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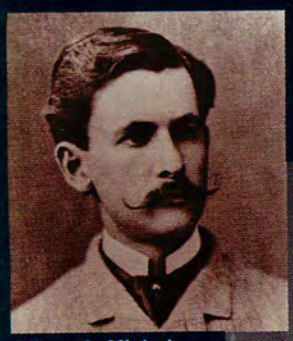
AIDS AND THE DUESBERG CONTROVERSY
p. 64

Michelson - Morley - Miller

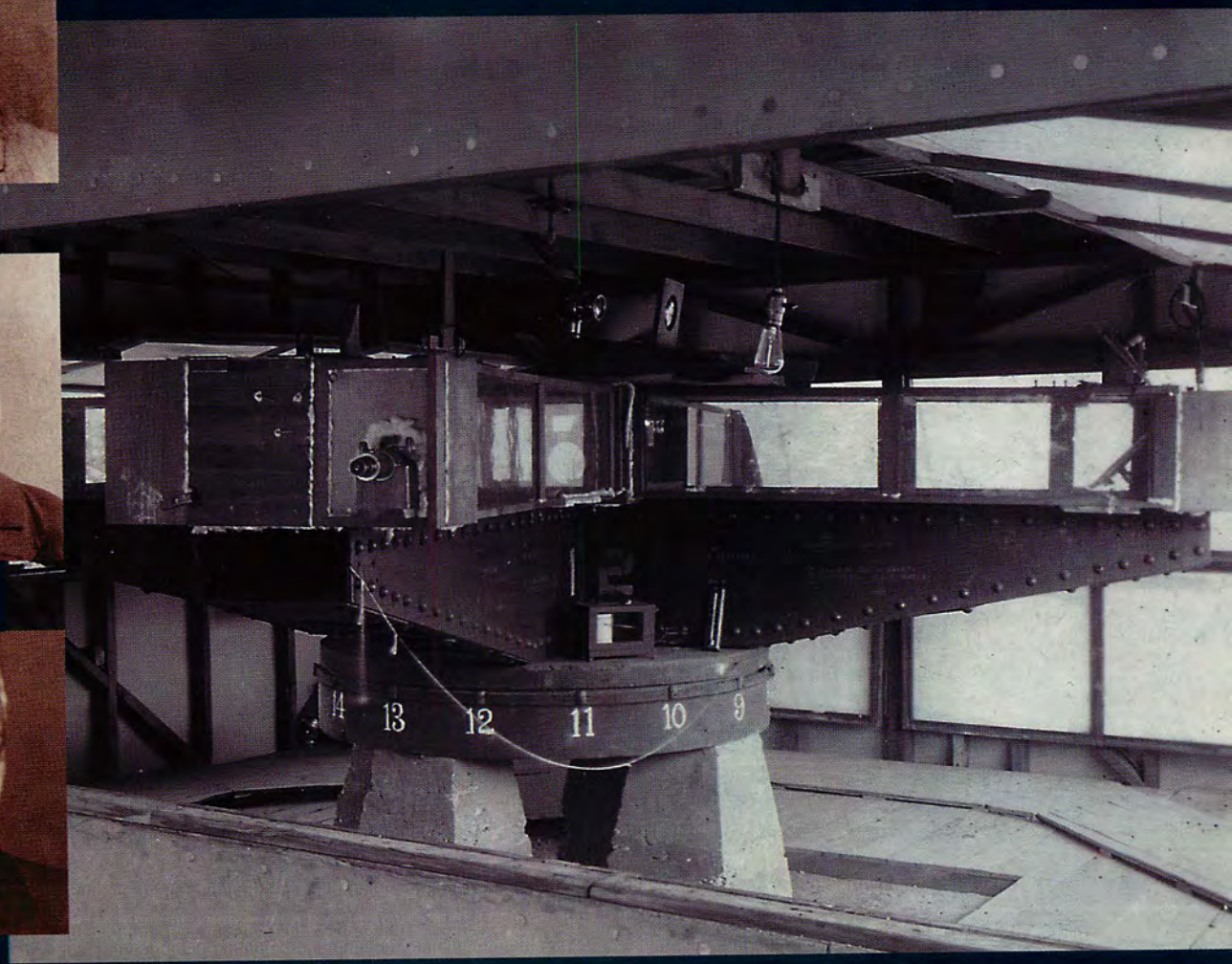
THE COVERUP



Albert A. Michelson

Edward W. Morley

Dayton C. Miller



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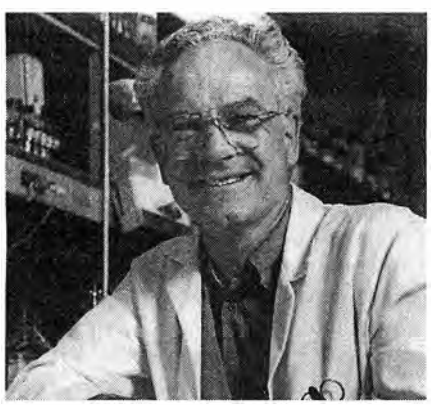
Features



Chris Duffey/University of California at Berkeley

Whoever still maintains, as does Peter Duesberg, that there is no clear correlation between HIV and AIDS, can no longer claim to be serious. *See p. 64.*

News

Departments

On the cover: The ether-drift apparatus of Dayton Miller at the Mt. Wilson Observatory in California, used between 1924 and 1926. Meteorological instruments are on the turntable; the optical pathways are enclosed in insulated glass boxes. The light beam source is at the center top, mirrors are on the right arm of the interferometer, and the telescope lens is left of center. This photo and those of Miller and Morley courtesy of Case Western Reserve University Archives; Michelson photo courtesy of Nimitz Library, U.S. Naval Academy, Special Collections and Archives. Cover design by Rosemary Moak.

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Unlock the Book on Physics!

If you've lived through the last 25 to 30 years, you know the stupefying effect on science—and the population—of environmental myths and Malthusian ideology. Ozone depletion, global warming, nuclear scares are some of the frauds now enshrined as "science."

Even more entrenched is the fraud that permeates the very foundation of 20th century physics: the Michelson-Morley-Miller coverup. The textbooks tell us that the Michelson-Morley interferometry experiments from the 1880s and into the turn of the century, produced a "null" result, thus proving that the speed of light is constant and that there is no ether-drift—which, they say, constitutes empirical proof that Einstein's Theory of Relativity was correct. Today's textbooks present this as an open and shut case; on this matter, the book on physics is closed tight, with no room for questions.

The reification (and deification) of Michelson-Morley's null result, and its implications, occurred after Einstein's death. Einstein, himself, was not so sure, and in fact, encouraged Dayton Miller in the 1920s to continue his experiments that found, contrary to the imposed consensus, that the interferometry results were not null.

(Similarly, in the 1950s, Einstein encouraged physicist Benny Soldano, a member of *21st Century*'s scientific advisory board, in his work that challenged the theory of equivalence of inertial and gravitational mass—work that will be presented further in a future issue. Again, it was not until Einstein's death that any challenge to Relativity was ruled out of order, and that Relativity Theory was set in stone.)

Debate Reopened

This issue's cover story opens the locked book. We intend, in fact, to reopen a full debate on the question of the nature of light, its propagation, and all the related and fascinating questions about how the universe works. This is not an arcane campaign, but one that aims to put the search for truth back into physics, and to remove the ideological and egotistical pillars of the physics edifice that get in the way of how science works today.

This campaign leads with the work of Nobel Laureate Maurice Allais, who reviews the 1925-1926 experiments of Dayton C. Miller. Not only were the interferometer results positive, Allais shows, but also, they probably cohere with the anomalies he found in his experiments in the 1950s with the paraconical pendulum. (The Summer 1998 issue of *21st Century* will continue this campaign with a presentation of Allais's work on the paraconical pendulum and related experiments in optics.)

Accompanying the Allais article is a historical review of the 19th and 20th century experiments and theory concerning the Michelson-Morley-Miller work, which will enable readers to situate the importance of Allais's work. Associate Editor Laurence Hecht begins with the origin of the wave theory of light, in the work of Augustin Fresnel and Thomas Young, and discusses the question of relative motion and aberration. Then Hecht describes the experiment that Michelson designed to test the Fresnel hypothesis in the 1880s, the subsequent experiments in the next few decades, and, finally, the debunkers of Miller's work.

And, while the book on physics is being pried open, we point out the article on physicist David Bohm in the Books section (p. 86). The review of Bohm's life and work by Caroline Hartmann, gives one the flavor (more precisely, the stink) of how the physics community molds and preserves its "consensus," discourages debate, and crushes dissenters.

Letters

Religion, Leibniz, and Darwin

To the Editor:

I pick up *21st Century Science and Technology* from the newsstand. I greatly appreciate the views expressed on nuclear energy and "environmental" issues. Until now, however, I never read any of the philosophical material.

With the Fall issue I decided to settle in and read the article, "Was Darwin an Evolutionist or Just a Social Reformer?" by Dino de Paoli, and I found it fascinating.

I admit I did not understand a fair amount of the philosophical details, but as somebody who has been self-consciously developing and building my own worldview from a coherent theological and philosophical base, I understood its thrust. I greatly appreciated the explanation of the impact of Darwinian thought on the idea of entropy and the notion that we are operating in a world with a pre-determined and fixed maximum size that impacts our views on society and sustainable population size.

Gottfried Leibniz's alternative views are very interesting and provide a very compelling rebuttal to the insanity of today's popular mentality. They also have many parallels with the Biblical worldview I have accepted, and it is these similarities that spur me to ask several questions, which would perhaps clarify his ideas further for me.

I am very interested in knowing something of the nature of Leibniz's own religious convictions. Essentially, I am wondering why his philosophy, with a few minor changes, could not be the Biblical worldview. Leibniz, for example, identifies man as unique, not just another animal, and this is certainly the message in the Bible. Man, as no other created being, is created in the image of God.

He also talks about a "light within us" that relates to our ability to creatively address our problems, develop new technology, and expand our world. The terminology in de Paoli's article sounds like the idea of man being God, or God-like. The Bible, though, says that man is in no way God—he is not created as part of God, or out of God (as a pantheist may argue)—but He is created in God's image, which is why he has thought processes, creativity, and an imaginative process which separate him from animals and which are not explainable from naturalistic and mechanistic presuppositions.

Certainly the view expressed in de Paoli's article about the tremendous potential man has demonstrated to improve his world, rather than the common view that he simply has to find his little niche in a mechanistic world, is very consistent with what I understand the Bible to be saying.

Many modern Christians have apparently rejected the historic Christian idea that sees God's redemptive plan as applicable to all of life, not just man's soul. This historic view, however, would defend, at least in principle, the importance of advances in industry and technology to expand the wealth and "size" of the world to facilitate larger populations. It recognizes moral and metaphysical entropy, but identifies redemption as a stronger initiative which can roll back the effects of entropy, if people exercise their responsibility to accept and apply God's redemption.

De Paoli also talks about the importance of reproduction in the advancement of human civilizations. The Bible consistently calls children a blessing and encourages procreation much more than modern Christians do.

Also, could Leibniz's idea of "a higher domain" be the Biblical God who, as the Creator, is separate from and outside of His creation? He is also unchanging and almighty.

Thank you for de Paoli's very insightful article. I welcome any comments.

Timothy Bloedow
Vanier, Ontario, Canada

Dino de Paoli Replies

I think that your insights are quite correct, and, de facto, they answer your own questions. Nevertheless, I will try to add some specification without going into any depth, which would require another article!

As far as I know, Leibniz not only was personally a religious man, but dedicated his life to try to find an intelligible form to St. Paul's statement: "The Law of God is written in our hearts" (Romans 2:15). From that standpoint, he looked for a common ground to reunify the different Christian doctrines, and also a common ground with other religions and cultures. To maintain this higher standpoint, he rejected, for example, the possibility of becoming a cardinal in the Catholic Church.

If you are interested in following this up, we can provide you with some references. In any case, I would suggest that you read Leibniz's *Theodicy* to get a direct impression on this issue.

