, 12 Apogee plants produced a total of 508 seeds. Dry-matter samples were taken, and most of the seeds were returned to Earth.

In the "Greenhouse 5" experiment, 10 of the space-produced seeds were planted, and one of them produced second generation space seeds. All the seeds developed during the Greenhouse 4 and 5 experiments were normal. They were planted on Earth, germinated, and produced healthy green plants.¹³

The last experiment in the SVET-2, "Greenhouse 6," was carried out in May-June 2000. Seeds of four different species of lettuce crops, genus *Brassica*, were planted by the last Mir space crew and grew normally. The plants were chosen for their short vegetation cycle. Samples of each plant were brought back to Earth, while, for the first time, the rest were tasted with pleasure by cosmonauts Sergei Zalyotin and Alexander Kalery "to evaluate the flavor qualities of the received plant production."

Basic Scientific Results on the Mir

There were more than 400 experiments on Mir during its 15 years in orbit, and the "Greenhouse" experiments are considered to be among the most important and successful. Unique results were obtained during the biological flight experiments in the SVET-GEMS complex in the field of fundamental gravitational biology. Reiteration of the seed-to-seed cycle was achieved, and the environmental variables in a human space habitat that have an impact on plant growth and development under microgravity were determined.

The successful *Brassica rapa* and Apogee wheat experiments proved that the lack of gravity was not an obstacle for normal plant development in space. The impact of microgravity as a stress operator on the second- and third-generation space-produced seeds, in respect to normal plant sizes and yields, can be seen on a cellular level. The scientific results obtained during the experiments answered a number of questions concerning plant growth under microgravity:



IBMP

Russian cosmonaut S. Avdeev enjoys his job, monitoring the maturation of wheat plants in the SVET Space Greenhouse aboard the Mir, in 1999.

- Light completely replaces the gravity vector and plants turn towards the light as they sprout. The plants which are in the middle of the sowing area turn upwards while the others turn to the side, because of the reflecting surface (mylar) put on the walls inside of the chamber.

- Seeds must be preliminarily oriented before sowing, because if the root begins to grow towards the light, the plant will die.

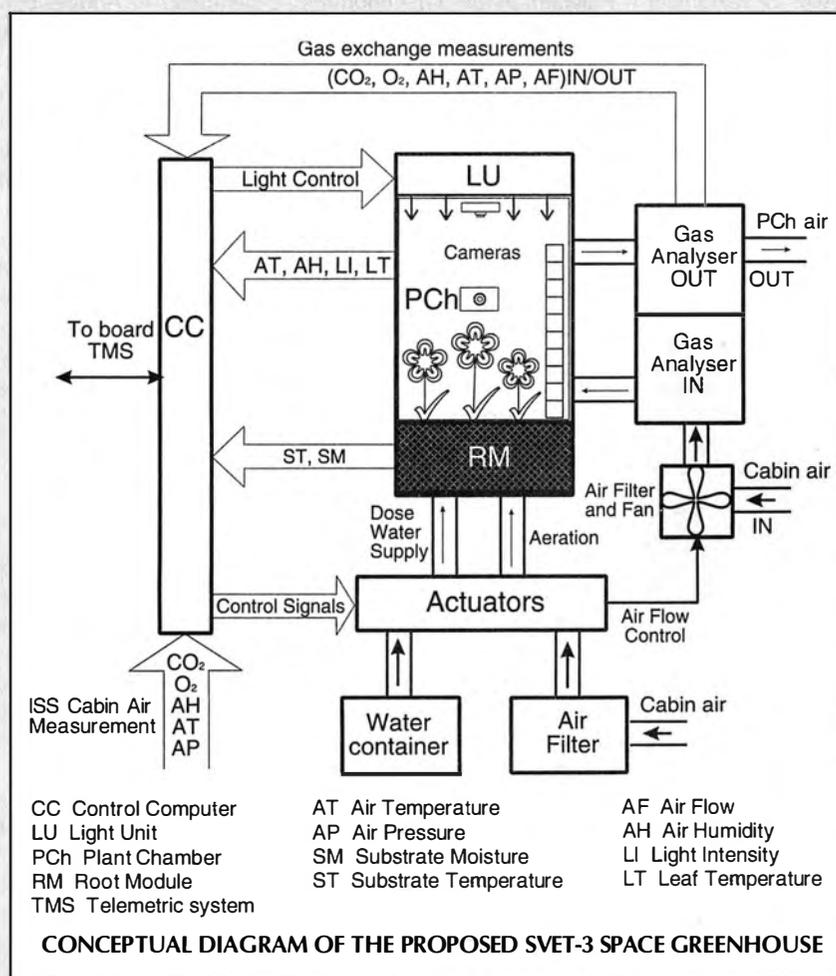
- The roots fill up the entire substrate volume and they are oriented not to the gravity vector but to substrate areas containing more nutrients and moisture.

- The nutrients flow towards the tuber, not because of gravity, but because of capillary osmosis (seen in radishes grown in 1990).

- The space plants take the same time to flower and produce seeds in microgravity as they do under normal gravity conditions.

The researches conducted in this facility brought the scientists nearer to the possibility of growing plants for food in space. They proved the feasibility of Biological Life Support Systems development, if appropriate equipment is designed. The biological results obtained during the "Greenhouse" experiments

The Proposed SVET-3 Greenhouse for ISS



The main units of the new Space Greenhouse concept, are the light unit (LU), plant chamber (PU), root module (RM), gas analyzers, actuators and control computer (CC).* The plant chamber has a plant growing area of at least 1,000 square centimeters. The environment within the Plant Chamber is partitioned off from the ISS cabin atmosphere.

The plant chamber provides a growing volume sufficient for economically important plant species. It can accommodate plants up to a height of at least 35 cm, and provides on-orbit access to the plant material for taking samples at different stages of development. A semi-transparent front window allows visual observation of the plants' status.

Two digital cameras photograph the plants from above and from the side, in order to evaluate the total leaf area. The cameras record the process of plant growth and development and downlink data via the telemetry system. Processing the data, scientists will obtain qualitative information about the state of the plants so as to understand and evaluate the experiment.

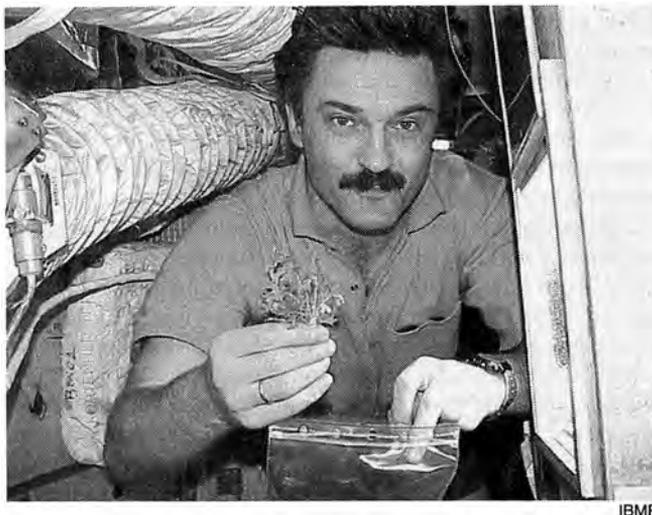
The light unit (LU) provides white light using fluorescent lamps with a spectrum concentrated in the red and blue spectral regions, as required for normal plant growth. The lamps are enclosed in pro-

suggest that the space biotechnology used is suitable for microgravity conditions and should be developed in the future.

Future Space Greenhouse Concept for The International Space Station

The International Space Station (ISS) will provide a perfect opportunity for conducting full life-cycle plant experiments in microgravity during the next 15 to 20 years. A number of plant growth facilities for scientific research, some of them based on the SVET Space Greenhouse's functional principles, are being developed by almost all advanced space countries.

Most of these facilities provide a fair level of environmental control to maintain defined environmental parameters considered adequate for normal plant growth. The first plant growth facility to support commercial plant experiments, already launched onboard the ISS in 2001, is called Advanced Astroculture (ADVASC), developed at the Wisconsin Center for Space Automation and Robotics.¹⁴ It is configured as a double Mid-deck Locker; it has a closed plant chamber with approximately half the SVET Space Greenhouse growing area, and a height of 34 cm.



Russian cosmonaut A. Kalery takes a plant sample during the "Greenhouse 6" experiment, carried out in the SVET-2 Space Greenhouse in 2000.

tective hermetic bodies. They are mounted outside of the Plant Chamber, in order to provide separate cooling. The light intensity level can be regulated from 0 to 500 $\mu\text{mol}/\text{m}^2/\text{sec}$ photosynthetic photon flux (PPF) in steps, and the light period can vary from 0 to 24 hours with increments of 1 hour.

The root module uses a substrate matrix of about 1 to 1.5-millimeter particle size as a medium for plant root development. The substrate moisture level in the nutrient matrix is measured by three sensors, located near the water source, in the most distant region, and in the middle. The dose water supply control system maintains the moisture automatically in the range of 5 percent to 95 percent by actuators—a pump injecting water portions through valves, and porous tubes into the substrate.

Aeration by a compressor ensures effective gas exchange (oxygen) in the root zone. The environmental parameters within the plant chamber, air temperature (AT), and humidity (AH), light intensity (LI), carbon dioxide and oxygen concentrations, are measured and registered. A fan maintains the air humidity and carbon dioxide concentrations, by controlling the rate of airflow entering the plant chamber from the cabin. An air filter removes the gaseous contaminants (including ethylene) from the ISS cabin air.

Two high-precision infrared gas analyzers (GA) are connected to the plant chamber inlet and outlet. The cabin airflow passes through a filter and is delivered to the GA inlet by a fan. Carbon dioxide, oxygen, water, humidity, temperature, air pressure, and air flow-rate parameters are measured in real time in the gas analyzer. The ISS cabin air parameters are currently measured by a different sensor system.

The airflow entering the chamber is distributed in the plant leaf area. After gas exchange caused by the plants' physiological processes, the air leaves the chamber, and enters the GA outlet, where the same parameters are measured. The water recovery system and ethylene scrubber (not shown in the figure) are available to clean the air outflow before entering the cabin.

The well-known method for photosynthesis evaluation by

carbon dioxide assimilation measurement is described above, but we are working on the question of how another one could be used. Different pigments, the most important of which is chlorophyll, absorb light—the energy that drives photosynthetic reactions. However, not all of the light absorbed is used in photosynthesis. Part of it is converted into heat, and another part is re-emitted as light—fluorescence—with a higher wavelength than the absorbed light. Most of the fluorescence is emitted by chlorophyll.

If conditions are unfavorable, leaf chlorophyll content will begin to decrease. By measuring leaf chlorophyll content, the photosynthetic rate can be evaluated, and from that, the physiological status of plants.

Leaf temperature, leaf area, and plant height are also measured. Having all these data, the computer calculates transpiration and photosynthesis, evaluates the state of the plants, and carries out adaptive control of both the root and shoot environments. The control computer collects and records sensor data, calculates plant parameters, and, as needed, changes adaptively the main controlling procedures in order to operate the actuators to provide the environment that the plants need. The control computer is connected to the ISS telemetry system, which downlinks data and carries out feedback control from Earth.

An LCD display and a keyboard give the crew the possibility of communicating with the greenhouse. An autonomous (manual) mode for control of each actuator is also provided for the experiment. The basic system is open for further modifications and extensions, depending on the experimental requirements. The proposed concept is feasible and can be used in the Brazilian Space Greenhouse project for ISS, if financial support is provided.

Notes

- * P. Kostov, T. Ivanova, I. Dandolov, S. Sapunova, and I. Ilieva, 2001. "Adaptive Environmental Control for Optimal Results during Plant Microgravity Experiments." 52nd International Astronautical Congress, 1-5 Oct. 2001, Toulouse, France, Rep. IAF/IAA-01-G.4.04.