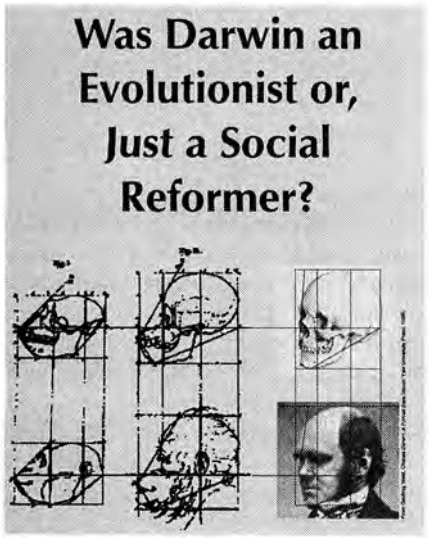
My general point of view is that the Bible, in itself, is a very inspiring, but difficult, book. Because it does not have to *explain* or *justify,* but to *inspire,* it necessarily uses ambiguities and metaphors, whose literal interpretations have often led to misunderstanding, and, de facto, to anti-Christian policies and practices. The case of Darwin, mentioned in the article, is not unique.

We have to rediscover also in us a living *certitude,* otherwise expressed in the Bible and books in general. This is universally necessary to acquire truth and any type of real knowledge, contrary to simple doctrinal learning. Man, to discover and follow the truth, has sometimes "to break the Law." This is the only way man can make "ontological jumps" (he, himself, being a reflection of one) and so help the world, sometimes even in contradiction to established do's and don'ts.

How does man find in himself, with all his imperfection, the references for the higher standpoint? Once "free will" is accepted as ontologically primary, when we accept that the world, in order to be, needed a free act of God's will, how do we know and act in a non-arbitrary way to respect God's Law of nature? In the article, I tried to give some answers to this, so I do not want to repeat myself here.

Leibniz's main thesis is, that to go from one given to the next, there is no simple automatism, no simple "repetition." The passage needed, and needs, a conscious and willful act of creation. This is the ac-

Continued on page 4



tual basis of all the insoluble paradoxes confronted by logical, biological, or materialistic monism or pantheism. We know this best, because we experience it, when we are confronted with the paradoxical nature of man.

From Plato to Leibniz, never was man considered a "god." Never was a finite considered an infinite, or a line a curve! Explicitly, Plato attacked the Sophists on this and rejected their thesis that "man is the measure of everything."

But what is, then, the measure? What is the meaning of "image of God"?

We cannot hope to judge directly, as God will one day judge. But we have no other means than to try to see, although as "through a mirror darkly"; we *cannot* avoid passing through the imperfect mediation of man's judgment. To escape from the sophist's moral relativism and subjectivism, we cannot use any simple "objective" measuring stick. The issue boils down, then, to grasp what is natural law, what is really the meaning of "image of God"? Religion and science here share the same difficulty and must operate in a common coherent fashion.

In my last article, as well as in three preceding ones (see *21st Century,* Summer 1997, Summer 1991, and *Executive Intelligence Review* Vol. 22, No. 31), I struggled precisely with the issue you raised: Pantheism is not only wrong theologically, but also scientifically.

Modern ecology is based precisely on the axioms of pantheism (for example, see Haeckel). But, to have a *human* ecology, we have to drop such simple monism, which negates the existence of a living God because it has to deny the efficient use of human creative powers; it wants to destroy human dignity and worth to prove that we are just working cattle! To get a better understanding of this, I recommend that you read some of the writings of Lyndon H. LaRouche, Jr., whose ideas, as far as I have grasped them, I used in part of the article.

To conclude and summarize: I think that Leibniz's concepts are probably one of the best expressions for the universality of Christianity. I hope these answers are helpful to you. Otherwise, feel free to keep up the dialogue.

On Science and Politics

To The Editor:

I have read the Darwin article in your Fall issue, and I would like to pose a question: Do political issues hinge on whether life has a random materialist origin? Catholics have their Crusades, and Hitler had his holocaust. Really, honest scientific debate does not control political action.

Darwin, although he did share the prejudices of his age, abhorred slavery, and he was an Englishman whose father and grandfather were highly regarded, famous physicians of their time. Darwin's grandfather treated the elite as well as whoever knocked on the front door of his home. To equate these people to the Nazis is very strange.

Herbert Spencer, Karl Marx, and many others focussed on the political fallout of science in Darwin's era.

It appears necessary to remind your editors that a decent respect for the opinion of others caused Thomas Jefferson to write the Declaration of Independence. Whether "inborn light" is de Paoli's euphemism for divine, or if, as Darwin says, we are ennobled by the story of evolution matters little to me. We all must live on the planet together, no matter what science says.

Tom Manaster
Albuquerque, New Mexico

Dino de Paoli Replies

Although your remarks enlarge the debate in very complicated areas, I will try to answer some of your questions.

(1) Does science have anything to do with political decisions?

Whatever our understanding of the physical world, life, the biosphere and *man* is, being able "to live on this planet together," has, or should have, a lot to do with the *cultural* (social, economic, political) choices which define the *reproduction of man* and our world!

It happens that social decisions are *also* controlled (sometimes totally) by other considerations. This is precisely what I tried to say in the article. It is *ideology* alone, which can destroy a civilization!

(2) Darwin's theory was flawed by *ideology.* I tried to show that this is not limited to the widely admitted "Malthusian ideology," but reaches the core of "Newtonian ideology."

(3) To share the prejudices (ideology?) of one's own age is not a crime, but it makes a big difference if you pretend to establish theories concerning natural laws! Normally, to do that, you should be able to *rise above* the prejudice of your own time!

I compared Darwin's social theories to Nazi ideology, not because he "shared the prejudice," *but because he tried to make simple prejudices appear to be natural law!* The racist conclusions at which he arrived, were *inscribed* in his premises. Nazi ideology, *at its core,* was Social Darwinism. So the comparison is not just an analogy.

(4) It appears to me, that sometimes you yourself reflect the "prejudice of *our* time," that is, what is called in France the *"Bof!* generation." "Bof" is a phonetic expression of a French youth who is unable or too lazy to speak, but who wants to say: "What do I care? What does it matter? It is all the same!"

The "decent respect for the opinion of others," means also the decent *criticism* of such opinion, especially when that opinion pretends to have the status of theories and policies. And such possibility of criticism is nowhere allowed so strongly as in the United States. Moral and social indifferentism characterize animal societies; there the choices are made by Mother Nature.

For us, the possibility of "living on the planet together," hopefully for a very long time, depends instead on *our own choices,* and on well-grounded ideas behind the *important choices.*

A New Radiation Unit for the Public

by Dr. John Cameron

The existing units that measure radiation—grays, sieverts, curies, becquerels, and the outmoded rads and rems—need to be supplemented by a unit that can be easily understood by anyone receiving a medical X-ray. I also propose a more appropriate scientific quantity for patient dose, *imparted energy,* which does not depend on uncertain biological constants, as do the present radiation protection quantities.

The pertinent question to ask with radiation from an X-ray is: "How long will it take me to get about the same amount of radiation from nature?" The answer should be given in terms of time: Background Equivalent Radiation Time or BERT, which is the unit I have proposed (Cameron 1991). The accompanying table lists the typical time it would take to get the same effective dose from nature for some common X-ray studies, ranging from about one week of background radiation for a dental X-ray, to about two years of background radiation for a fluoroscopy study of the lower bowel.

The BERT value varies a great deal with the size of the patient, and the part of the body being X-rayed. A larger patient needs a larger dose, and, therefore, would need a longer time to accumulate the same effective dose from nature. It also takes a lot more radiation to go through the abdomen or lower back than through the neck or chest. The BERT value is further affected by the parameters of the X-ray unit, such as the filtration and the exposure time, as well as the sensitivity of the image system.

Bear in mind also, that the annual background radiation varies widely. The average for the United States, excluding radon contributions, is about 1mSv. But if you live at higher elevations, such as Denver, it is about 2mSv.

First Defined in 1928

When the discovery of X-rays was announced by Roentgen in early 1896, it was a scientific sensation. The news that X-rays permitted one to see through the human body astounded the world. It was clear from the very beginning, that X-rays were produced by converting high-voltage electrical energy across a partially evacuated Crooke's tube, into X-ray energy. However, the amount of X-ray energy is exceedingly small—much smaller than could be measured by any instrument at the time, or even now. Medical physicists still do not measure the energy; they estimate the energy from some other measurement, usually the amount of ionization produced in air.

It was more than 30 years after the discovery of X-rays before radiation physicists defined the roentgen unit for radiation, in honor of the discoverer of X-rays. They did not give the name *exposure* to the corresponding quantity until many years later, and this radiation quantity is now out of scientific favor.

The roentgen is a measure of the amount of ionization produced in air. That is, X-rays knock electrons off atoms and molecules and produce electric ions in the air. The electrons (negative) and the positive ions can be separated and collected. If you have an electroscope with a positive charge, the collected electrons cause the electroscope to discharge.

The Curies used this simple but sensitive technique to measure the radiation from the minute amounts of radium they purified from tons of uranium ore. Modern measurements of ionization use more sophisticated instruments, but their sensitivity is not appreciably better.

During the first 30 years after their discovery, X-rays were used primarily for producing images of the inside of the body, mostly of the skeleton. As long as there were enough X-rays, the amount of radiation to the patient was not important in determining the diagnosis.

Today, it is rare for an expensive X-ray unit in the United States to include a meter to measure the radiation to the patient even though such meters have been available for over 30 years. The radiologist has little interest in measuring the radiation to the patient, even for the largest doses. One possible reason for this is that the recorded patient dose information might later be used in a legal suit against the radiologist, to allege that an excessive dose was the cause of cancer. (Note, however, that there is no evidence of any

TYPICAL BERT VALUES FOR X-RAY STUDIES OF AN ADULT

Type of X-ray	BERT: The time it takes to get the same amount of radiation from nature
Dental, intra-oral	1 week
Chest X-ray	10 days
Dental, panoramic	2 weeks
Thoracic (upper) spine	6 months
Lumbar (lower) spine	1 year
Upper digestive system	1.5 years
Lower digestive system	2 years

Source: Adapted from Wall et al. 1988.

cancer risk to patients from ordinary diagnostic X-rays.)

The National Council on Radiation Protection and Measurement (NCRP) recommends that the dose to the patient in diagnostic radiology should be "as low as reasonably achievable," a concept known as the ALARA principle of radiation protection. It is like asking drivers to drive more slowly, without providing them with a speedometer! When the dose to the patient is rarely measured, it is not practical to apply the ALARA principle. The NCRP has not recommended that clinical X-ray units include a meter to measure the radiation to the patient. It is well known that the dose to a patient for a given image varies greatly from one X-ray set to another, even in the same X-ray department.

Radiation for Cancer Therapy

Radiation therapy for the treatment of cancer was proposed soon after the discovery of X-rays. The success of X-ray therapy for cancer in the early years was not dramatic. The low-accelerating voltage of the early X-ray units used for imaging did not produce penetrating X-ray photons. X-ray therapy was mostly limited to treating superficial cancers. The use of radium sources in contact with the cancer (brachytherapy) was more successful.

By 1930, radiation therapy was a recognized specialty in Europe and the United States, and there was a need for a quantitative way of describing the radiation to the cancer. The roentgen was not an ideal unit for this purpose.

It was only after World War II, that high energy (megavoltage) X-ray beams became available, which had sufficient penetration to be able to treat a cancer deep in the body. The need for accuracy in measuring the dose to the cancer was widely recognized. It is now routine to determine the dose to the cancer and normal tissues to an accuracy of better than 5 percent. A 10 percent overdose may lead to life threatening complications while an underdose of 10 percent significantly reduces the chance of a cure.

After World War II, the International Commission on Radiological Protection (ICRP) defined a more appropriate quantity for cancer therapy—the absorbed dose in terms of the energy deposited in matter. The unit was the rad (1 rad = 100 ergs/gram). The absorbed dose was calculated from measurements of ions in air. In 1977, the rad unit was replaced by the gray (Gy), which is defined as 1 joule per kilogram; 1 gray equals 100 rads.