The principal ADVASC systems maintain constant parameters of the plant chamber environment, and full substrate wetting, ethylene removal, and water recovery. Light in the red and blue spectrum is provided using light emitting diodes (LEDs). Seed pods grown in this facility in the first 8-week plant experiment with *Arabidopsis thaliana*, conducted during May-July in 2001, were returned to Earth with seeds.

Our former partners in the Russian Institute for Biomedical Problems, and Utah State University in America, developed the LADA plant growth facility, with the same infrastructure, and based on the same functional principles as the SVET, for the Russian Service Module onboard the ISS. LADA has two growth chambers with a smaller volume, one quarter the size of SVET,¹⁵

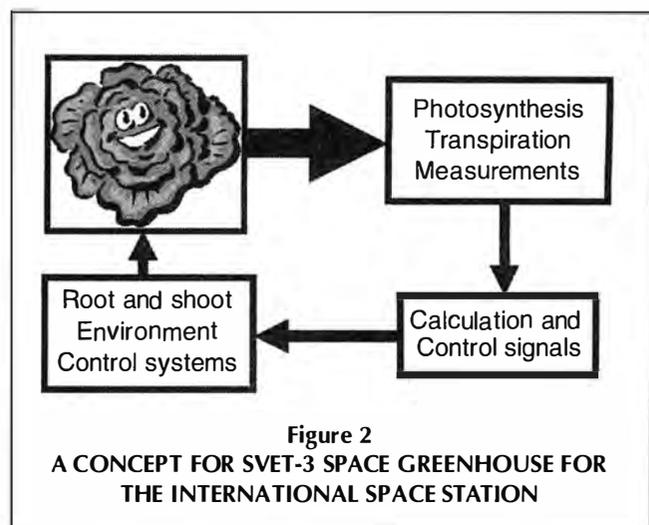
The achievements reached during the SVET Greenhouse experiments, as well as the photosynthesis and transpiration measurements made by the American GEMS equipment, encouraged the Bulgarian researchers to continue working on the SVET Space Greenhouse project. The next step is to create a fully automatic space greenhouse that can measure plant growth-physiological parameters during the entire plant life cycle, and can change the period of lighting, the water content in the root module, and the rate of gas-exchange between the plant chamber and the cabin air, depending on the requirements for these parameters. The goal is to maintain "non-stop" optimal conditions for plant growth, because plants are very sensitive to any change in the environment.

Plants do not have a developed nervous system and thus adapt to the extreme space conditions with much more difficulty than can man and animals. They react to unfavorable environmental conditions with "stress," stoppage of growth, and even death. Early signs of stress are invisible to the naked eye, and by the time these signs become visible, plants may already be too damaged to be saved. Crops need to be monitored to determine if they are healthy.

On Earth, crops can be monitored frequently to ascertain how they are growing, but in space, astronauts have too many different duties to be able to do this, and the crops must be monitored automatically. Photosynthesis and transpiration are important plant processes whose normal rate can be affected by unfavorable environmental conditions. By measuring these processes as well as the environmental variables, and by knowing how they affect plant physiological parameters, researchers will receive the feedback to provide a "stressless" growth environment for the plants.

Photosynthesis is the most important process in green plants, and is, therefore, an excellent indicator of the physiological state of plants. Photosynthesis is the process in which plants absorb carbon dioxide and water, and by aid of light, convert them into organic compounds, with oxygen as a waste product. A classical method to evaluate photosynthesis is to measure the carbon dioxide assimilation of plants, which requires a partial enclosure of the system.

Plants regulate their temperature by evaporation of water from the plant shoot zone, a process called transpiration. Rates of transpiration increase with temperature. Leaf temperature could be measured to take account of water stress in plant. The correlation between leaf temperature and water stress is based on the assumption that as a crop transpires, the water evaporated cools the leaves below the air temperature.



As the crop becomes water stressed, transpiration will decrease, and the leaf temperature will increase. The American GEMS equipment was designed to use both methods, and its effectiveness was proven during the 12-day measurements in the SVET-GEMS complex in 1997. But the measurement data obtained were stored for further analysis on Earth, and not used at the time for evaluation of the photosynthesis rate, which would have enabled the researchers to change the growth conditions in real time through feedback.

The new concept for an advanced SVET-3 Space Greenhouse for the ISS, based on the Bulgarian experience and know-how, as well as international experience, is shown in Figure 2. The absolute and differential air plant chamber parameters and some plant physiological parameters are measured and processed in real time. On the bases of the photosynthesis and transpiration measurement data, the necessary calculations are made and the plant status is evaluated.

As a result, adequate controlling signals are applied to the root and shoot environment control systems in order to provide the most favorable conditions for plant growth at every stage of plant development. The plant chamber parameters, optimized autonomously, provide "stressless" plant growth, in order to obtain optimal results from the microgravity experiments. This feedback concept for adaptive environmental control is new; it differs from the SVET-GEMS on Mir (only passive parameters were monitored) and ADVASC on ISS (constant parameters are maintained).

Food for Thought and Action

In developing space greenhouses for the ISS, scientists suffer the contradiction between their wish to enlarge the growing area so as to allow more effective experiments, and the almost non-stop reduction of funds for space research, with a view to the strained international situation and economic crises.

ADVASC, the first ISS greenhouse, does not allow observation of the plants growing in the chamber. There is only a miniature video camera, which records, in shadowy violet color (a combination of the red and blue LEDs), what is going on inside with the plants. Because the systems that maintain the environmental parameters at fixed levels fill the limited chamber volume, only

a very small space is left for the plants. The plant air volume could be enlarged, but only at the expense of the other systems.

The astronauts like the experiments very much, and take real pleasure in taking care of the growing plants. During our Greenhouse series of experiments on Mir, instead of watching over the plants once every five days, as prescribed in the instructions, astronauts "floated" to the greenhouse at least five times a day to enjoy the growing plants.

In an interview with astronaut Michael Foale, who worked with the SVET Space Greenhouse in 1997, *21st Century* Associate Editor Marsha Freeman asked him if he "would consider taking plants on long duration missions just to take care of them, and not as subjects for experiments."¹⁶ The answer was categorical:

Yes, very much so. I think, just like we have house plants for no reason but for their being there, I think exactly the same—in fact, more so—would we value having Earth plants in space, for no reason but that they're pretty, or that they're a reminder of Earth. It's something to follow. They grow, they flower.

The chamber of a future ISS greenhouse should be large enough to accommodate more experimental plants and should be well illuminated, using white light with characteristics similar to normal sunlight. It should also be visually open, allowing easy access by the astronauts attending on the plants; there should be a large window, as the psychological effect of viewing the plants should not be underestimated.

Plant species resistant to the extreme ISS conditions have to be selected in advance, based on Earth investigations. For example, if the Apogee variety of wheat used in 1998-1999, which is resistant to the high ethylene concentrations in the Mir environment, had been chosen earlier for the 1996-1997 plant experiments, the failure of the months-long, high-cost Super Dwarf wheat experiments could have been avoided.

We recommend using leaf crops with rich biomass and a short vegetation cycle, which grow well in high cabin temperatures (25 to 28°C), and low lighting (because of the limits on energy available). Their rich biomass may meet the crew's needs for fresh food, and they could be used to clear the cabin air by absorbing carbon dioxide. And, not least of all, their luxuriant green mass would delight the astronauts' eyes through the transparent chamber wall as "a reminder of Earth."

The possibilities of long-term manned missions have been continuously increased in recent years. Astronauts from all over the world have stayed for long times in space on board the Mir and International Space Station. A fifth Expedition crew is working successfully on the ISS now, and new crews will stay on the station an average of three months. The experience of these station missions will serve the long-term purpose of mankind—expeditions to Mars and the other planets. That is why providing crews with food is a central problem at present.

As a result of the international experiments in the Bulgarian SVET Space Greenhouse facility, half the way from growing wheat seeds to making "space" bread has already been travelled. The experience gained will help to improve the technology for growing plants in space in the future. But there is still much to be done before habitable bases on the Moon, still in our dreams, become a reality.

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Acknowledgements

The author acknowledges the assistance of the scientific team from the Space Biotechnology Department, Space Research Institute of the Bulgarian Academy of Sciences, which developed the SVET Space Greenhouse: research fellows Plamen Kostov, Ivan Dandolov, and Svetlana Sapunova, as well as Ph.D. student Iliana Ilieva, in preparing this paper. The author also acknowledges the successful collaboration with the Institute for Biomedical Problems in Russia, the Space Development Laboratory at Utah State University, and the Mir crew members who carried out the experiments with SVET Space Greenhouse.

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100th Extrasolar Planet Candidate Found

by Marsha Freeman

An exciting milestone in astronomy was reached on July 1, 2002, when the discovery of the possible 100th extrasolar planet was posted on the Internet web site of the Extrasolar Planets Encyclopedia. But there was no press conference, no big announcement. The discovery of planets around stars outside our Solar System has become so commonplace over the past few months, that no one made much of a fuss.

Until 1995, no one had collected precise enough data to indicate, with a high degree of confidence, that there were extrasolar planets, although most astronomers thought they surely should exist. It was not that scientists had not looked for such cousins to our planetary system before. But such small bodies, so far away from Earth's observing instruments, and so relatively close to their stars, could not (and still cannot) be imaged.

Other, more imaginative, techniques had to be created to discern the existence of planets around other stars. These methods are based upon the *indirect* observation of such planets through their effect on their host stars. One such method, which has proven the most productive in the search, measures the shift in the frequency in the light of a star, as its motion (toward or away from the observer) changes—a Doppler shift. It is inferred that this change in radial velocity of the star, or wobble, is caused by the gravitational effect of a planet orbiting around it. (Jupiter produces such a measurable effect on the Sun).

Other methods have been developed to find extrasolar planets.¹ The transit method measures differences in the light emitted by a star, using these photometric observations to detect an extrasolar planet as it transits across the face of its star, blocking out a small portion of the star's light. So far, one extrasolar planet has been confirmed through this second planet-hunting method, which can only be used to detect such planetary transits



Lynette Cook/NASA

More than 100 extrasolar planets, most larger than Jupiter, have now been identified. This artist's concept depicts such a planet orbiting the star 55 Cancri. A possible moon of the planet is shown, although none has been detected, but astronomers think such moons would be common around this type of planet.

when the orbital plane of the extrasolar planet brings it between the Earth observer and the star. Or, the planetary plane must be "edge on" when viewed from Earth.

The more than 100 reported objects so far (the 101st was reported eight days after the 100th) are considered "candidates" because their status may change as more data are acquired. Some may be reclassified as brown dwarfs, or failed stars, and be part of a binary star system, for example. The measurements are so difficult, and rely upon such small-scale effects, that some candidates may not hold up to further scrutiny.

But the cataloguing of the 100th object thought to be an extrasolar planet is an impressive milestone, which was reached in only seven years. Two years ago, there were only 28 extrasolar planet candidate objects. More than a dozen new ones were announced in the month of June 2002 alone, and scientists expect the pace of new discoveries to quicken in the near future.

The major reason for this burst of discoveries is that astronomers prefer to observe the effect of a proposed planet around a star for one full period of its revolution, to give greater confidence to the observations. So far, mainly large planets close in to their stars have been discovered, because they complete a full revolution in a relatively short period of time, and have the greatest gravitational effect on the star.

According to the scientists involved in this research, there are numerous candidate objects that they have been tracking for years which are as far from their stars as Jupiter is from the Sun. This means it will take more than 10 years to observe the object's full trip around its star. And because observations began more than a decade ago, many of those objects will be ready to be revealed relatively soon.

More sophisticated and new techniques are already leading to cascades of extrasolar planet announcements. In addition, looking for other clues to plan-

et formation are enriching this new field of astronomy, which eventually will reveal if there are any other Earths.

Putting Jupiter in Its Place

The first extrasolar planets found were multiples of the mass of Jupiter, orbiting close to their stars (some as close as at the distance of Mercury from the Sun, in our Solar System), many in highly elliptical orbits. It is assumed that these are gas giants like Jupiter, with little expectation that the conditions for the development of life would be present.

On June 13, 2002, Drs. Geoffrey Marcy and Paul Butler, members of the team of scientists that has found half of the extrasolar planets thus far, announced at a press conference at NASA headquarters, that they had discovered 15 additional extrasolar planets, including the smallest one ever found, which is 40 times the mass of Saturn. They also announced the discovery of the first Jupiter-class planet at an orbital distance similar to that of Jupiter (Figure 1).

This "Jupiter cousin" revolves around the star 55 Cancri and is the second planet to be found there. It is approximately four times the mass of Jupiter, and is orbiting its star at a distance of 5.5 A.U. (an A.U., or Astronomical Unit, is the distance between the Earth and the Sun, about 93 million miles), taking 13 Earth years to complete one revolution, compared to 11.86 years for Jupiter, at 5.2 A.U.

As exciting as the discovery of any extrasolar planet would be, the objective is both to find other solar systems, in order to have a sample of more than one system to help understand the process of planet formation, and to locate terrestrial planets with the characteristics of Earth, which would enable the development of life.

The large, close-in, Jupiter-like planets that were found first, it has been believed, would be formed farther away from the star in the protoplanetary disk of material "left over" from star formation. At some point, these planets would "migrate" in toward the star. In so doing, they would sweep away any forming or existing smaller planet, such as one similar to Earth.

The new planet that Marcy and Butler found orbiting 55 Cancri, has at least one Jupiter-sized companion planet very close in to the star, which indicates that even if gas giants did form and migrate inwards, there was still enough material in the outer protoplanetary disk to form at least one more planet, such as the one they recently verified. If so, perhaps other, smaller planets also formed after the gas giant's inward migration, and perhaps these still exist.

At the June 13 press conference, Dr. Marcy conjectured that perhaps the gas giants formed first, and that as they slowly migrated inward, "trailing behind was protoplanetary disk material that could

form other planets."

These findings led to more questions, of course, than answers. Why would some gas giants stop migrating, rather than just collapsing into the star? How could the process of planet formation be spread out over time? How much material is in the protoplanetary disk to begin with? And what dynamic process determines which kind of planets will form, and where?

As it turned out, the June 13 announcement by Marcy and Butler was the first in a slew of new discoveries, announced the next week at a conference on "Scientific Frontiers in Research In Extrasolar Planets," held at the Carnegie Institution in Washington, D.C.

Planets in the Pipeline

A European team led by Michel Mayor, which had made the first discovery of an extrasolar planet in 1995, reported at this conference that its recent observations at the Geneva Observatory in Switzerland uncovered the likely existence of 12 new planets. Eight of these were previously unknown, and three had been announced the prior week by Marcy and Butler. In the space of five days, more than 20 new planets were announced.

One new extrasolar planet, in particular, caught their attention. Orbiting star HD 1903602, the planet closely resembles Jupiter, in mass and distance from its star. In addition, there do not appear

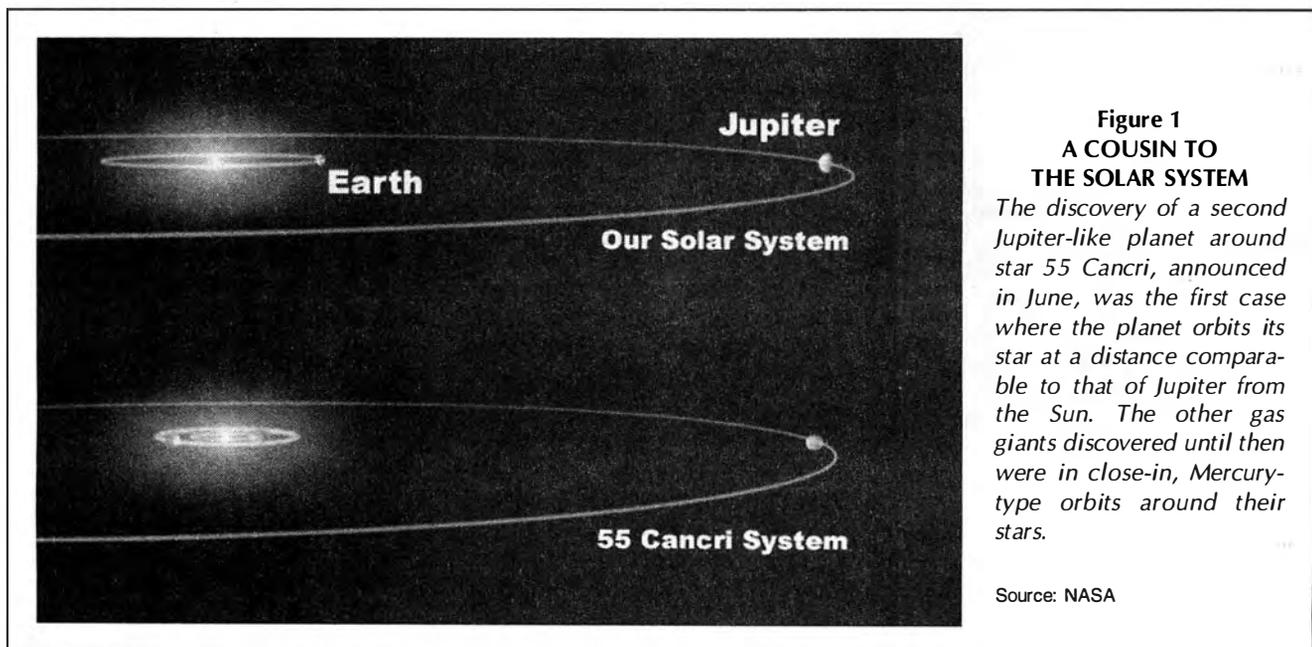


Figure 1
A COUSIN TO
THE SOLAR SYSTEM

The discovery of a second Jupiter-like planet around star 55 Cancri, announced in June, was the first case where the planet orbits its star at a distance comparable to that of Jupiter from the Sun. The other gas giants discovered until then were in close-in, Mercury-type orbits around their stars.

Source: NASA

to be any other gas giants around the star, which makes it more like our Solar System than the first Jupiter-like planet that Marcy and Butler announced.

In an interview with *space.com*, Dr. Stephane Udry, who made the announcement, explained that "there is space for terrestrial planets in the inner regions" of this faraway solar system, because of the absence of gas giants near the star. Also, its orbit is nearly circular, like Jupiter's, and not as elliptical as the earlier planet circling 55 Cancri.

At the conference, Dr. Udry cautioned that there were various "black sheep" among the planetary candidates, which would be reclassified as more data became available. Doppler-shifted changes in radial velocity, for example, could be produced by surface effects on the star, not just planetary gravitation, he explained.

Debra Fischer, another member of Marcy and Butler's team, summed up for *space.com* June 28 the new tally from the rash of recent discoveries: Included in the total of 96 planets at that time, are eight doubles (two planets around the same star), and two triples. Indicating

what will soon come, Fischer said that "statistically, about two-thirds of our 'single' planets show signs of another companion."

Asked when new planets will be announced by her group, Fischer replied, "We have planets coming down the data pipeline in a steady stream. We pluck them out as soon as they complete one orbit, add them on the pile of known planets, and then keep searching for additional sibling planets around that same star."

"Perusing our database, it appears that we will continue to find anywhere from one dozen to a few dozen planets per year for several more years," she stated. Dr. Udry indicated that the European team will likely announce more extrasolar solar plants before the end of this year.

Not only more extrasolar planets, but smaller and more Earth-like ones, will come into view, as new technologies become available.

'Seeing' Planets in Formation

Since early this year, significant progress has been reported using the transit method of planet detection, where

astronomers look for the light of a star to diminish with a predictable frequency, because of a planet transiting across the star's face, as it orbits around it.

In February 2002, the European Optical Gravitational Lensing Experiment team announced 42 possible extrasolar planet candidates among the millions of stars it monitors. In June, scientists at Princeton University said their Extra-Solar Planet Occultation Research project had identified up to four candidates in a survey of 38,000 stars. Researchers expect that some of these candidates will turn out to be planets.

During the mid-June extrasolar planet conference held in Washington, a report of a transit, or partial eclipse, around star KH 15D promised for the first time to reveal the process of planet formation around a star. The international team of scientists explained that KH 15D is a young star, residing in the "Cone Nebula" which is a birthing place for stars. The scientists reported that the star "winks" at them, when only a tiny fraction (about 4 percent), of the star's normal luminosity is visible.

After years of observation, the team

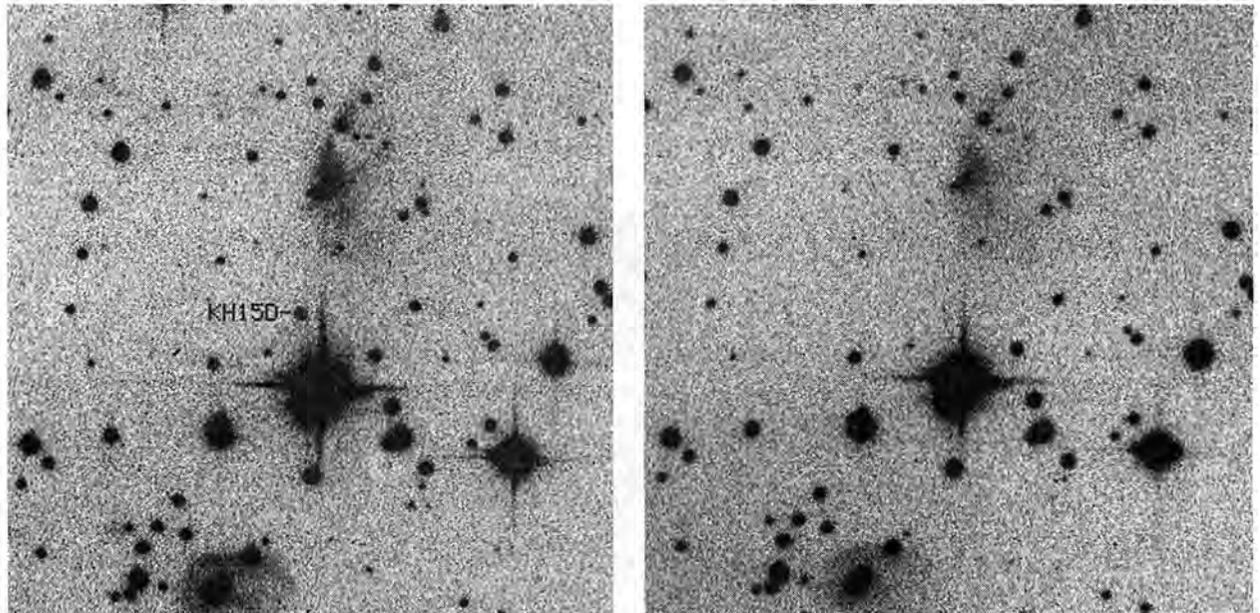


Figure 2
A STAR IN AND OUT OF ECLIPSE

In 1997, astronomers at Wesleyan University's Van Vleck Observatory discovered that star KH 15D "winked" at them, as its light radically diminished periodically. After years of global observations, the periodicity of the eclipses was revealed, which the scientists believe is caused by a disk of material that may be clumped into planetesimals, orbiting the star.