Hard to Measure

An X-ray beam deposits most of its energy near the skin where it enters. The "entrance skin dose," or ESD, is the most common measurement of radiation to the patient. Although it is easy to measure, it is only a crude indicator of the X-ray energy absorbed by the patient, and it cannot be related to the radiation the patient gets from nature.

To give an indication of the difficulty: The ESD for a dental X-ray is about 30 times greater than the ESD for a chest X-ray, even though they both deposit about the same amount of X-ray energy in the body. This difference is because the ESD does not take into account the surface area of the patient exposed to the X-ray beam. For example, the exposed area for a chest X-ray is about 30 times greater than for a dental X-ray.

Ideally one would like to measure the X-ray energy imparted to the patient. In 1961, Dr. Russell Morgan of Johns Hopkins University described an instrument to be attached to an X-ray unit to measure the imparted energy to the patient. He recommended that this

Radiation Protection Quantities and Units

There are two quantities defined by the ICRP for radiation protection: equivalent dose and effective dose. The risk of producing a fatal cancer in any tissue of the body is assumed to be proportional to the equivalent dose to the tissue. If the radiation is non-uniform, the risk of fatal cancer is assumed to be proportional to the effective dose.

There is no evidence that either of these assumptions is correct at the low doses from diagnostic X-rays.

The equivalent dose is the absorbed dose multiplied by a radiation weighting factor, or W_R. W_R is a biological constant that is assumed to be a measure of the biological damage to the tissue from a given type of radiation. Values of W_R are specified by the ICRP. For X-rays, the W_R is 1.0; for alpha particles from radon progeny (which gives our lungs a large annual dose equivalent), the W_R is 20.

If the absorbed dose is in Gy, the equivalent dose is given in sievert (Sv).

If the radiation dose is not uniform over the body, the ICRP assumes that the relative risk of fatal cancer to the body is proportional to the effective dose to the whole body. The effective dose is calculated by obtaining the equivalent dose for each organ and multiplying it by its tissue weighting factor, W_T. The sum of these values for all the organs is the effective dose, or E.

The value of the W_T for a given organ is assumed to be a measure of the risk of radiation inducing a fatal cancer. The ICRP has specified W_T values based primarily on studies of cancer incidence among A-bomb survivors. The unit used here for effective dose is also the Sv. Since a Sv is a relatively large effective dose, it is common to use the millisievert (mSv), which is one-thousandth of a sievert.

A study by an NCRP Scientific Committee of Q values (now called W_R values) concluded that it was not possible to specify Q (now W_R) values for any type of radiation (NCRP Report No. 104). No independent group has evaluated W_T values. ICRP values of W_T changed significantly from 1977 to 1991.

You will occasionally also see rem, the outmoded radiation unit for equivalent and effective dose; 1 Sv = 100 rem. You may also see the rad, the outmoded absorbed dose unit; 1 Gy = 100 rads.

quantity be regularly measured for epidemiological studies (Morgan 1961).

A commercial instrument was developed to measure the exposure times the exposed area of the patient. The exposed-area relation can be converted to the imparted energy to the patient, if the accelerating voltage and beam filter are known (Wall et al. 1988). This instrument is the most useful way to monitor radiation to patients during fluoroscopy, and fluoroscopes in the United Kingdom and Germany are required to have them.

The NCRP, however, has made no similar recommendation in the United States, and these instruments are relatively unknown here.

Radiation Protection Regulations

Even though the International Commission on Radiological Protection (ICRP) was formed in 1928, and the U.S. National Council for Radiation Protection and Measurement (NCRP) was formed the next year, neither organization gave advice on safe limits of radiation until 1934. The NCRP recommended that radiation workers be limited to 0.1 roentgen per day. The ICRP later chose the same value. These organizations considered that this level of radiation represented no significant risk to a radiation worker.

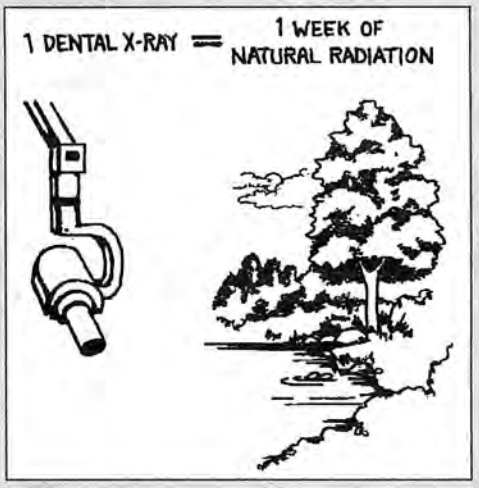
There is still no scientific evidence that this radiation level is detrimental to the health of workers. Nevertheless, the permissible dose rate for workers has been reduced several times since 1934, based on *nonscientific* reasons, rather than because of new evidence that lowering the permissible dose would save any lives. These reductions in the permitted level gave the public the erroneous impression that new evidence had demonstrated that the old levels were not safe (Taylor 1980).

The ICRP and NCRP have defined special quantities and units for radiation protection (see box, p. 6). However, the biological constants used to calculate these quantities are incorrect, because they do not take into account the dose rate of the radiation.

It has long been known that tissues can tolerate a large amount of radiation spread over a long period of time. The natural protective mechanisms of the body can take care of cellular damage at low dose rates. The existence of such repair mechanisms is the primary reason that radiation therapy is given over many weeks, rather than as one large dose. The normal tissues have time to repair when the radiation is given in small fractions.

Medical X-rays

Medical X-rays contribute the great majority of all man-made radiation to the public, far greater than the dose from any other man-made source. There is no evidence of any harm to patients from ordinary diagnostic X-rays. Malpractice suits in diagnostic radiology are more apt to involve a missed diagnosis. Various factors can cause a missed diagnosis but a common cause is a poor X-ray image. Such poor images can be minimized by quality control of the various components that contribute to the final image.



Radiology departments that have an active quality control (QC) program are more able to make a correct diagnosis. Such a QC program always involves keeping the dose as low as practical. If the dose is too low, however, the image may not be of optimum quality. I am more interested in the existence of an active QC program, than I am in the dose I will receive when I get an X-ray. I always ask about the dose, however, to help educate the X-ray techs and radiologists that the patient is entitled to this information, and I recommend that others do the same.

John Cameron is Professor Emeritus at the University of Wisconsin at Madison and a Visiting Professor at the University of Florida. An internationally known radiation scientist, he is considered one of the world's pioneers in medical applications of physics. In the 1960s, he developed thermoluminescent dosimetry, the basic method for measuring radiation received by nuclear workers. He is also a founder of the non-profit Medical Physics Publishing, which has published about 60 books.

References

J.R. Cameron, 1991. "A Radiation Unit for the Public," *Physics and Society News.*

Russell Morgan, 1961. *Radiology*, Vol. 76, pp. 867-876.

B.F. Wall, R.M. Harrison, and F.W. Spiers, 1988. *Patient Dosimetry Techniques in Diagnostic Radiology* (York, England: The Institute of Physical Sciences in Medicine).

This is also known as IPSM Report 53.

L. Taylor, 1980. "Some Non-scientific Influences on Radiation Protection Standards and Practice," *Health Physics*, Vol. 32, pp. 851-874.

L.E. Feinendegen, V. Bond, and C.A. Sondhaus, 1998. "Low level radiation may prevent cancer," *Physics and Society News* (Spring).

NCRP, 1990. *The Relative Biological Effectiveness of Radiations of Different Quality.*

Low Doses May Prevent Cancer

The small amounts of radiation we receive from ordinary X-rays are completely harmless. They may even be beneficial for our health: There is good evidence that low to moderate doses of radiation stimulate the immune system and other cellular protective mechanisms, such as apoptosis (Feinendegen, et al. 1998), which is the body's way of protecting itself against damaged cells. In apoptosis, damaged cells are programmed to die to protect the body.

Three of these protective mechanisms are most effective at moderate doses up to about 0.1 to 0.2 Gy—about the amount of radiation that you receive from nature in 30 to 60 years. At higher doses, apoptosis continues to be beneficial. It is significant that there is no evidence from the A-bomb survivor studies of any statistical increase in cancer below about 0.2 Gy.

IN MEMORIAM

Benjamin Sonnenblick
(1909-1998)

EDITOR'S NOTE

Dr. Benjamin Sonnenblick, a member of the scientific advisory board of 21st Century, *died Feb. 3 at the age of 88. We will miss him. Ben reviewed our articles on biology and medicine, as well as other topics, and was a wonderful source of the news behind the science news, able to tell you of his encounters with the good, the bad, and the famous in science. He was also a good friend; you could be sure that when you asked for his opinion, he would tell you the truth.*

We will publish some of his colorful memoirs in a future issue.

This obituary is written by his son, Mark.

Dr. Benjamin Sonnenblick, my father, died, Feb. 3, near his home in Southbury, Connecticut, of what he would have called "the interaction of multiple factors."

Last year, Lyndon LaRouche cited Ben as one of the only remaining "truthful scientists." In November 1974, when LaRouche convened the founding meeting of the Fusion Energy Foundation, Ben was there. He was one of the few scientists with the integrity to serve on the Scientific Advisory Board first of FEF and *Fusion* magazine, and then of its successor, *21st Century Science & Technology*.

Sonnenblick should be remembered for two important advances in medicine and public health. The first was his postdoctoral discovery, in the late 1930s, of a technique for slicing, staining, and photographing fruit fly eggs. His description of the geometry of cell division and differentiation in embryos was a necessary step toward later progress in genetics.

The second was his pioneering of radiation protection. Although thousands of radiologists and technicians used X-ray machines and fluoroscopes in the early 1950s, none of them thought to ask how much radiation they and their patients were really receiving. He "raised the question," as he liked to put it. His study, which found that the machines were emitting up to 100 times the radiation needed for the X-ray picture, was so shocking that the state of New Jersey formed a Commission on Radiation Protection, upon which he served from 1958 until 1985. He drafted the first state law requiring training for operators of diagnostic radiology equipment, calibration of machines, and lead shielding. He also got fluoroscopes removed from shoe stores.

Ben Sonnenblick in his laboratory at Rutgers in the 1950s.

Ben was recruited to play a similar role in drafting standards for the National Commission on Radiation Protection. In the 1970s, he assembled 5,400 studies of low-dose radiation effects into a comprehensive bibliography, which made research reports showing the beneficial effects of very low doses of radiation (hormesis) more widely available.

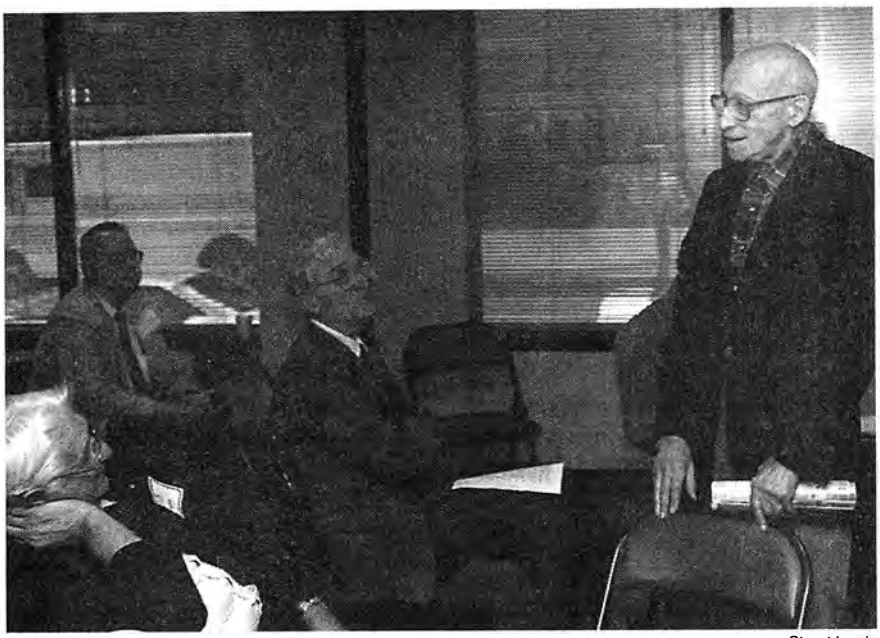
Ben's proudest achievement was to serve as an inspiration to the thousands of students he instructed in zoology at the Newark colleges of Rutgers University from 1947 until 1966. His election as "Outstanding Teacher of the Year" in 1965 reflected long hours preparing lectures, passion and lucidity in delivering them, and the openness and humility with which he counselled students and faculty.