Source: Wesleyan University

An Open Letter For Support of UNSCEAR

by Zbigniew Jaworowski, M.D., Ph.D., D.Sc.

determined that the star "faded" every 48.3 days, and stayed faint for about 18 days. No solid object orbiting a star could block out its light for such long periods of time. They believe that "only a collection of smaller objects—dust grains, rocks, or perhaps asteroids orbiting together in a strung out, clumpy arc—could possibly explain such a lengthy eclipse." Such a string could produce a gravity density wave, and the drawn-out eclipsing effect the astronomers observe.

The astronomers noticed changes in the characteristics of the occultation over the past few months. If this is the result of changes inside the clump of material, it is the first time the detailed structure of a disk around a star is being observed over months and years, while it is evolving, and perhaps forming planets. In order to collect data on the star on a 24-hour basis, researchers in Uzbekistan, Israel, Germany, and several U.S. institutions contributed to the observations. Other teams of astronomers are investigating protoplanetary disk formations around other stars using both ground-based observations and the Hubble Space Telescope.

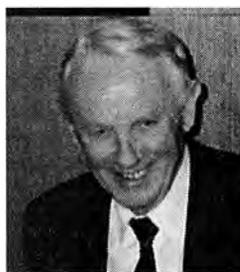
Over the next few years, it is expected that dozens more extrasolar planets will be announced, which astronomers have been monitoring already for years, using the radial velocity method. At the same time, increasingly sophisticated and sensitive ground-based telescopes, outfitted with adaptive optics that can compensate for the disturbances in the Earth's atmosphere, will extend the observational reach of scientists and enable the discovery of smaller, Saturn- and Neptune-sized planets.

Finding analogues to our terrestrial Earth is expected to require sending a new generation of instruments above the Earth's atmosphere, into space. A half dozen such projects from around the world are now being planned. We are moving closer and closer to finding the first planetary system like our own, containing at least one planet within the "habitable zone" that can support the development of life.

Notes

1. See "The Growing Evidence of Planets Beyond Our Solar System," by Marsha Freeman in the Spring 2000 issue of *21st Century* for a comprehensive review of the history and technologies employed in this field.

Dr. Zbigniew Jaworowski, of the Central Laboratory for Radiological Protection in Warsaw (jaworo@clor.waw.pl.), is the current representative of Poland to the United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR. He circulated this letter in April 2002.



A leading expert worldwide on the effects of radiation, Dr. Jaworowski is a former chairman of UNSCEAR. He is a multidisciplinary scientist, who has studied pollution with radionuclides and heavy metals.¹

Dear Friends:

I am writing this letter to ask you to help the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), critically beset by financial difficulties, which have presently restricted its activity to the extent that it is unable to convene this year to continue its scientific work.

UNSCEAR was established in 1955, as the only organization of the United Nations specifically entrusted with responsibility for compilation of scientific data on the sources of ionizing radiation, and for assessing their impact on man and environment. In recognition of the importance of this issue for the current and future health of mankind, the Committee was mandated to report directly to the General Assembly.

The Committee is composed of 21 member States (Argentina, Australia, Belgium, Brazil, Canada, China, Egypt, France, Germany, India, Indonesia, Japan, Mexico, Peru, Poland, Russia, Slovakia, Sweden, Sudan, United Kingdom, and United States of America). About 140 persons are engaged in the work of the Committee: two members of the Secretariat; about 120 members of

the national delegations including 21 representatives and about 100 advisors; and a team of about 15 consultants recruited by the Secretariat, from among the pre-eminent and internationally recognized scientific experts.

Under the guidance of the Scientific Secretary, the consultants draft scientific documents requested by the Committee for review and discussion at its annual sessions.

During the past four decades, the Committee has estimated the effects of nuclear test explosions, of civilian and military nuclear fuel cycles, of medical irradiation, of occupational radiation exposure, of nuclear accidents, and of natural radiation. The Committee has also studied the basic biological processes required to understand the mechanisms of somatic and genetic effects of radiation. The Committee developed a unique, highly effective and competent method of authoritatively reviewing original scientific information, which has been regarded as exemplary for other fields (See editorials in *Nature*, Vol. 349, p. 189; and Vol. 371, p. 269).

Several conclusions reached by the Committee have had considerable impact in the scientific community. More recently, in its 1994 *Report*, UNSCEAR for the first time officially examined the evidence for adaptive and beneficial effects of low levels of radiation. In the 2000 *Report* on the health effects of the Chernobyl catastrophe, the Committee estimated that in addition to the 30 deaths of power plant employees and firemen—apart from an increase of thyroid cancer in children—no increases have been observed in overall cancer incidence or mortality, or in the incidence of hereditary disorders, that could be attributed to ionizing radiation.

Because of the high standard and objectivity of its work, UNSCEAR became the most authoritative international scientific body in the matters of radiation. Its reports became a virtual "Bible" for all scientists working on radiation effects. Its work became one of the principal factors in developing the nuclear atmospheric test ban treaty, and has provided an objective and independent basis for developing the regulatory systems of radiation protection on international and national scales.

The United Nations General Assembly highly appreciates and endorses the work of UNSCEAR in its consecutive Annual Resolutions, including the most recent one of Feb. 27, 2001, in which it:

"Commends the United Nations Scientific Committee on the Effects of Atomic Radiation for the valuable contribution it has been making in the course of the past 45 years, since its inception, to wider knowledge and understanding of the levels, effects, and risks of ionizing radiation, and for fulfilling its original mandate with scientific authority and independence of judgment."

Until about 1994, the relatively small funds provided to UNSCEAR by the

United Nations were sufficient to maintain an adequate level of its operation. Since that date, however, the per annum allotment has been considerably decreased. For example, the allotment for consultants decreased during the past eight years from \$84,250 for the 1994-1995 period to \$13,900 in the year 2002. The allotment for travel of the Scientific Secretary was dropped from \$7,200 in 1994-1995 to \$1,500 in 2002.

In the same period, the travel expenses of the representatives were decreased by 25 to 44 percent. As a result, for the first time since its establishment in 1955, UNSCEAR was forced to postpone its 51st session, originally scheduled for May 6-10, 2002.

This budgetary situation brought forth a substantial diminution of pace of the current work of UNSCEAR, and could conceivably lead to its dissolution, with incalculable loss to world science and to the future development of the radiation protection system. This system is now beginning to apply the new understanding of biological effects of radiation, and beginning to better recognize the important role that biological responses to induced damage play in minimizing radiation effects.

According to the estimate of the UNSCEAR Secretariat, the amount needed for restarting the operation of the Committee is about \$80,000 per year. Sixteen sponsors contributing each \$5,000 a year could save the future of UNSCEAR.

I am urging you to help UNSCEAR in

two ways: (1) a long-term solution, by diplomatic efforts, and (2) by short-term fund-raising activities, which will enable the continuation of the work of the Committee over the next 2 to 3 years.

Your country, as a Member State of UNSCEAR, may suggest to the Fourth Committee of the United Nations that it act rigorously to return support for UNSCEAR to at least the 1994-1995 levels.

As a temporary solution, the Secretariat of UNSCEAR is preparing, together with UNOV Finance, a trust fund at the United Nations headquarters in New York. The prospective donors to the UNSCEAR trust fund could come forth from domains other than industry, thus maintaining the independent status of the Committee. In this vein, I am asking you to kindly provide me with a list of persons or organizations in your country that could then be approached by the UNSCEAR Secretariat for such support.

I thank you in advance for your consideration and help.

Zbigniew Jaworowski
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Radiological Protection
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Tel. (48-22) 754-4434
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Notes

1. See, for example, "Ionizing Radiation and Radioactivity in the 20th Century," and "The UNSCEAR 2000 Report: The Truth About Chernobyl Is Told," both in the Winter 2000-2001 issue of *21st Century*.

CORRECTION



The description of this painting on the back cover of the Spring 2002 issue should have included the following:

Frederic Church, *Tamaca Palms*, 1854, oil on canvas, 27 3/4 × 36 1/2 inches. In the Collection of The Corcoran Gallery of Art, Gift of William Wilson Corcoran.

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SURREY'S NANO-SATELLITES

Bringing Developing Nations Into the Space Age

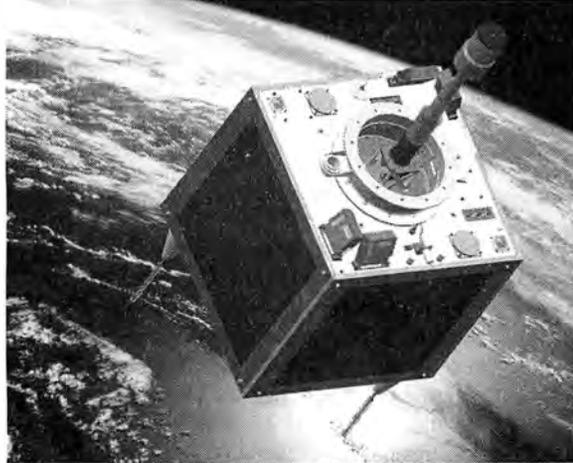
by Marsha Freeman

Many of the world's nations do not yet have extensive telephone service, or fleets of aircraft to observe their land and oceans, or adequate health care facilities, or enough educators for every town and village. Along with the deployment of the most advanced technologies in electricity generation, transportation, health care, and clean water, space capabilities can help them to leapfrog yesterday's infrastructure technology, and enter the 21st Century. But until recently, satellites and space systems, used by every industrial country for communications, education, weather forecasting, and remote sensing (and by some, for defense), were too complex and expensive to be used by many developing nations.

For the past 15 years, the University of Surrey in England has operated a satellite program to make satellites affordable, and to train the personnel needed to make use of them.

Economic development requires the introduction of revolutionary new technologies, to increase the productivity of work and the standard of living of the population. The most critical prerequisite, is the creation of a core of scientific and engineering manpower that can translate breakthroughs in science into new technologies for broadscale application.

In the 1950s, under President Eisenhower's Atoms for Peace program, dozens of developing nations were given access to small-scale nuclear fission research reactors, to create such a needed cadre of scientists and engineers. Unfortunately, the Malthusian anti-population faction internationally cut short the promise of Atoms for Peace before it could fully bring industrialization and progress



All illustrations are courtesy of Surrey Satellite Technology Limited

Surrey Satellite Technology specializes in the development of small satellites in collaboration with developing nations. Pictured here is an artist's drawing of one of five satellites in the Disaster Monitoring Constellation, now under development.

to the developing sector. But the principle remains sound, and to bring developing nations into the space age, a similar approach is needed. The Surrey satellite program provides a step in this direction.

Thinking Big About Micro-satellites

In 1978, a group of students at the University of Surrey in England began a series of experiments in microsatellite technologies. Their goal was to develop small satellites, in the range of 10 to 100 kilograms (approximately 10 to 200 pounds), costing \$3 to \$6 million each, as compared to conventional commercial satellites, which cost in the tens of millions of dollars. Low-cost satellites, they reasoned, would make space technology applications available to every nation in the world.

To reduce the cost, the satellites would be built on a standardized platform that could be virtually mass produced. The satellites would take advantage of the

microminiaturization that was fast occurring, particularly in the consumer electronics market, and use commercial off-the-shelf components. While "space nations" were designing larger and larger satellites, with ever broader capabilities (requiring larger and more expensive launch vehicles), Surrey's aim was to develop smaller and smaller satellites, each designed for a specific purpose.

Depending upon the instruments placed on the standard platform, these small satellites could be applied to communications, Earth observation and remote sensing, small-scale space science experiments, technology demonstration, and, most important, education and training.

In 1981, the first University of Surrey satellite, UoSAT-1, was launched by NASA, free of charge, on a Thor Delta rocket as a secondary payload. The UoSAT-1 microsatellite weighed 70kg (154 pounds). When the technology was proven, with the second, 1984, UoSAT mission, it was recognized that there would be a commercial market for these small, affordable satellites. So in 1985, the University formed Surrey Satellite Technology Limited (SSTL), which it owns.

Although Surrey Satellite Technology Limited has provided satellites and space technology for European and American space programs (civilian and military), the most innovative aspect of its work is to use funds from its commercial sales to involve engineers from nations that have no space programs of their own, in small satellite projects for their countries.

More than 70 foreign engineers have been trained so far through the "knowhow transfer and training program" at Surrey, and an additional 320 have graduated from the University with Master of Science degrees in related fields. These scientists and engineers then go back to their own countries, and form the core of cadre who advise their governments, and become the private entrepreneurs, to bring their nations into the space age.

To date, Surrey has built and launched microsatellites for Pakistan, South Africa, South Korea, Chile, Portugal,



Figure 1

THE DISASTER MONITORING CONSTELLATION

The five satellites in the Disaster Monitoring Constellation will be placed into orbits that are complimentary, as shown here, to increase the coverage for all of the nations participating in the project.

Thailand, Singapore, Malaysia, and China. Satellites for Turkey, Algeria, and Nigeria are under development. Engineers from those nations come to the Surrey Space Centre for training, and an engineering test model of the satellite is also constructed, and shipped to the country itself, for research and testing.

Now, Surrey Satellite Technology Limited is embarked on next-generation multi-mission satellites, satellites down to the "nano" and "pico" size, and small satellites to fly in constellations for a variety of applications.

North Africa in Space

One of the most pressing needs for space technology in developing countries is to be able to monitor the conditions that cause natural and man-made disasters—everything from monsoons and other violent weather systems, to out-of-control fires, volcanoes, floods, and other catastrophes. When such disasters cannot be prevented, timely and accurate information is needed to assess the damage and provide guidance to relief agencies. Often, because of a lack of infrastructure, these data are difficult to collect on the ground.

Surrey is now developing a project that will coordinate the data collection from five satellites, owned by five different nations, in five different Earth orbits, to form a space-based Disaster Monitoring Constellation. All five microsatellites will be launched together, on a Ukrainian Dnepr rocket.

This year, Surrey plans to launch the Disaster Monitoring Satellites into orbits

that will complement each other in terms of coverage of the Earth (see figure). Each approximately 100-kg microsatellite will be owned independently, but all will have the capability to work together. About 5 percent of the time, the data from all five satellites will be coordinated at Surrey's ground control station, to contribute to global disaster monitoring for governments and relief agencies. For most of the time, each satellite will provide data crucial to each nation's economic development.

The countries involved in the Disaster Monitoring Constellation are Algeria, Britain, China, Nigeria, and Thailand. Nigeria is also negotiating with Surrey on the Gemini project, which would be a small geostationary communications satellite.

At the 52nd Congress of the International Astronautical Federation, held in Toulouse, France, Oct. 1-5, 2001, Dr. Azzedine Oussedik and Mohammed Bekhti, from the Centre National des Techniques Spatiales in Algeria, described ALSAT-1—part of the Disaster Monitoring Constellation, and Algeria's first satellite. Algeria, with a land area of 2.5 million kilometers, they said, needs remote sensing data to monitor agriculture, land use, and pollution, as well as for cartography, to aid in the development of infrastructure, such as roads and rail networks. In addition, Algeria is concerned about the increase in desertification, because it is on the boundary of the Sahara Desert.

The Algerian researchers observed

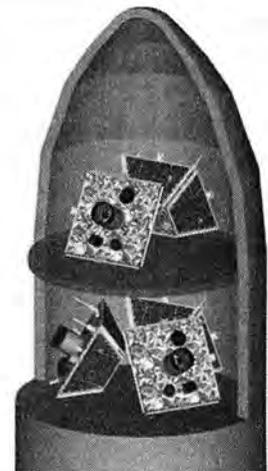


Figure 2

ARTIST'S DEPICTION OF THE FIVE SATELLITES

The five Disaster Monitoring satellites are small enough to be launched together on one rocket. They are shown here inside the payload fairing for a Russian Dnepr launch vehicle.

that "space is no longer the preserve of a few wealthy nations." Small satellite technology, which Surrey has provided, has enabled nine developing countries so far, to "take a confident first step into orbit," they said.

ALSAT-1 will image the Earth with multi-spectral cameras in three bands covering green, red, and infrared wavelengths. The green band can provide penetration in areas of deep water. Combining green with red gives excellent identification of silty water flowing into clear water. Red wavelengths penetrate the atmosphere well, and are preferred for high-contrast imagery. The near-infrared is optimal to delineate water bodies, and the combination of red and near-infrared images is useful in geological studies and differentiating soil types.

Oussedik and Bekhti explained that up to 5 percent of the mapping capacity for each of the five disaster-monitoring satellites in the constellation will contribute to monitoring disasters, such as recent floods in Mozambique. The data will be available via the Internet through Reuters Alert Net, and distributed free to relief agencies.

Through the coordination of the five spacecraft, each international partner will

also be able to view its own territory on a daily basis, thanks to the wide geographic spread of the countries that are participating. By comparison, a single remote-sensing satellite, such as Landsat, can take up to 17 days to revisit the same area of the Earth.

The Algerian participants note that a team of 11 engineers was stationed at Surrey for 15 months, during which time they were trained on all aspects of mission analysis and design, and the engineering and management of the satellite. The Algerian team carried out the construction of an engineering model, while the Surrey team built the flight model of ALSAT-1.

Based on the experience of working with Surrey Satellite Technology, Algeria is already planning its ALSAT-2 satellite. A second constellation, the researchers report, could focus on different applications, such as earthquake research.

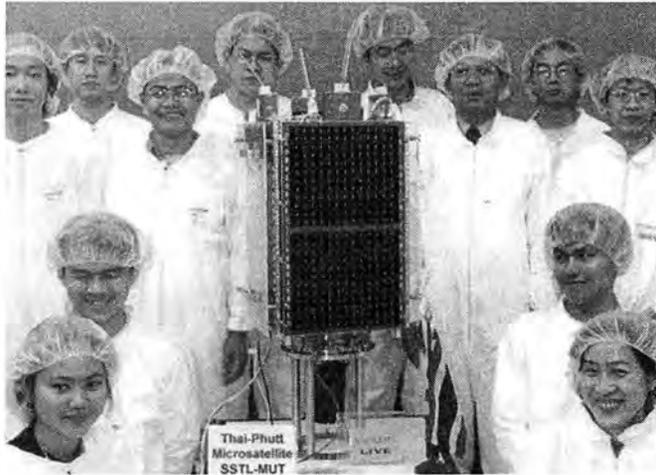
A second important application of space-based technology in developing countries is communications. Also reported at the Toulouse IAF Congress was progress in designing a small, \$12 million satellite to provide worldwide telecommunications capabilities to the North Africa countries of the Maghreb.

In another report presented at the conference, Drs. Mustapha Masmoudi, Najib Abida, and Ahmed Ben Ammar stated in their introduction that "ordinary Maghrebi citizens and experts alike have always cherished the dream of space exploration." They also noted the success of the ARABSAT satellite as one of the "rare fields where Arab countries have had any success in operating jointly."

Morocco, Tunisia, Libya, and Algeria have been discussing such a project, and at the July 2001 meeting of the Telecommunications Minister of the Maghreb, it was decided to carry out a technical feasibility study of a Maghrebi satellite project. The target date for launch would be 2005.

From Micro to Nano

On June 28, 2000, a tiny 6.5 kg (14.3 pound) satellite, designed and built by Surrey in less than one year, was suc-



The goal of the Surrey Satellite Technology programs is to educate and train a cadre of scientists and engineers from developing countries in space technology. Seen here, with their microsatellite, is the team from Thailand that trained at Surrey.

cessfully launched into orbit. SNAP, for Surrey Nano-Satellite Applications Platform, was the first nano-satellite to use an onboard propulsion system to perform orbit-changing engine firings, and an American Global Positioning Satellite system for orbital navigation.

SNAP was launched aboard a Russian Cosmos rocket, along with a Russian Nadezhda search-and-rescue satellite and China's 50 kg microsatellite, Tsinghua-1, also built by Surrey. Two seconds after SNAP was deployed, it used its "machine vision system" to take a photograph of the Russian satellite, when the two spacecraft were about 2.2 meters (8 feet) apart.



Surrey's SNAP, its first nano-satellite, is remarkable in its capabilities, given its small size.

SNAP also took a picture of Tsinghua-1 at a distance of about eight meters, or 30 feet.

After the pictures were released, Dr. Craig Underwood, chief architect of the SNAP program at Surrey explained: "One of the principal objectives of the SNAP-1 mission is to demonstrate the ability of nano-satellites to act as robotic 'eyes-in-the-sky' to allow astronauts and ground controllers to examine the outside of their space vehicles," including the International Space Station.

The SNAP nano-satellite design is well suited for mass production, making it appropriate for constellations, or "swarms" of spacecraft. These could provide multi-point measurements of specific Earth phenomena, creating a three- or multi-dimensional view. Such swarms could also be used as distributed sensors, where each nanosat forms a part of a larger "virtual" instrument, similar to an array of ground-based telescopes, through which multiple signals are combined into one.

Many military and defense applications can also be envisioned for swarms of nanosats. Two nanosat assemblies have been delivered by Surrey to the U.S. Air Force European Organization for Aerospace Research & Development.

For developing countries, and Surrey Satellite, Earth orbit is not the limit. Under development is a mini-satellite platform, in the 400-kg range, which is designed for lunar and interplanetary missions. The first application of the mini-satellite system will be a mission to the Moon. The total mission cost for the lunar orbiter is targeted for 15 million British pounds.

The primary aim of the mission is education, with students worldwide able to take part in the project via the Internet. The mission will also have the objective of imaging the south polar region of the Moon, where it is believed there are caches of water ice.

In the future, many countries will be able to participate in flights of payloads to the Moon, and their scientific return. In the process, more and more nations will join today's spacefarers, in the great project of space exploration.

PPPL CELEBRATES 50 YEARS OF FUSION RESEARCH

Putting Fusion Back on the Front Burner

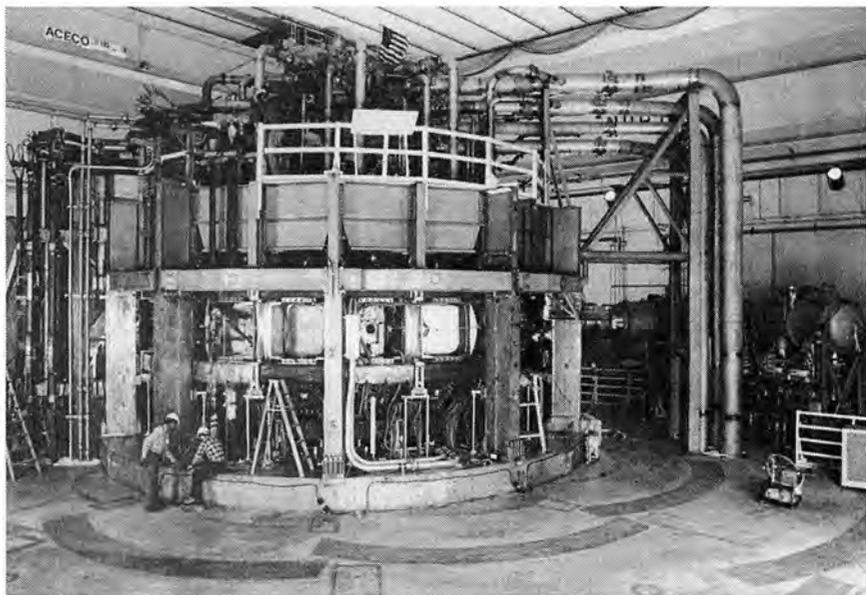
by Charles B. Stevens

Princeton Plasma Physics Laboratory, home of the largest U.S. magnetic fusion projects, celebrated half a century of fusion research June 5-7, 2002. The conference—initially planned for October 2001, but postponed because of the events of September 11—was attended by 200 or so staff members and others.