'B.P. Sonnenblick Blues'

An ode titled "The B.P. Sonnenblick Blues," found in a final exam blue book of his 1976 course on radiation biology, reflects the war he waged against the lack of truthfulness in modern science. It begins, "Take 35 roentgens and throw them at a *Lilium;* Feed a little mousie a contraceptive pillium; Induce mutations in Drosophila flies, But you won't find out why an old man dies." And it ends, "Cause a monkey's not a man, and a man is not a mold; and a mold is not an orange tree growing in the cold. So be careful what you say about a given effect. . . . What's sauce for the Goose may break the Gander's neck."

Sonnenblick's favorite spot was the Marine Biological Laboratory in Woods Hole, Mass. For the past 45 years, he spent almost every summer doing research in the labs or reading in the library. There, as everywhere, he preferred the company of janitors, librarians, and scientists who were unpretentious like him, to that of Nobel Prize winners and other "big wheels." A memorial celebration will take place for him there on July 18, at which time, in accord with his instructions, his ashes will be scattered on the waters, and the 40th symphony of his favorite composer, W.A. Mozart, will be played.

Sonnenblick was often retiring and sometimes heroic. He helped form the nation's first teachers' union. He jumped on an obviously disabled knee until an Army induction medic acceded to his desire to fight the Nazis. He was a Captain in the Army Air Corps during the war, and later his remorse at being pe-



Stuart Lewis

Ben (right) speaking at a December 1989 meeting of the Committee to Defend Scientific Freedom, in Washington, D.C., which celebrated the court victory of the Fusion Energy Foundation against the federal government's illegal forced bankruptcy of the organization in April 1987.

ripherally associated with the dropping of the atomic bombs on Japan helped impel him towards his vocation of radiation biology.

At Rutgers he was one of the few professors to stand up against McCarthyism. Later, for more than 20 years, he defended fellow mavericks Lyndon LaRouche and LaRouche's associates from persecution. He would constantly ask what more could be done to free *21st Century* associate editor Larry Hecht and the other imprisoned associates of LaRouche from unjust incarceration.

A year ago, he wrote to each member of the Senate Judiciary Committee to demand a full investigation of misconduct by the Department of Justice in the LaRouche cases. Introducing himself as "an octagenarian American of Jewish descent," Sonnenblick condemned *The New York Times* for initiating the lie that LaRouche is "anti-Semitic."

An Open Mind

Like Socrates, Sonnenblick was more often "raising questions" than giving answers. Unlike many protesters, he was usually willing to reverse his opinion when it was demonstrated to him that it was wrong. For example, after decades of "sowing doubts" in his expert testimony on the safety of nuclear power plants, he changed his mind. When confronted with the fact that abundant energy and technology are the only way to end the abysmal poverty I had witnessed in the Peruvian Andes, where 10 percent of children die in their first year, he readily came around to view Barry Commoner and others of the "environmentalists" with whom he had worked, as contemptible "fakers."

He participated in a few of the seminars LaRouche held in the 1980s with scientists from a variety of backgrounds. Had the persecution of LaRouche not interrupted these interactions with scientists, Sonnenblick might have gotten closer to accomplishing his late-life goal of reorienting the life sciences away from reductionism, and toward coming to grips with the "complexities" arising from "interactions of multiple factors."

For him, the uniqueness of the individual organism, not the average of a group, was what was most important. In his later years, he fought against the dominant notion that simplistic probabilities explained anything important in natural science or medicine. His phenomenal memory was always available for *21st Century* editors to shake, for a harvest of "pearls of wisdom."

Sonnenblick waited eagerly for his weekly copy of the political newspaper *New Federalist* to arrive. He read it cover to cover, starting with the letters page. *New Federalist* served as an antidote to the cynicism engendered by his daily reading of *The New York Times*. If a few issues didn't arrive, he became despondent about the fate of the human race. He always sought to help us win, often by "raising questions" about how we could do things better. Some of the most satisfying moments for him—and for me—in the last few years, were our discussions of LaRouche's battle plan to defeat "the Wall Street hyenas" and their oligarchic backers.

Having been affected by anti-Semitism as a youth, Sonnenblick felt that every Jew had a special responsibility to work for justice for all members of the human race. Thus, nothing disgusted him more than "that bastard Henry Kissinger," as he called him. For him, there was nothing worse than "a Jew who acts like a Nazi swine."

He enjoyed confounding banality and mindlessness. When a clerk wished him, "Have a nice day," he would beam and courteously reply, "Thank you, but I have already made other plans."

Ozone Holes Are A Natural Phenomenon

by Julian Kinisky

The British medical journal *The Lancet* reported Aug. 23, 1997, that HCFCs, which are now used to replace the condemned CFCs as refrigerants, have caused severe or acute hepatitis. I was angered that the use of HCFCs was introduced before their toxic effects had been determined, when it is already known that CFCs are relatively safe.

That concern encouraged me to review my own role in spectroscopic measurements of ozone during the International Geophysical Year (1957) in Edmonton, Alberta, some 40 years ago. At that time, Dr. Gordon Dobson, of Oxford, who had invented the Dobson Double Monochrometer Photoelectric Spectrophotometer, was supervising worldwide measurements. He regularly sent a special lamp to each measuring station in the world network, so that the performance of a "standard lamp test" would assure comparable calibrations.

Two incidents come to mind. The first was that the British in the Antarctic were unable to measure any ozone in the

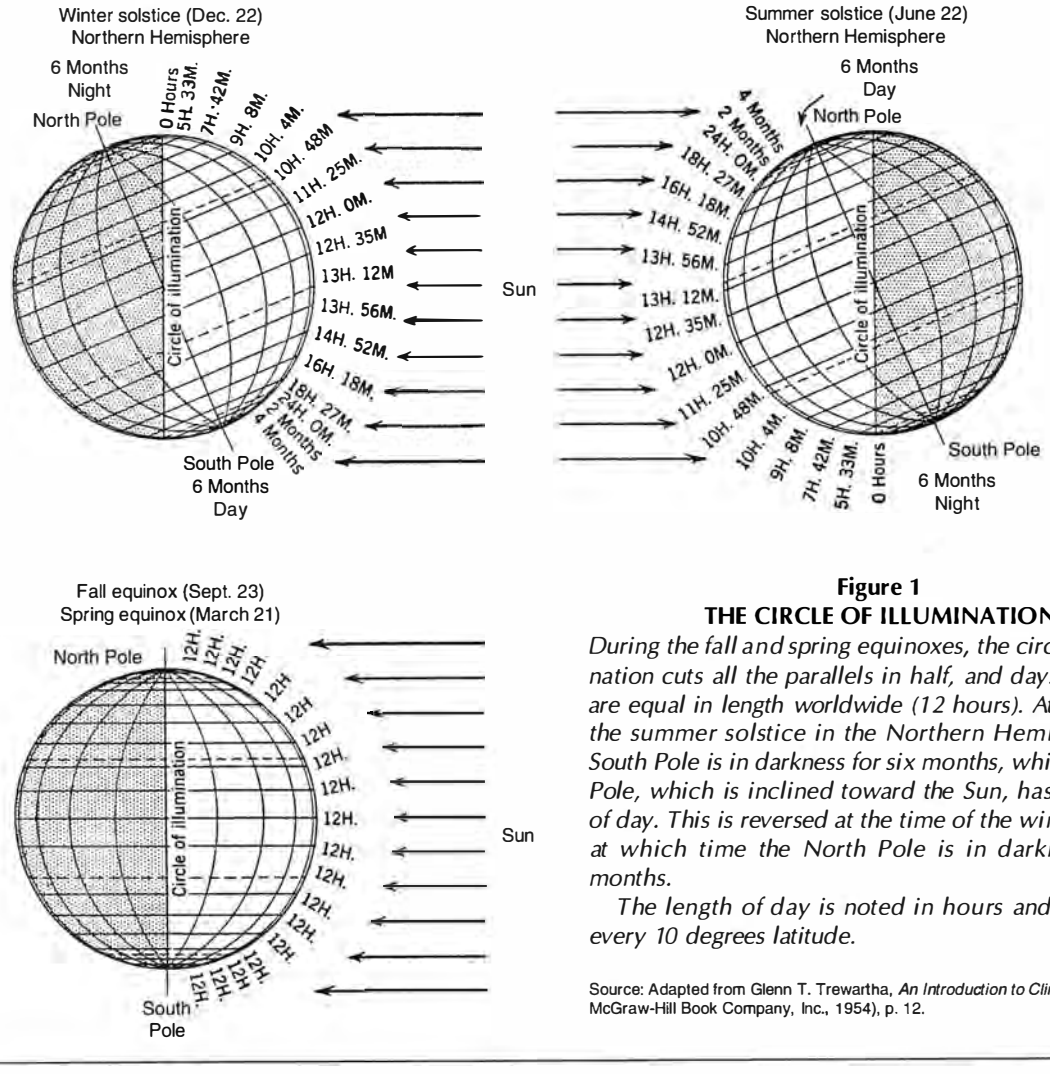


Figure 1
THE CIRCLE OF ILLUMINATION

During the fall and spring equinoxes, the circle of illumination cuts all the parallels in half, and days and nights are equal in length worldwide (12 hours). At the time of the summer solstice in the Northern Hemisphere, the South Pole is in darkness for six months, while the North Pole, which is inclined toward the Sun, has six months of day. This is reversed at the time of the winter solstice, at which time the North Pole is in darkness for six months.

The length of day is noted in hours and minutes at every 10 degrees latitude.

Source: Adapted from Glenn T. Trewartha, *An Introduction to Climate* (New York: McGraw-Hill Book Company, Inc., 1954), p. 12.

early Antarctic spring. The following spring, a colleague who was located at Resolute, North West Territories, had the same experience. At that time, I assumed that they had not properly calibrated their instruments. Now that I look back, I suspect that, in fact, neither instrument was faulty, but that there was simply no ozone to be measured!

We know that, when ultraviolet radiation impinges on oxygen in its diatomic form, the excited molecule can split to produce two oxygen atoms. This atomic oxygen is unstable and quickly takes one of two paths; it will pair up with another oxygen atom and become a diatomic oxygen molecule again, or it will join a diatomic oxygen molecule and become the triatomic form of oxygen (ozone). The process is ongoing just so long as ultraviolet radiation of sufficient strength impinges on the atmosphere.

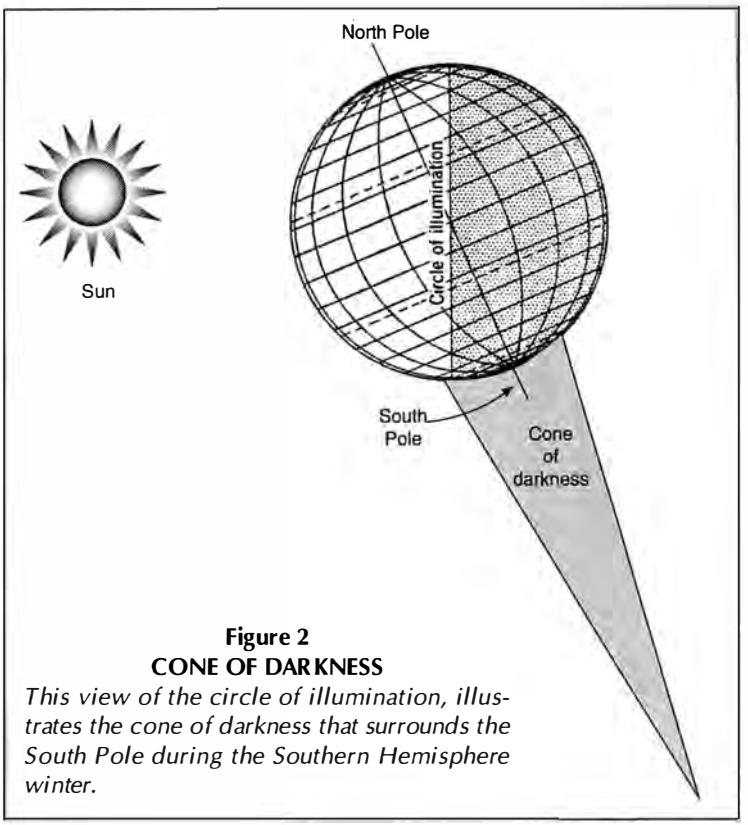


Figure 2
CONE OF DARKNESS
This view of the circle of illumination, illustrates the cone of darkness that surrounds the South Pole during the Southern Hemisphere winter.