Titled “A Celebration of High Temperature Plasma Physics,” the event may well mark not only the completion of 50 years of work on fusion research at Princeton, but a new beginning for unleashing the unlimited potentials of nuclear fusion energy.

Princeton Plasma Physics Laboratory (PPPL) was initiated in 1951 as part of the secret H-bomb program. It was directed at harnessing the nuclear fusion of hydrogen in the laboratory through the use of magnetic “bottles” to insulate and confine gases at the 100-million-degree temperatures required for igniting the nuclear fusion reaction. At these temperatures, all the hydrogen atoms are ionized gas—a plasma.

The generation of magnetically confined hot plasmas in the laboratory also provides the means for studying the conditions found in both the stars and inter-



PPPL

The Tokamak Fusion Test Reactor (TFTR) was the first magnetic fusion device to demonstrate a net energy output. Here it is shown in construction in 1983.

stellar material, such as the solar wind. So, magnetic fusion research provides a unique means of also experimentally exploring astrophysics.

The Princeton conference reviewed the work of PPPL both on magnetic fusion research and astrophysical stud-

ies. The status of the alternative inertial confinement, or laser-pellet approach was also reviewed.

Fusion and Astrophysics

Among the presentations were Prof. John Bahcall on Solar Fusion and Solar Neutrinos, Prof. James Drake on Magnetic Reconnection, Prof. Robert Rosener on Magnetic Activity of the Sun and Stars, Prof. Jeremy Goodman on Unsolved Problems in Astrophysics, and Dr. Jill Dahlburn on Inertial Fusion Energy.

The highlight of the conference was the banquet presentation by Dr. Raymond Orbach, director of the Department of Energy Office of Science. Dr. Orbach reported that the U.S. government was seriously considering rejoining the international fusion project known as ITER—International Tokamak Energy Reactor. He also reported on the surprising recent development in which Japan has succeeded in overtaking the United States in the construction of large-scale comput-



DOE

The Princeton Large Torus (PLT) preceded the TFTR. Here, technicians assemble the toroidal field coils for the machine. The PLT achieved the adequate confinement, plasma density, and heating required for practical fusion.

ers. The Japanese now have a computer 50 times more powerful than any that the United States has.

Dr. Orbach noted that this is most disturbing, because the United States puts the lion's share of its R&D resources into computer science, yet the Japanese were able to overtake the United States through innovation.

There were many other ironies revealed at the conference. For example, PPPL had been founded to explore the stellarator approach to magnetic fusion. This magnetic bottle concept was invented by the first director of PPPL, Professor Lyman Spitzer. But after the development of the Russian tokamak approach in the 1960s, PPPL transformed its stellarators into tokamaks. And, in fact, the Princeton Tokamak Fusion Test Reactor was the first magnetic fusion device to demonstrate a net energy output.

At the same time, the Russians and other countries began to take up



PPPL

PPPL Director Rob Goldston (right) taking participants at the 50th anniversary celebration of the laboratory on a tour of the National Spherical Torus Experiment (NSTX).

research of the stellarator. Now, with advances in the science of magnetic plasma confinement, it appears that the stellarator may very well end up as the

best main-line magnetic confinement approach. And PPPL is participating in the design of new major stellarator experiment.

Practical Fusion Power Is a Question of Political Will

by Dr. Stephen O. Dean

Excerpted from an article in Nuclear News, July 2002.

There is little disagreement among fusion researchers that the most assured path to net fusion energy, based on currently demonstrated magnetic confinement physics, is through the tokamak path. If science were the only criterion for setting fusion policy, then the fastest way to fusion power by magnetic confinement is by following the tokamak development strategy—i.e. to build a sequence of higher performance tokamak facilities, including a demonstration power plant. Studies have shown that tokamak power plants could be competitive with other sources at some time in the future, depending on fuel availability, pricing, and environmental constraint assumptions.

A significant number of fusion researchers, however, believe that we can do better than the tokamak. The tokamak is indeed a cumbersome configuration from the viewpoint of power plant design. It is mechanically donut-shaped, which presents difficult materials damage, construction and

maintenance challenges. Most would agree that a cylindrical configuration in which all the mechanical equipment surrounds the plasma (rather than threading it, as is the case for tokamak and tokamak-like geometries) would be preferable. A number of such configurations exist, but have very modest funding. . . . A series of Innovative Confinement Concept workshops have been held during 2000-2002 to explore these concepts.

Inertial confinement fusion is receiving significant funding from the DOE's weapons program as part of its stockpile stewardship program. . . . A large laser facility, the NIF, is under construction. Congress has provided additional funds, not asked for by the DOE, to develop high average power lasers capable of pulsing several times per second, as required for power plant operations. Nevertheless, a new, major repetitively pulsed facility would still be required before an IFE power plant could be built.

Fusion research has been under way for a little more than 50 years. Some

believe that commercial fusion power is still another 50 years away. Under present U.S. government policy, there is no timetable for fusion. If, however, timely commitment is made to engineering development—admittedly not a likely scenario—fusion power could still be on the grid in a demonstration power plant far sooner. As former Grumman Corporation President and CEO Joe Gavin once said to me, "If you try to develop fusion in 20 years, it may still take you 25 or 30 years, but if you try to develop it in 50 years, it will take at least 50 years." Fusion has been certified as ready for engineering development for more than 20 years, but a weak-willed government has been unwilling to manage and fund the program to accomplish its avowed practical purpose.

Dr. Stephen O. Dean was director of the Magnetic Confinement Fusion Systems Division of the U.S. Department of Energy in the 1970s. He is now President of Fusion Power Associates, a non-profit research and educational foundation.

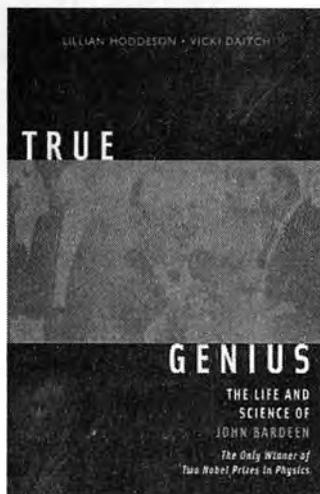
John Bardeen, Superconductivity, And Edwin Hall's Unanswered Questions

by Laurence Hecht

True Genius: The Life and Science of John Bardeen

by Lillian Hoddeson and Vicki Daitch
Washington, D.C.: Joseph Henry Press, 2002
Hardcover, 480 pages, \$27.95

Whether or not John Bardeen (1908-1991), the Nobel Prize-winning solid state physicist who developed the transistor, and the BCS (Bardeen-Cooper-Schrieffer) theory of superconductivity, is a "true genius," this new biography is a useful account of his work. I read the book, hoping to get an overview of the historical development of modern solid-state theory, and to better understand the peculiar phenomenon of superconduc-



tivity. I got some of what I was looking for. As to coming to a clear understanding of the cause of superconductivity and such curious phenomena as the Meissner Effect, I ended not much closer than I have ever been on my long frustrating search of many years.

On the scale of things in postwar 20th Century science, Bardeen's work is as good as any that I know of. For attempting a mastery of what that scoundrel Wolfgang Pauli called "the physics of dirt," Bardeen wins my respect. As I had learned from some close encounters with the history of nuclear science, it was almost always the chemists who got there first, as with Marie Curie and radi-

Postscript: Have Hall's Questions Been Answered?

Shortly after completing the above review, a photocopy of a 1933 paper by Edwin H. Hall on the subject of superconductivity¹ more or less fell out of a file folder into my hands: "I venture to raise two questions, each perhaps heretical, concerning metals in the supraconductive state," Hall begins, thus instantly capturing my attention. "The first relates to the Hall effect; the second will be stated somewhat later."

It was the second question that most interested me:

"Is there conclusive evidence that the persistent currents which Ounes and others have observed are anything more than the aggregate of microscopic electric whirls within the metal? Is there conclusive evidence that the persistent current which is ordinarily assumed to be circumferential within a supraconductive ring or shell is really circumferential?" Hall asks.

The fact that this question could still be asked in 1933, and by no less a figure than the discoverer of the Hall Effect and Harvard's senior expert on electron con-

duction, seemed astounding. For the London theory of superconductivity, put forth in that year, and upon which all the rest of the theoretical superstructure, including Bardeen's work is built, assumes the very thing that Hall here challenges.

A basic assumption of the theory is the hypothesis of Kammerlingh Onnes (Ounes) which had the support of Lorentz, that the superconducting electrons flow in channels or tubes, the walls of which preclude transverse motion. Today this is sometimes described as a *macroscopic quantum state*. Is it possible that the whole modern theory is based on a mistaken interpretation?

Hall's probing analysis of the experimental evidence which led, or perhaps misled, Onnes to the assumption of these circumferential, tubular currents is compelling, and seems worth reproducing here:

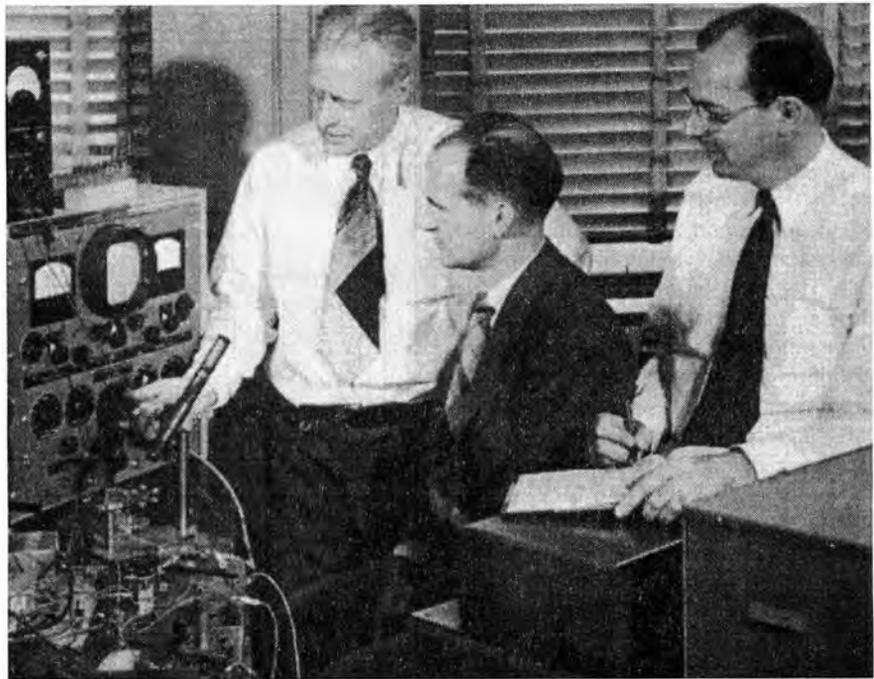
"As bearing on this question I will quote two passages from the 1924 Solvay Conference paper of Ounes. On p. 251 of the Conference Report, he speaks of an experiment of Mr.

Langevin "où une bobine à circuit ouvert montrait un courant persistant" [where a coil in open circuit would show a persisting current—LH]. On pp. 263 and 264 he describes an experiment of his own made with a ring consisting of 24 alternative sectors of tin and lead. These metal sectors, which were soldered together, were thin layers covering a ring of ivory, the junctions between them being on radii of the ring. "Le courant [persistant] fut établi avec un champ perpendiculaire au plan de l'anneau, puis celui-ci fut tourné d'un angle de 30°. Nous avons pensé que nous trouverions un courant qui s'étendrait au bout d'un certain temps [because the soldered junctions were not supposed to be supraconductive] mais l'expérience a montré que des courants continuaient à circuler dans l'anneau et, lorsque l'expérience fut répétée avec l'anneau coupé, celui-ci montra le même moment magnétique." [The (persisting) current was created by a field perpendicular to the plane of the ring, which was then rotated by 30°.

um, Chicago University's William Draper Harkins's 1919 recognition of the neutron, and German chemist Ida Noddack's 1933 detection of nuclear fission by chemical analysis. The work of physicists, who assumed the task of probing the microphysical phenomena in the solid state, seems in some ways comparable, whether they would recognize it or not.

Yet there was also a measure of truth in Pauli's ironic quip. Blackboard mathematical physicist that he was, one suspects Pauli recognized that the thatched-over composite we have come to know as quantum mechanics would not really hold up under close physical scrutiny. The devil was in the detail, and the task of adapting the never-too-sound theory to fit it was left to those who would dare.

Any modern description of superconductivity, or virtually any other solid state phenomena, seems to derive in some way, as Bardeen notes, from the early 1930s work of those three small teams of collaborators that took up this



AT&T Archives

The team of Brattain, Bardeen and Shockley at Bell Labs during the development of the transistor. Brattain (left) is at the apparatus, while Bardeen (right) enters data into their notebook, and Shockley looks on.

We had expected to see the current expend itself after a certain time (because the soldered junctions were not supposed to be supraconductive) but the experiment showed that the currents continued to circulate in the ring and, when the experiment was repeated with a cut ring, this showed the same magnetic moment—LH.]

"A chain being no stronger than its weakest link," Hall continues, "it seems probable that local currents of very limited radius would be more likely to persist than currents having a long cyclic path. Currents of the latter description may well be induced in a supraconductor when the original penetrating magnetic field is varied but they are likely to die out sooner than the local whirls of current. Is it not reasonable to suppose that we have here an explanation of the fact noted by Ounes, on p. 255 of the Solvay Report, that just after a change of the imposed magnetic field the induced current "varie encore un peu?" [still varies a little—LH].

"I must, of course, speak very cautiously of this matter, for I have never even seen an experiment on supracon-

ductivity. It seems to me, however, that, for example, the conclusions reached by McLennan [*Phil. Mag.* 168-180, July (1932)] and his co-workers as to the existence and strength of circumferential persistent currents in small rings of tantalum, lead, and tin, respectively, are open to question. These investigators make no mention of the possibility that the currents are not circumferential. They assume them to be circumferential and on this assumption estimate their strength, from the observed magnetic torque between each supraconductive ring and a neighboring coil of copper wire carrying a current. I believe, however, that all of the phenomena they describe are quite consistent with the supposition that the persistent currents were local whirls within the metal rings, not circumferential currents at all.

"Apparently a test of the question here raised could be made by determining the direction and intensity of the magnetic field along an axis common to the ring and the surrounding coil of current-bearing wire. The investigators assumed, I believe, that the magnetic flux along the axis was zero

after the persistent current in the ring was established. If my idea of the matter is correct, there should be along this axis a permanent flux corresponding to the direction of the current circulating in the copper coil," Hall concludes.

We do not know if Hall's test was ever made. If not, there is some considerable explaining to be done. (And even so, there is much yet to explain, some also relating to the first of Dr. Hall's "heretical questions," wherein he seems to provide the explanation for the not-yet-demonstrated Meissner Effect.)

In either case, one finds in Hall's comments the true spirit of physics, so hard to find today. How the old master proves himself here, at age 78, every bit as sharp and unwilling to be humbugged as he was at age 24, in 1879, when he made the discovery which both bears his name, and has proved itself an indispensable tool in solid state research, by questioning the truth of a passage in Maxwell's famous textbook.

—Laurence Hecht

Notes

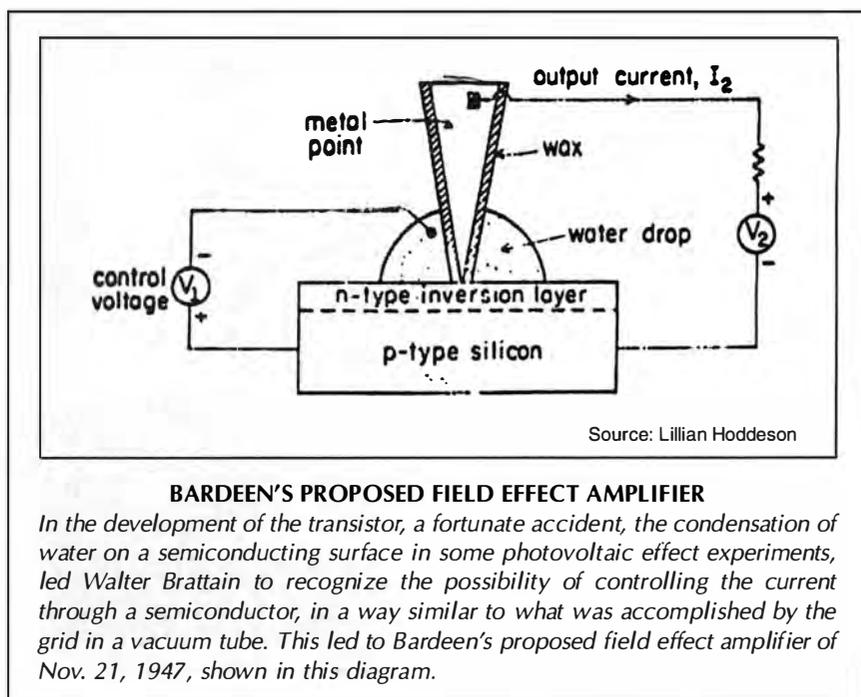
1. E.H. Hall, 1933. "On Superconductivity and the Hall Effect," *Proc. Nat. Acad. Sci.*, Vol. 19, p. 619-623.

project—Eugene Wigner’s students at Princeton, John Bardeen and Fred Seitz; John Slater’s group at the Massachusetts Institute of Technology; and Lennard-Jones, Mott, and Jones at Cambridge—for better, or for worse.

The Transistor and Shockley

To understand any scientific subject, an historical development is indispensable. The merit of this work is in the historical recounting of the modern development of the field. The enormous contribution to postwar science deriving from the wartime research efforts at the MIT “rad lab” and the Manhattan Project are ever evident. The chapter on the development of the transistor at Bell Labs is especially clear and informative. By telling the story of this invention in a way one suspects it might have happened, one learns more than many textbook pages can ever convey.

The balanced treatment of the imbalanced William Shockley, who went off to Harvard in the mid-1950s, after having contributed to the development of the transistor, to refund race “science,” is also welcome. One is pleased to learn



BARDEEN'S PROPOSED FIELD EFFECT AMPLIFIER

In the development of the transistor, a fortunate accident, the condensation of water on a semiconducting surface in some photovoltaic effect experiments, led Walter Brattain to recognize the possibility of controlling the current through a semiconductor, in a way similar to what was accomplished by the grid in a vacuum tube. This led to Bardeen's proposed field effect amplifier of Nov. 21, 1947, shown in this diagram.

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that Bardeen despised the racial IQ theories of his former collaborator (a collaboration that had become so strained by Shockley’s maniacal egotism that Bardeen finally left Bell Labs to avoid it).

What is disappointing about it all is, and is not, the authors’ fault. The acceptance of the irrational, positivist view—something to the effect of “all that we know is what we can measure, and to look for causality is a waste of time”—is the tragedy of science in the post-1927 Solvay Conference era. As in all true tragedy, the problem is not some set of circumstances dictated from without, but rather the refusal on the part of those living it to break with the underlying assumptions which lead them, with each step, deeper into the pit of an ugly irrationality that mocks the very purpose of science.

Thus, in my view, the very strength of the book, its detailed portrayal of how modern physics is done, is also its shortcoming. For in the end, there is a lack of beauty to the final result that no amount of writing and research skill can overcome.

John Bardeen is the only winner of two Nobel Prizes in physics, first with William Shockley and Walter Brattain for the transistor, then with Leon Cooper and J. Robert Schrieffer for the BCS the-

ory of superconductivity. Does he represent “true genius?” I found that aspect of the book, deriving from its title, to be the most annoying—almost as annoying as it was to learn of the new academic discipline known as “scholars of genius and creativity.” (The “of” refers to object not subject.)

I cannot differ with the author’s concluding words on the subject: “They are real people, highly motivated to develop the human elements of genius that exist potentially in all of us.” Yet, to separate the question of the cultivation of genius from the classical standards of education and moral practice which we have all but abandoned as a nation, seems to me inexcusable.

If one accepts the popular premise that the award of a Nobel Prize is the unflinching measure of true genius, I suppose the case for Bardeen is open and shut—twice. If one questions such assertions, and prefers a universal standard of truth, then the currently faddish preoccupation of historians of science to arrive at a definition of genius by sociological means appears a silly spectacle. I suspect that feeling may even be shared by many among those who have become the subject of such academic games, be they living or dead. I would like to think the ever modest Dr. Bardeen might even agree with me on that score.

Looking for the First Americans

by David McVey

Bones: Discovering the First Americans

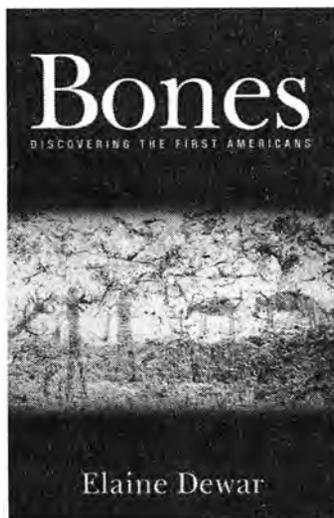
by Elaine Dewar
New York: Carroll & Graf, 2002
Hardcover, 628 pp., \$30.00

Bones is an inspired documentary by a Canadian writer who decided that she was no longer going to accept the vague history of where the first Americans came from.

Elaine Dewar explains: "One Saturday morning in the spring of 1995 I was out in front of my house, groveling in the dirt, trying to wrench beauty and order out of nothing. Moving this bush, cutting that hunk of sod, I sliced my hands on coal clinkers and broken glass, pieces of sharp pottery and bits of metal. The Earth belched up an old bone near the roots of the forsythia. It was dark, dank, redolent of mildew and rot and it rolled lasciviously among the lilies of the valley. Human or animal? . . . I couldn't stop thinking about it. . . . The recognition that I had no knowledge of the prehistory of where I live, no idea who was here before me, came up out of the ground with a bone."

With that idea, she sets out on a very bumpy journey, loaded with all kinds of hazards, but never getting discouraged by any of them. Dewar's *Bones* is probably the most extensive account that has been produced to date of ancient graves found in the New World—giving the lie to the prevailing academic view that the first arrivals in the New World walked across the Bering Strait landbridge, into Alaska, 11,000 years ago, at the end of the last Ice Age.

Dewar documents more than a dozen graves from Canada to Brazil, some of them in areas that have been completely covered over, with the only thing left being the recollection of the person who discovered the grave. She takes you to one find after another, examining case after case, with undeniable proof in most cases, that ancient human existence in America was comprised of residents and travellers from all over the world, and may reach back thousands of years.



Several of the graves are obviously not those of Native Americans, although they are fiercely claimed to be. There is very strong agreement with what she reports and the findings of epigrapher Barry Fell, who documents these ancient travellers in his three books, *America B.C.*, *Saga America*, and *Bronze Age America*.