Winter's Cone of Darkness

During the Antarctic winter, when the Sun is well north of the equator, there is a large cone of darkness which envelopes this area, thus robbing it of ultraviolet radiation. Under such conditions, there is no ozone being made, and the oxygen system becomes very stable and is composed almost entirely of the normal diatomic form of oxygen. During winter in the Northern Hemisphere, the same is true, as the apparent position of the Sun is well south of the equator.

This cone of darkness is effectively much larger than that which the geometry would dictate. Immediately outside that cone of darkness, solar radiation must pass through an extremely thick layer of atmosphere and has what is called an extremely high *mu* value—path-length through the atmosphere. The scattering and absorption of this layer renders ultraviolet radiation ineffective in the production of new ozone.

As a result, the cone of ultraviolet radiation darkness is very much expanded.

However, the circumpolar circulation patterns of the Antarctic and the Arctic are quite different. In the Antarctic, the circulation has a strong tendency to be zonal, which generally prevents the advection of ozone from more northerly latitudes. In the Northern Hemisphere, the circulation pattern is much more meridional, and expressed as Rossby waves, which quite often penetrate well into the high Arctic, thus advecting some ozone.

A Natural Phenomenon

Accordingly, one could expect serious ozone deficiencies during the winter, and, especially, the spring months at both polar regions, with this deficiency somewhat more pronounced in the Antarctic. I would suggest that this is a quite natural phenomenon, which existed well before the use of CFCs or any other refrigerant.

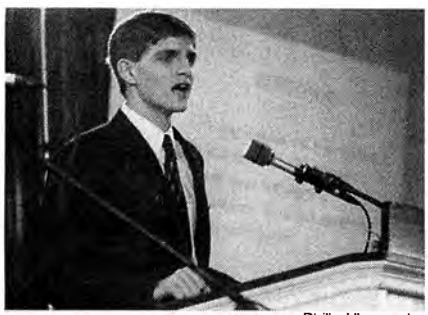
In contrast to the polar geometry, the Edmonton Municipal Airport, where I measured ozone locally, showed a different pattern. I have not reviewed my measured data since 1957-1958, but I do have a recollection that the data showed very high ozone measurements during the winter and very low measurements during hot summer days. I recall these measurements ranging from .450 cm in winter, to as low as .150 cm during hot summer days. I have not seen any recent data, but I would doubt that ozone levels, even today, drop much below .150 cm. Moreover, I further recall that ozone levels varied as warm air aloft began to move in.

I can only conclude that, in some way, ozone was tied into frontal activity, although I was never able to come up with an acceptable hypothesis.

What a terrible pity that some scientists, the environmental movement, and, especially, the politicians jumped on the ozone depletion bandwagon at Montreal, thus introducing HCFCs while punishing those who persist in using CFCs. I sincerely hope that my refrigerator, which is relatively new, is using CFCs as a refrigerant rather than deadly HCFCs. It is enough that I have to suffer the foolishness of proposed global warming without having to worry that a fault in my refrigerator may bring on an attack of acute hepatitis.

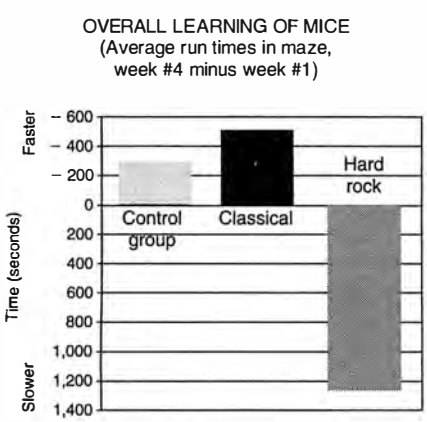
Julian Kinisky, now retired, worked as a meteorologist for 45 years, and lives in Calmar, Alberta.

NEWS BRIEFS



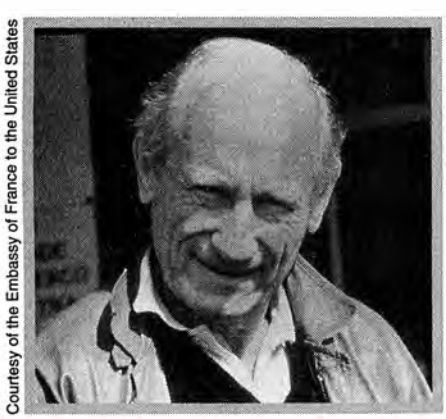
Philip Ulanowsky

David Merrell on his project: "It's too bad that it's not a subject that is widely publicized, because I found multiple areas of research, which are extremely significant."



The mice that listened to classical music learned faster than the control group, while the mice that listened to hard rock (Anthrax) went downhill.

Source: Courtesy of David Merrell



Courtesy of the Embassy of France to the United States

Haroun Tazieff (1914-1998)

CLASSICAL MUSIC IMPROVES THE MINDS OF MICE—AND MEN

Mice that listened to the music of Mozart daily improved their cognitive skills (the ability to run through a maze) over those of normal mice, while those subjected to hard-rock music became so aggressive that they literally killed each other within days. These were the research findings of David Merrell, a 17-year-old high school student in Virginia, whose two-year science project has won top honors in regional and state science fairs. Merrell presented his findings at a Feb. 7 symposium in Washington, D.C., sponsored by the Committee for Excellence in Education Through Music and the Schiller Institute. A detailed report on Merrell's speech appears in "Classical Music Improves the Mind!" by Marianna Wertz, *The New Federalist*, March 2, 1998.

U.S. NUCLEAR ENERGY RESEARCH INITIATIVE IS POSITIVE, BUT LIMITED

In its fiscal year 1999 budget request for the Department of Energy (DOE), the Clinton Administration has included a Nuclear Energy Research Initiative, to be funded at a level of $24 million next year. It is the only worthwhile line item in the $2.7 billion that the White House is proposing be spent on its Climate Change Initiative over the next five years, the rest going mainly for "energy efficient" appliances, buildings, and automobiles. According to Bill Magwood, from the DOE Office of Nuclear Energy, the Initiative responds to the recommendation by the President's Committee of Advisors on Science and Technology (PCAST), which recognized the strategic importance of nuclear energy as a "carbon-free" electricity source.

The government will not set any long-term goal for nuclear energy, Magwood said, but will fund peer-reviewed research proposals in nuclear technology. He expects that research in advanced reactors, advanced nuclear fuel, and proliferation-resistant designs will be proposed, but he does not see a rebirth of high temperature reactor work, or any other large-scale (that is, expensive) technology demonstration. The DOE is interested in developing a small, 50-MW "proliferation-resistant" reactor that would be suited for developing nations with limited infrastructure. The DOE, Magwood said, is also discussing joint R&D programs with the French nuclear industry.

FRENCH SCIENTIST HAROUN TAZIEFF DIES FEB. 2

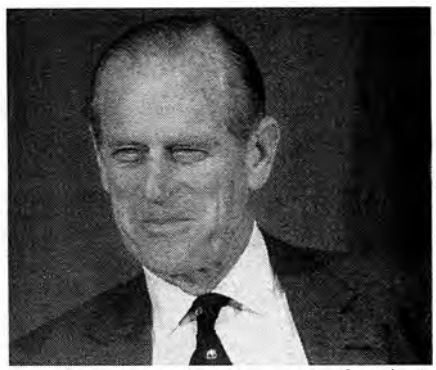
Haroun Tazieff, a volcanologist who was one of France's most beloved scientists, died of cancer Feb. 2, at age 83. After working as an agricultural and mining engineer, Tazieff embarked on a career in volcanology in 1948, during which he led four expeditions to the Erebus volcano in Antarctica.

Although Tazieff was one of the first in France to fight against pollution, he never conceived of it as a fight against progress. When he entered politics in 1981, as the Secretary of State for Natural and Major Risks, Tazieff launched scientific studies of the technology catastrophe scenarios promoted by the greens—the PCB accident at Seveso, nuclear accidents, man-caused climate change. He then publicized his findings, debating the non-science of the catastrophe supporters. In his foreword to *21st Century*'s book *The Holes in the Ozone Scare,* Tazieff talks of his political career and "the quite solitary path that I followed in discovering that the catastrophes announced by great blowing of the trumpets are no more than windmills for naive ecologists to tilt at."

Tazieff never sacrificed the search for truth nor compromised for the sake of his career or media approval. As he wrote in the Spring 1996 issue of *21st Century* about "finance-corrupted 'scientists'" in the ozone mafia: "I do not hesitate to compare this big brainwashing enterprise and deliberate lying, to that of the Comintern between 1920 and 1955, which induced tens of millions of left intellectuals to transform themselves into as many militants willfully made stupid."

PRINCE PHILIP BRINGS TOGETHER WORLD BANK, GREENS, AND RELIGIONS

The World Wide Fund for Nature (WWF), presided over by Prince Philip, and a WWF offshoot, the Alliance of Religion and Conservation, sponsored a conference Feb. 18-19 in London of top religious and World Bank leaders for the purpose of shaping "the underlying philosophical assumptions and axioms in economics . . . in an era when the nation-state is crumbling, and must be superseded."



Stuart Lewis

Prince Philip wants to supersede the nation-state and "weed" out most of the human race.

BBC TELEVISION HITS MYTHS OF OVERPOPULATION, ENVIRONMENTALISM

A three-part series on the British Broadcasting Corp. Channel 4, which aired in November and December 1997, attacked major features of green ideology, including the myth of overpopulation. According to a just-received summary transcript, the broadcasts presented arguments showing that global warming is a hoax, that the environment in the developed world is improving, that overpopulation is a lie, and that the greens are fascists.

"It can be argued that Africa is underdeveloped precisely because it is underpopulated," the BBC said. "[I]f there are more people, there will be more ideas, which in turn will lead to better technology and an improved quality of life. In the West, every indicator of quality of life has improved as the population has grown."

As for green fascism, the broadcast noted that "Greens are often portrayed as left-wing radicals, battling against a backward-looking establishment. But they are in fact part of a long tradition of conservatism that idealizes nature and the past. . . . The most notorious environmentalists in history were the German Nazis. . . . Adolf Hitler and other leading Nazis were vegetarian and they passed numerous laws on animal rights." Although the broadcasts included many themes familiar to *21st Century* readers, the BBC refrained from noting the Nazi roots of Prince Philip.

7,000-YEAR-OLD SOLAR OBSERVATORY FOUND IN BAVARIA

A team of archaeologists, headed by geophysicist Helmut Becker, has discovered a 7,000-year-old solar observatory in Bavaria of "unbelievable precision," according to a report in the Feb. 14 German daily *Frankfurter Rundschau.* The elliptical constructions at the Landau-Meisternthal observatory site were used as a solar calendar, to determine the solstices and equinoxes. The newspaper report notes that "the neolithic engineers must have had a knowledge of mathematics, astronomy, and geometry far exceeding that of most people today." There are similarities to the Stonehenge constructions in Britain, but the Bavarian observatory is about 2,000 years older.