The Kennewick Man

One of the cases that Dewar returns to over and over again, is that of the Kennewick Man. The skeleton remains referred to as Kennewick Man were found in Washington state, accidentally discovered by two men who were trying to find a good vantage point from which to view a hydro-plane boat race. The county coroner called in a local archaeologist, John Chatters, to help the police to determine whether the remains were the result of a murder. As soon as Chatters saw the skull, he knew that it could quite possibly be ancient.

Chatters visited the site and determined that the remains had washed out of a nearby bank, because of some flooding in 1996. He was able to recover more of the remains, but his adventure was cut short. As soon as he had established the fact that the original burial site was nearby, the Army Corps of Engineers hauled in 500 tons

of rock by helicopter to bury what Chatters believed to be the original burial site.

Chatters made a cast of the skull, and took as many measurements as possible. He had enough of the remains to be able to establish that the man was what archaeologists refer to as "Caucasoid." He worked as fast as he could, because he knew he would be stopped.

In Chapter 7 of *Bones*, Chatters reports that he sent fragments of the bones to the University of California at Riverside for dating. Meanwhile, from his own observations, he noted that Kennewick Man was of European origin: "It's very obvious this is not a wide face. It's narrow, and the canine fossae are prominent. It's a small face. You find it in Western Eurasian people, the ones referred to as Caucasoid."

Chatters points out that the Kennewick's femur bone is round, compared to the American Indian's femur, which is somewhat flat. He documented that Kennewick man had an injured chest, an injured arm, a spear point in his hip (which was not of American origin), and a depressed skull fracture that had healed.

Then the report came back from the University of California, stating that the remains were carbon dated to 8,400 years before the present. At that point, Chatters announced his discovery, and was immediately attacked. The local Umatilla Indian authority called him on the carpet: "You dug up sacred bones from a sacred burial ground. . . . How dare you dig up bones of five different tribes? You violated NAGPRA."

Then the sheriff came in, grabbed the bones, and locked them up.

Sen. McCain's NAGPRA

One of the important things that *Bones* elaborates is the legislation pushed through by Sen. John McCain, called the Native American Grave Protection Repatriation Law, or NAGPRA, which was signed into law by President George Bush, Sr., in 1990. This law makes the inaccurate assertion that

all ancient burial sites in the United States, which are more than 500 years old, are American Indian, and therefore, that such grave remains should be protected, because the Indians consider them sacred. (Many tribes, of course, do not subscribe to this theory of “sacred” burial grounds.) As a result of NAGPRA, many studies are not made public by archaeologists, for fear that they will lose the chance to study ancient American history. Dewar certainly witnesses some of these cases.

In the case of Kennewick Man, although Chatters proves that the remains are not those of an American Indian, it does not matter, because NAGPRA categorizes *all* ancient remains as Indian. In other words, if this skeleton would have been discovered wearing full medieval Roman armor, complete with sword, it would have been classified as Indian simply because it was more than 500 years old.

The accepted view in the scientific community, which we have all heard, is that the American Indian lived for a longer period of time, in perfect harmony with the Universe, in total balance with his environment, than any other people in history.

Let us look at this statement closely for a moment. Even though the world’s peoples had suffered a Dark Age, they were

later building ships, building cities out of stone, weaving cloth, carrying out various forms of mining, and navigating with a very good degree of skill. Yet, in the currently accepted view, the American Indian during this same time period lived happily in a tee-pee. According to what Americans are taught in school, Indians were for the most part, a hunting and gathering people, who remained in exactly the same state for thousands of years—rowing around in hollowed logs and deerskin canoes, and so on.

If this is the accepted wisdom about the American Indian, we are not calling our Indian friends unique; we are calling them stupid! But because all men are created equal, and made in the image of God, it must be the case that this picture of the American Indians and of human history is flawed. There had to have been a higher culture here, whose civilization collapsed, leaving the Indians as remnants.

It is equally false to believe that the Indian did not want other civilizations here, when the European migrations to America occurred. Indians immediately began city building, and made many other cultural leaps. For example, in 1810, Chief Sequoia invented the Cherokee alphabet in order to write down the Cherokee language. And there was a very large contingent of Indians who

fought for America in our revolution.*

It was the British practice of theft and brutal murder, as well as French machinations, that caused this disenfranchised North American people to begin to rebel. Early on, the American Indian had welcomed the first settlers with open arms.

Bones raises as many questions as it answers about the ancient peoples who settled America, but one thing it makes clear, is that one can never say, that man has lived in a stagnant state for any length of time. When human progress is hampered, humanity deteriorates; it doesn’t become serene and static.

For those who are looking into the subject matter of ancient America, *Bones* is an essential contribution. Even for those who aren’t, the book is interesting and worth reading.

Notes

- * When preparation was made for the Revolutionary War’s summer campaign in White Plains, just north of the Bronx, Major General Gates had with him Joseph Chenegun, Benjamin Mehaueamen, David Naunehnuawalt, Jacob Pauhauwaupt, John Seepaubwant, John Nimham, Ebenezer Manawsett, and Benjamin Wauohnauweet, all of whom were standing commanders—and American Indians. They were joined by General Washington’s army by late July 1778, and fought a brutal battle with the British, in which they were all killed. This battle then inspired more Indians to join the American cause.

Eclipsing the Mind

Eclipse: The Celestial Phenomenon that Changed the Course of History

by Duncan Steel
Washington, D.C.: National Academy Press, 2002
Hardcover, 492 pp., \$24.95

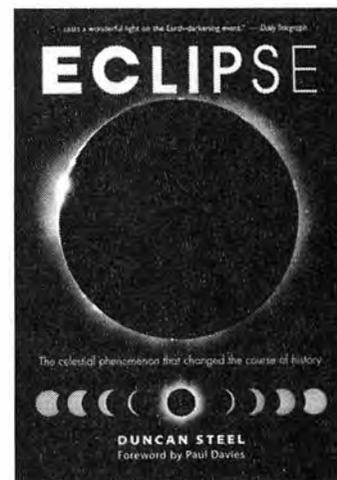
This book has been given a big promotion in the British and other press, but it is primarily a piece of junk, with almost no redeeming features.

Take the idiotic opening: The author asks “which Eclipse has exerted the greatest influence over our affairs,” and he proceeds to compare the eclipse that seems to have followed the death of Jesus Christ on the cross, with the “most famous Eclipse of all time . . . an eighteenth-century British racehorse by that name.”

This sets the tone for the rest of the book. Cognition is never addressed; and

Steel’s explanations, plausible or not, consist of fallacies of composition or wild metaphysics, as if the author had never heard of Socrates, let alone Kepler.

Steel makes much of the famous story in which Columbus allegedly saved his life by convincing the Indians that he was going to make the Sun disappear. But Steel makes no mention of the earth-shaking significance of such an event, if it did take place; namely, that if Columbus did get the time of the eclipse right, he would have had to have known his longitude with a fair degree of accuracy! And Steel knows the importance of such an achievement, because he himself describes in this same book, how Captain Cook was still trying to find his longitude 300 years later!



Eclipse also contains a list of upcoming eclipses, but because it is not done from the standpoint of developing the reader’s capacity to predict, at least lunar eclipses, it is no more than information, of rather marginal value.

—Richard Sanders

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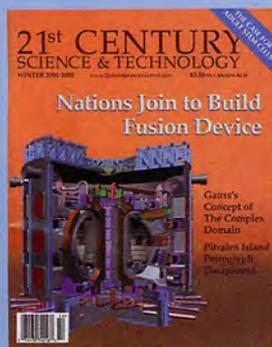
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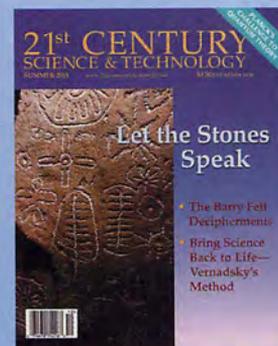
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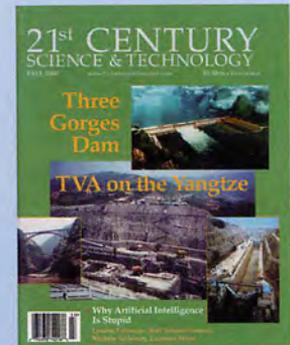
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In This Issue:



Illustrations by Christopher Sloan

The DDT hoax liberated the mosquito and other insect populations at the expense of human lives.



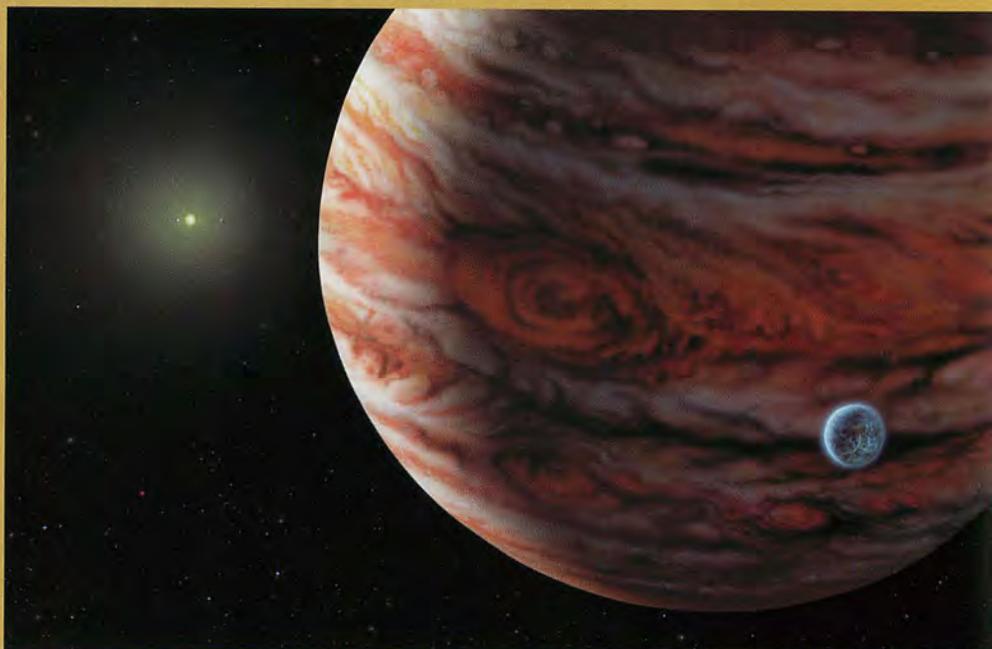
BRING BACK DDT, NOW!

The U.S. ban on DDT in 1972 has killed 60 million people worldwide, and condemned many millions more to the ravages of malaria—most of them people of color in the tropical regions of the world. The truth is that Rachel Carson was a liar, as you may learn in the editorial on page 2. DDT is the safest insecticide ever developed, not harmful to man or beasts.

It's time to repeal the genocidal U.S. ban on DDT. It's time to return to a sane public health policy that funds mosquito control, disease tracking, and health infrastructure. To date, only one U.S. Presidential candidate, the very electable Lyndon H. LaRouche, Jr., has called for bringing back DDT, as a part of his FDR-style infrastructure development program to reverse a worldwide economic collapse.

PLANETS BEYOND THE SOLAR SYSTEM

More than 100 objects have now been identified as candidates for extrasolar planets. Most are thought to be of the gas-giant type, like the planets Jupiter and Saturn, but occupy close-in, Mercury-type orbits. Two planetary candidates have been identified around the star 55 Cancri. One is in a close-in orbit, while the second occupies an orbit about the same distance as Jupiter from our Sun. Marsha Freeman describes the science of extrasolar planet identification in the Astronomy section.



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Artist's concept of a Jupiter-like planet orbiting the star 55 Cancri (the bright point at left), about 41 light years from Earth. A possible moon around the planet is shown, because such moons are thought to be common around this type of planet, although no moon has been detected.