RADON REPORT FAILS TO CONSIDER IMPORTANT EVIDENCE, RSH SAYS

In a preemptive press conference Feb. 18 in Washington, D.C., the Radiation, Science, & Health (RSH) organization urged reporters and science writers to look carefully at the National Research Council's report on radon and health, and "judge whether all contradictory evidence has been properly considered. . . ." The report, "Health Effects of Exposure to Radon," was scheduled for release the following day. RSH expected—correctly—that the report would continue recommending strict limitations on radon, even though the data show that radon is "not only harmless even at the highest levels encountered in homes, but that it might even be beneficial." The radon report does not even consider the work of radiation expert Prof. Bernard L. Cohen, whose study measured radon in 350,000 homes and found that the higher the radon level, the lower the cancer rate—the opposite of the assumptions of the current regulatory model.

RSH charged that "hundreds of billions of dollars are being committed to protect people from a natural environmental condition that has never been shown to be hazardous."

ALL CHERNOBYL'S VICTIMS

A Realistic Assessment of Chernobyl's Health Effects

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

Fear of radiation, reinforced by press scare stories and unwise policies, has created a shocking number of psychosomatic illnesses in the Chernobyl region. A leading radiation expert reviews the situation, and scores the faulty assumptions of the radiation regulatory agencies.

P. Pellerin

The damaged Chernobyl nuclear plant in 1992.

The 11 years that have passed since the Chernobyl catastrophe are more than enough for a realistic assessment of both the early and the late health effects of the nuclear accident.

The early effects are those deaths caused by acute radiation sickness, and thermal and mechanical injuries, while the late radiation effects are cancers and hereditary diseases. In this latter group, the maximum number of excess deaths caused by radiation-induced leukemias appear three to five years after exposure, and of solid cancers after nine to eleven years (Darby, et al. 1987). Thus, these late effects, if any, should now be visible.

It was expected that such late effects would occur among three categories: (1) the 106 persons who survived acute radiation sickness after receiving very high doses of radiation; (2) the several million inhabitants of contaminated regions in Ukraine, Belarus, and Russia who received doses comparable to their average natural lifetime dose; and (3) the 600,000 to 800,000 accident recovery workers ("liquidators"), who received similar doses in the 30-km zone around the Chernobyl reactor (Table 1).

As I shall show, by far the largest group affected are those people in the three post-Soviet countries (Ukraine, Belarus, and Russia) whose real, but psychosomatic health effects are caused not by radiation, but by the policy and actions of the political and regulatory authorities, and by the mass media.

Several large international projects, and many hundreds of studies, were dedicated to examining the effects of Chernobyl. Their results were presented at various international symposia over recent years (the largest to date was: "One Decade after Chernobyl: Summing up the Consequences of the Accident," Vienna, Austria, in April 1996) and in the scientific literature. Information now available allows us to estimate the true impact of Chernobyl. Unfortunately, the mass media often play down, or ignore, publications which show the effects of this catastrophe in a rational perspective. Instead they perpetuate the scare stories.

For the anti-nuclear lobby, the Chernobyl disaster was a godsend for the promotion of radiophobia: irrational fear of ionizing radiation. When the Chernobyl reactor was still on fire, the mass media were filled with false and terrifying information. For example, the London *Daily Mail* on April 29, 1986, filled half its front page with the words "2000 DEAD," and reported that "80 persons were killed on the spot, 2000 died on way to hospital," and their bodies "are not buried at the cemeteries, but at Pirogovo, in the radioactive wastes depository."

The next day, *The New York Post* screamed on the front page, "MASS GRAVE," and claimed that 15,000 bodies had been bulldozed into nuclear waste pits. *The National Inquirer* reported, "From Chernobyl, Russia, comes news of a radioactive, 6-foot-tall monster chicken, a pathetic victim of the world's worst nuclear disaster. . . . The chicken is taller than most men and it must weigh close to 250 pounds." One month after the catastrophe, Thomas Cochran from the Natural Resources Defense Council, in Washington, D.C., projected that there would be 110,000 post-Chernobyl cancers in the Soviet Union, Eastern Europe, and Scandinavia (Sweet 1996).

The press coverage has not improved in more recent years. For example, Reuters announced on Oct. 13, 1995, that "800,000 children were hit by Chernobyl, as in a nuclear attack." The BBC Monitoring Summary of World Broadcasts reported on a release from the Ukrainian news agency, UNIAR, Dec. 23, 1995, that "3.3 million people became victims of the accident, among them 1 million children. . . . [M]ore than 125,000 have already died." The British television documentary, "Igor—Child of Chernobyl," stated that "1 million children were heavily deformed." The Polish daily *Dziennik Polski* wrote on Feb. 8, 1996, that there were "100 Chernobyl deaths per day," and a "permanently increasing number of leukemia cases." And in 1996, Greenpeace announced that 30,000 persons had already died as the result of post-Chernobyl cancers (Sweet 1996).

Table 1
ACUTE RADIATION EFFECTS IN EMERGENCY WORKERS

Dose range (mGy)	Number of patients with acute radiation sickness	Number of deaths
800-2,100	41	0
2,200-4,100	50	1
4,200-6,400	22	7
6,500-16,000	21	20
Total	**134**	**28**

Source: Adapted from Ilyin 1995

Faulty Assumptions

Perhaps the most important factor in creating the Chernobyl mythology was the assumption that any radiation dose, even one close to zero, has some detrimental effect. This assumption, on which the International Commission on Radiological Protection (ICRP) based its regulations (ICRP 1959), is called the linear hypothesis, or the linear no-threshold hypothesis. This holds that there is no threshold, or limit, below which the effects of radiation (that are known and observed at high doses) cease to appear.[1]

This assumption, however, contradicts experimental and epidemiological observations, which show that low doses of ionizing radiation are beneficial for living organisms. As the well-known Swedish radiobiologist, Prof. Gunnar Walinder, has documented, the current radiation protection and ICRP regulations, based on the linear no-threshold assumption, are a real health hazard (Walinder 1995).

Walinder's statement fits the Chernobyl aftermath: The application of the ICRP regulations and recommendations, by Soviet and post-Soviet authorities, has dramatically increased the suffering, morbidity, and impoverishment of people in vast regions of Ukraine, Belarus, and Russia.

The staggering numbers of Chernobyl deaths, so often cited by the media, are *not* a result of epidemiological observations. Sometimes, in fact, they are pure lies, as in the UNIAR report, or the British TV documentary noted above. More often, they are simply *estimates,* calculated using the linear no-threshold hypothesis, as a simple extrapolation of the effects of the atomic bombs observed in Hiroshima and Nagasaki. But in these Japanese cities radiation doses were higher by orders of magnitude, and were absorbed in a period shorter by a factor of 10^{15}, than were the doses from the Chernobyl fallout.

No epidemiological data exist to indicate that a linear, dose-effect relationship holds in the Chernobyl situation. Protracted radiation doses, such as those from Chernobyl, are much less effective than the single short-term ones. Further, the radiation doses from Chernobyl fallout *are lower than the 200 mSv level below which* ***no*** cancers were detected at Hiroshima and Nagasaki. As Prof. Walinder has stated, "The hypothetical nature of this calculational method (based on the linear no-threshold dose-response assumption) is completely unscientific, and I consider it to be more or less criminal to specify figures of this kind, bearing in mind the damage and anxiety they can provoke. . . ."

Early Effects

At the time of the accident, there were about 470 people on the site of the Chernobyl Nuclear Power Plant: about 200 personnel on duty, about 250 construction workers, and about 20 firemen and guards on-duty. Among them, 134 (about one third) were diagnosed with acute radiation sickness, or ARS (Ilyin 1995). These ARS patients received high radiation doses, and 28 of them died in the first four months after the accident (Table 1).

The death of 26 of these patients was associated with radiation skin lesions involving more than 50 percent of the total body surface area. Two more patients died during the first few days as a result of severe thermal burns and mechanical accidents. One further death was thought to have been the result of coronary thrombosis. Thus, the total number of deaths caused by the early effects of the Chernobyl accident amounts to 31.

Late Radiation Effects

Acute radiation sickness patients. Over the last 10 years, 14 persons have died, among the 106 ARS patients who survived the acute phase. These later deaths (caused by car accidents, lung gangrene, coronary heart disease, tuberculosis, thigh sarcoma, and so on) are not directly attributable to radiation exposure (Wagemaker et al. 1996). However, there must be follow-up of the surviving ARS patients for the next two or three decades, to distinguish between any radiation-related diseases and confounding factors intrinsic to the population.

Inhabitants of contaminated regions in the former Soviet Union and elsewhere. The late effects in the inhabitants

Table 2
DISTRIBUTION OF WHOLE BODY DOSES 1986-1989 AMONG INHABITANTS OF REGIONS CONTAMINATED WITH >555 KBQ/M² OF CS-137

Dose (mSv)	Number of persons
5-20	88,000
20-50	132,000
50-100	44,000
100-200	1,500
200-250	420
>250	250
TOTAL	**273,000**

Source: Adapted from Barkhudarov, et al. 1994

of contaminated regions can be estimated from epidemiological observations, and on the basis of the radiation dose they received from the deposited radionuclides.

The greatest contamination covered several regions in Belarus, Ukraine, and Russia, often in the form of islands, tens and hundreds of kilometers away from Chernobyl. Contamination with cesium-137 above 185 kBq/m² covered 1,530 km² in Belarus, 8,130 km² in Russia, and 4,630 km² in Ukraine (Anonymous 1996a). About 1.06 million people lived in these regions. Even in the regions contaminated above 555 kBq/m², only a small number of persons (about 670) received whole-body radiation doses higher than 200 mSv, in the years 1986 to 1989 (Table 2).

It should be noted that below the dose of 200 mSv, epidemiological studies in Hiroshima and Nagasaki did not find an increased incidence of cancers (UNSCEAR 1994). However, the former Soviet Union carried out a mass relocation of people from areas where the radiation contamination from cesium-137 was even lower—37 kBq/m²) (Anonymous 1996b).

There were also islands of high contamination in regions remote from the former Soviet Union. For example, in the Oppland region of Norway, contamination with radiocesium reached 104 kBq/m² (Backe et al. 1986), and in Gävle region in Sweden, it reached about 200 kBq/m² (Snihs 1996). Such islands, with radiocesium contamination reaching up to 120 kBq/m², were also found in Greece, Romania, Switzerland, Austria, and southern Germany.

The average deposition density of cesium-137 in Europe, outside the former Soviet Union, ranged from 20 Bq/m² in Portugal to 23,000 Bq/m² in Austria. These deposition densities of cesium-137 were usually measured in a 10-cm-thick layer of soil, and they can be compared with the average content of natural radionuclides (potassium-40, 14 members of the uranium-238 family, and 10 members of the thorium-228 family) in the same volume of soil or rock (Table 3).

Even in highly contaminated areas of the former Soviet Union, the level of cesium-137 is lower than the level of natural radionuclides. In Europe, outside the former Soviet Union, the amount of cesium-137 from Chernobyl is two to three orders of magnitude lower than the level of natural radionuclides, and in most regions is lower than or similar to the average deposit from the nuclear weapons tests of 5,000 Bq/m².

The average, whole-body radiation doses received in the period 1986-1995, in the most contaminated regions of the former Soviet Union, were lower, by a factor of 3, than the average lifetime doses that the population of the Earth receives from natural radiation sources (Table 2). However, in regions with high natural radiation background—where, in India, for example, people have been living for 30 generations—the typical, average, whole-body doses are *more than 20 times higher* than the doses in contaminated parts of Ukraine, Belarus, and Russia from which people were evacuated.

No adverse health effects have been found in these regions of high natural radiation. To the contrary, some of the residents of these areas have been found to live longer and have fewer cancers (for example, see Jaworowski 1997).

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has estimated the whole-body doses from Chernobyl fallout for inhabitants of the Northern Hemisphere. These data suggest that the average lifetime (70-year) doses will range from 0.004 mSv in Canada, to 2.3 mSv in Bulgaria. In Central Europe, this lifetime dose will reach about 1 mSv; that is, about 0.6 percent of the average natural lifetime dose of about 180 mSv.

About 74 percent of the whole-body dose from the Chernobyl fallout comes from cesium-137, 20 percent from cesium-134, 1 percent from iodine-131, and 5 percent from other radionuclides (UNSCEAR 1988).

Now, for comparison: The average radiation dose from the natural radioactive gas radon-222, is about 25 times higher indoors than outdoors (UNSCEAR 1988). In Poland, a country closest to the former Soviet Union, the average annual whole-body dose of radiation from indoor inhalation of radon is 1.4 mSv. An average Pole, who remains at home for about 15 minutes longer, daily, for 70 years, will receive from radon an additional dose of natural radiation equivalent to that of the Chernobyl fallout (that is, 1 mSv in 70 years). Thus, to eliminate the imaginary carcinogenic effect of whole-body irradiation from the Chernobyl fallout in Poland, it is sufficient to

Table 3
AVERAGE CONTENT OF CS-137 FROM THE CHERNOBYL AND NUCLEAR TEST FALLOUT AND OF NATURAL RADIONUCLIDES IN 10-CM-THICK LAYER OF SOIL (IN BQ/M²)

Cs-137 from Chernobyl: Europe outside the former Soviet Union	20-23,000	UNSCEAR 1988
Cs-137 from Chernobyl: Contaminated regions of the former Soviet Union	40,000-5,000,000	OECD 1996
Cs-137 from nuclear tests: Central Europe	5,000	UNSCEAR 1993
Natural radionuclides: K-40, members of the U-238 and Th-228 families	177,000-6,500,000	UNSCEAR 1982

remain outdoors daily for 15 minutes longer than usual.

No Cancer Increases Found

The whole-body doses from Chernobyl, outside the former Soviet Union, are so small, that no increase in cancer or in the incidence of hereditary diseases should be expected. Indeed, no increase that could be related to Chernobyl radiation has been found. Epidemiological studies in 19 European countries also reveal no increase of the incidence of Down's syndrome after May 1986 (De Wals et al. 1988).

In three studies, there was a statistically significant increase of Down's disease reported from Berlin, Scotland, and Sweden, but radiation from the Chernobyl accident was regarded as an unlikely factor in this increase (Burkard et al. 1997). Also, in the former Soviet republics with the highest Chernobyl fallout, there was no change of congenital anomalies found that might be associated with radiation (Little 1993). This finding agrees with the earlier observations in Hiroshima and Nagasaki, where no increase in genetic effects has been observed among offspring of survivors of the atomic bombings (UNSCEAR 1994).

No increase in the incidence of solid cancers or leukemia, that could be attributed to Chernobyl radiation, has been detected in countries outside the former Soviet Union (Cardis et al. 1996; Parkin, et al. 1996). An increase in infant leukemia was reported from Greece (Petridou et al. 1996), in children exposed *in utero* to about 0.33 mSv of Chernobyl radiation, and from Germany exposed to about 0.49 mSv (Michaelis et al. 1997). Petridou et al. (1996) interpreted their results as indicating a two-fold to three-fold increase of infant leukemia in Greece resulting from Chernobyl radiation. However, after analyzing these Greek and German results, Michaelis et al. (1997) concluded that the observed leukemia increase in both countries was *not* caused by uterine exposure to ionizing radiation from the Chernobyl accident.

In the highly contaminated regions of the former Soviet Union, no increase in leukemia or solid cancers was found, except for thyroid cancers (see below), in a study carried out four years after accident by a group of 200 international experts (ICP 1991), and in later studies (Cardis et al. 1996).

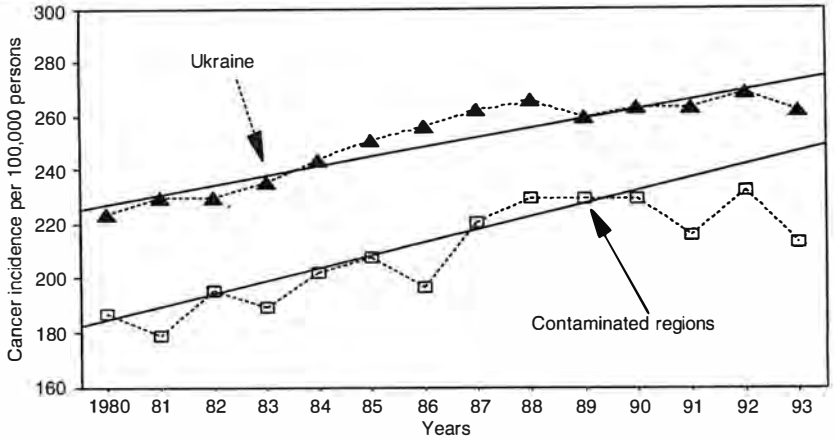


Figure 1
INCIDENCE OF ALL MALIGNANT NEOPLASMS IN CONTAMINATED REGIONS OF UKRAINE, AND IN ALL UKRAINE

Source: Prisyazhniuk et al. 1995

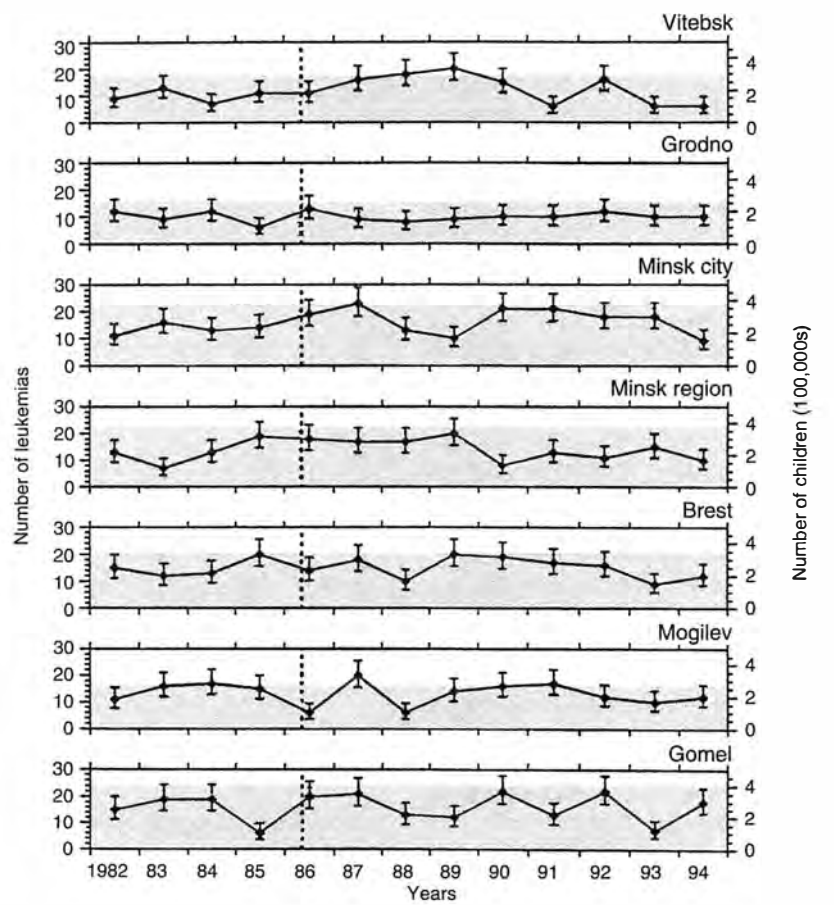


Figure 2
NUMBER OF NEW LEUKEMIAS IN CHILDREN IN CONTAMINATED REGIONS OF BELARUS

The shaded area shows the number of all children.

Source: Ivanov et al. 1996

The incidence of all cancers in the contaminated regions of Ukraine has increased systematically in time (Figure 1), as it does in the majority of other countries, mostly because of the aging of the population (Zatonski 1993). In the contaminated regions of the Ukraine, this incidence is lower than the average for the country. In the contaminated regions of Belarus, the incidence of leukemia (a maximum of which should appear by about 1991) did not change between 1982 and 1994 (Figure 2).

The majority of people living in contaminated regions received radiation doses ranging between 5 and 100 mSv. Epidemiological studies of survivors of nuclear attacks on Hiroshima and Nagasaki show that, at such doses, a *decrease* of leukemia incidence, not an increase, can be expected. This has also been shown for leukemia and solid cancers by numerous epidemiological studies of people working in the Canadian, American, and British nuclear industries; of patients irradiated during X-ray diagnostics; and people irradiated in villages in the Eastern Urals, after a thermal explosion in a Soviet military facility (see review in Jaworowski 1997).

"Liquidators." The follow-up of the recovery operation workers in Belarus, Ukraine, and Russia is much more active than that of the general population of these three countries. The intensity of this screening, in fact, may greatly influence the observed incidence of diseases. Among the "liquidators" general incidence of diseases (980 per 1,000 men of working age per year) is about 25 percent lower than among the general population of Russia (1,300 per 1,000), and no increase in the rate of leukemia was observed (Tukov and Dzakoeva 1993).

According to Logachev, et al. (1993), the number of all neoplasms in "liquidators" from Ukraine did not increase during the the first seven years after accident. Among the "liquidators" from Belarus, the incidence of cancers was lower than in the general population by 22 percent (in men), and 9 percent (in women) (Okeanov et al. 1996). Well-organized studies, based on comparisons with appropriate control groups have shown identical morbidity and mortality for "liquidators" and for other population groups (Logachev et al. 1993; Nilova et al. 1995; Okladnikova et al. 1992).

Table 4
AVERAGE WHOLE-BODY RADIATION DOSES AFTER CHERNOBYL AND FROM NATURAL SOURCES

Population	Dose (mSv)	Duration of exposure
Chernobyl		
Inhabitants of the most contaminated regions of the former Soviet Union	50-60	1986-1995[a]
Inhabitants of other contaminated regions of the former Soviet Union	6-20	1986-1995[a]
Liquidators	170 130 30 15	in 1986[b] in 1987 in 1988 in 1989
135,000 persons relocated from the 30-km zone around the Chernobyl plant	15	in 1986[c]
In: Europe Asia Northern America	0.15-1.2 0.006-0.12 ~0.003	lifetime (70 years)[d]
In Poland	0.3 0.9	in 1986[e] lifetime (70 years)
Natural		
Worldwide	168	lifetime (70 years)[f]
In regions with high natural radiation, typical dose	1,200	lifetime (70 years)[f]

Sources: (a) Cardis et al. 1996; (b) Sevankaev et al. 1995a; (c) Sevankaev et al. 1995b; (d) OECD 1996; (e) Jagielak et al. 1996; (f) UNSCEAR 1988

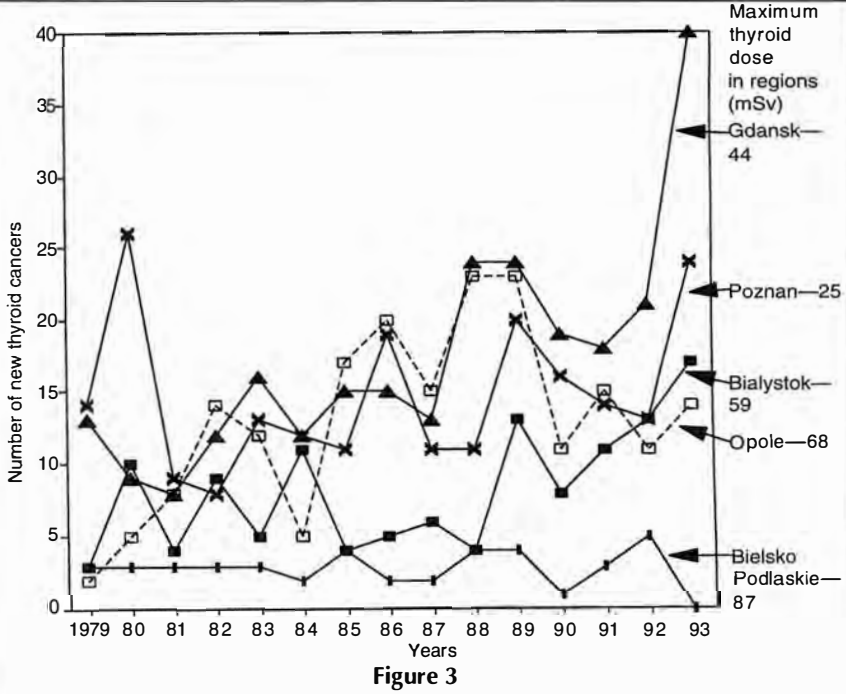


Figure 3
THYROID CANCERS IN INHABITANTS OF FIVE REGIONS (VOIVODITIES) IN POLAND (AGE 0-85 YEARS)

Source: Centrum Onkologii 1979-1996

Thyroid Cancers in Children

Estimating the effects of radioiodine dispersed from the Chernobyl reactor and concentrated in the thyroids of people in contaminated regions, is more difficult than estimating the effects of whole-body irradiation. One reason is that there is great uncertainty in the esti-

Table 5
AVERAGE THYROID DOSES FROM I-131 AND THYROID CANCERS IN CHILDREN

Region	Thyroid radiation dose (mSv)	Thyroid cancers	
		Per 100,000 in 1993 and 1991-1994	Total number in 1986-1995 [increase since 1986]
Belarus (all)	51[a]	3, 4[b]	424 [45][b, c]
Gomel	200[a], 290[c], 1,000[n]	9,4[b]	
Mogilev	70[a], 90[c]	2,4 [b]	
Brest	20[a], 30[c]	6,7 [b]	
Minsk	16[a], 20[c]	1,1[b]	
Grodno	10[a], 15[c]	1,5[b]	
Russia(all)	2[e]		
Contaminated regions	30-63 [d,f]	6[p]	17 [4 in 7 contaminated regions][b,c]
Ukraine(all)	13[g]	0,39[i,j]	211 [4][h,i]
8 contaminated regions around Chernobyl plant	380[j]	1,1[i,j]	
One settlement	3,300[k]		
Kiev	18-104 (aver. 37) [o]		
Total number of cancers 652			
Poland* (all)	—	0,1[l]	24 [2][l]
Western	2-30[m]		
Eastern	10-90[m]		
Opolskie region	9-68[m]		
5 percent children	200[m]		

Notes
* Range of doses

Sources: (a) Gavrilin et al. 1996; (b) Demidchik et al. 1994; (c) Cardis et al. 1996; (d) Zvonova and Balonov 1993; (e) Balonov 1996; (f) Stepanenko et al. 1996; (g) Likhtarev et al. 1995; (h) Tronko et al. 1994; (i) Williams and Tronko 1996; (j) Likhtarev et al. 1993; (k) Williams et al. 1996; (l) Centrum Onkologii 1979-1993; (m) Krajewski 1991; (n) Barkhudarov et al. 1994; (o) Likhtarev et al. 1994a; (p) Remennik et al. 1996.

mates of the thyroid radiation doses received in these regions. In addition, the epidemiological studies of patients receiving radioiodine (iodine-131) for therapeutic and diagnostic reasons, have demonstrated a lesser incidence in thyroid cancers after doses that were higher than those received by inhabitants of contaminated regions.

Although several hundred measurements of radioiodine in thyroid were performed in Belarus, 150,000 in Ukraine, and 60,000 in Russia, these measurements were of poor quality, because of inadequate instrumentation and measurement conditions (OECD 1996). In Poland, the country closest to Chernobyl outside of the Soviet Union, only 1,400 direct measurements of iodine-131 in thyroid were done (Krajewski 1991). Therefore, thyroid doses are usually reconstructed from measurements of other radionuclides, mainly cesium-137, in the environment, foodstuffs, and in the human body. Such reconstructions are subject to great uncertainty.

It is well known that thyroid cancers appear six to nine years after external irradiation with X-rays or gamma rays. No childhood study has found an excess of thyroid cancer within five years of exposure, even after high-dose radiation therapy (Tucker et al. 1991; Ron et al. 1995). However, in the former Soviet Union, the rise in the incidence of thyroid cancer was registered as soon as four years after the accident (Prisyazhniuk et al. 1991; Kazakov et al. 1992), and even after one year (Remennik et al. 1996).

In studies of more than 34,000 Swedish patients who received large doses of iodine-131, and whose thyroid radiation dose reached up to 40,000 mSv (with an average dose of 1,100 mSv), there was no statistically significant increase in thyroid cancers detected in adults or children who had not already been thought to have cancer before treatment with iodine-131 (Holm et al. 1988; Hall et al. 1996). In fact, an opposite effect was observed: there was a 38 percent decrease in thyroid cancer incidence as compared with the non-irradiated adult population.

Similar results were found in other studies in children who received even larger therapeutic doses of iodine-131 (Holm et al. 1991; Tucker et al. 1991; Ron et al. 1995). Maximum thyroid doses in children from the former Soviet Union were not higher than in the Swedish patients. In Belarus, these doses reached above 10,000 mSv in only about 300 children (Ilyin et al. 1990; Zvonova and Balonov 1993; Buldakov 1993). The average thyroid doses in various contaminated regions of the former Soviet Union ranged from 10 mSv to 3,300 mSv (Table 5).

If these estimates of thyroid doses are correct, then, according to Swedish studies of iodine-131, one should not expect any increase in thyroid cancers in Belarus, Ukraine, and Russia. Why, then, during the last 10 years, has the number of registered thyroid cancers in children increased by a factor of 45 in Belarus, and in Ukraine and Russia by a factor of 4 (Table 5)?

The total number of thyroid cancers in children registered until 1995 in contaminated regions of these three countries is about 650, and to date, three children have died OECD 1996). Thyroid cancers are curable in more than 90 percent of the cases (Reiners, et al. 1996).

The Screening Factor

There was also an increase in the incidence of thyroid cancers observed in the adult recovery operation workers ("liquidators") from Russia, Belarus, and Ukraine (Cardis et al. 1996). But it is still not clear whether the observed increase in thyroid cancers is caused by radioactive iodine-131 from the Chernobyl reactor, or by some other factor. The most important among such other factors are probably the increase in screening procedures, and the increased awareness of parents, teachers, and medical doctors (Ron et al. 1992; Beral and Reeves 1992; Shigematsu and Thiesen 1992; Hall et al. 1996; Remennik et al. 1996).

That Chernobyl radiation is a cause of the thyroid cancers in children is suggested by the age distribution of children with these cancers in Belarus and Ukraine: The greatest incidence of these cancers appeared in a group of children

that were 1 to 2 years old at the time of the catastrophe—that is, in the period of when the thyroid gland has the greatest radiosensitivity (Reiners, et al. 1996). However, this group may be the one whose parents were most aware of the need for screening.

The incidence of thyroid cancers was not directly related to the thyroid radiation doses in particular regions (Table 5). For example, among five regions in Belarus, a Brest oblast (region) has the second highest incidence of thyroid cancers, but thyroid radiation doses were lower there than the average in the country; in fact, the Brest doses were similar to those in the region of Minsk, where the lowest incidence of cancer was found. In the Mogilev oblast, thyroid doses were three times as high as in Brest, but the incidence of thyroid cancer was almost three times lower in Mogilev than in Brest.

In a part of Poland adjacent to the Brest oblast (Bialystok and Bielsk Podlaski provinces), where the thyroid doses in children were similar to those in Brest (in the Bialystok province, the average thyroid dose was 20 mSv), there was no increase in the incidence of cancers (Figure 3). There were no increases found in the rest of Poland, even though 5 percent of Polish children had thyroid doses of 200 mSv, which was similar to that of the highly contaminated Byelorussian region of Gomel (Table 6).

In 1993, the highest number of thyroid cancers in Poland were observed in regions where thyroid radiation doses were lowest (Poznan and Gdansk). The lowest number of thyroid cancers were found in the Opole province in southwestern Poland, and Bielsk Podlaski province, which had the highest thyroid doses (Figure 3).

In view of the Swedish studies mentioned above, the radiation doses to the thyroid in Poland were too small to cause the thyroid cancers. The low thyroid doses in Poland may be in part the result of the administration of stable iodine to 10.5 million children and 7 million adults, which saturated the thyroid glands, and thereby partially blocked the uptake of radioiodine of a large portion of the Polish population. (This included about 90 percent of children 0 to 16 years old, 40 percent of youngsters 16 to 19 years old, and 20 percent of adults).

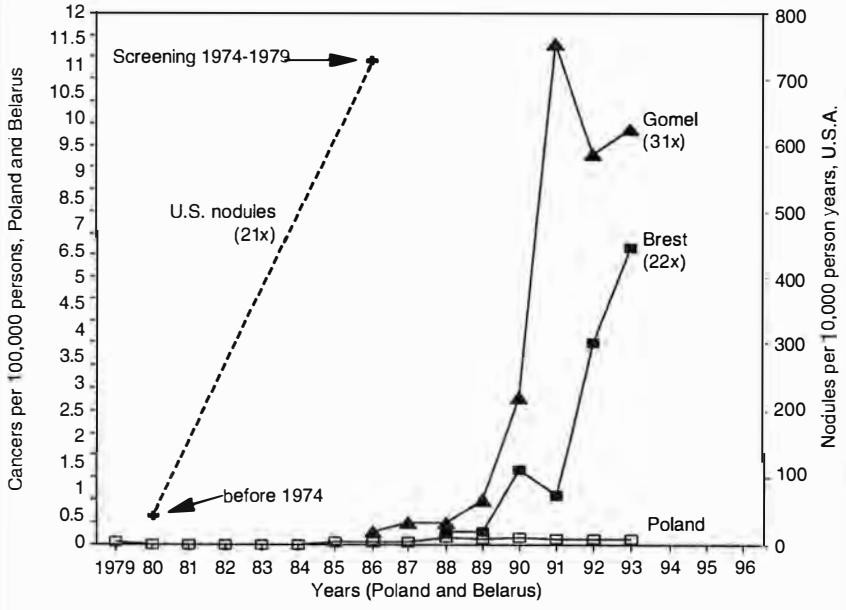


Figure 4
INCIDENCE OF THYROID CANCERS IN CHILDREN

Compared here is the incidence of thyroid cancers in children (per 100,000 persons) in Belarus (age 0-11 years), in Poland (age 0-14 years), and of thyroid nodules in a population group in the United States (among which 68.5 percent were children, age 0-15 years).

Source: Centrum Onkologii 1979-1996; Ron et al. 1992; Demidchik et al. 1994.

Table 6
INCIDENCE OF THYROID CANCERS IN CHILDREN IN POLAND (AGES 0-14 YEARS), IN GOMEL AND BREST REGIONS IN BELARUS, AND IN BRANSK REGION IN RUSSIA

Years	Poland, all country	Belarus, Gomel	Belarus, Brest	Russia, Briansk
1981	0.05	—	—	0.1*
1982	0		—	—
1983	0	—	—	
1984	0	—		
1985	0.05		—	—
1986	0.05	0.05	0.3	—
1987	0.05	0.5	—	0.3
1988	0.15	0.5	0.3	0.3
1989	0.1	1.0	0.3	0.0
1990	0.1	3.3	1.7	0.6
1991	0.1	11.3	1.1	0.0
1992	0.1	8.8	4.5	0.6
1993	0.1	9.4	6.7	0.3
1994	—	—	—	2.5

Notes
*Estimate for years 1981-1986.

Source: Centrum Onkologii 1979-1993; Demidchik et al. 1994; and Remennik et al. 1996.

The lack of increase of registered thyroid cancers in Poland, however, was probably caused by a more important factor, of a political, not a radiological nature. As opposed to Belarus, Ukraine, and Russia, neither eastern Poland, nor any other parts of Poland, were declared "contaminated," and there were no economic or psychological motivations for increased awareness by parents and medical staff, and for a change in the number and quality of medical examinations.

If such motivation were present, then one would expect a multifold increase in the number of thyroid cancers in Poland—or in any other country. Such an increase might also occur after the implementation of an epidemiological project which aimed to detect any increase in thyroid cancer. This is because of the very high number of hidden thyroid cancers, those with no clinical manifestations, which occur in normal populations (Fransilla and Harach 1986; Harach et al. 1985).

Table 7
INCIDENCE OF OCCULT THYROID CANCERS IN NORMAL POPULATIONS, OBSERVED AT AUTOPSIES, AND MAXIMUM INCIDENCE OF CLINICALLY DIAGNOSED THYROID CANCERS IN CHILDREN IN BELARUS

Country	Incidence per 100,000 persons
Colombia	5,600
Canada	6,000
Poland	9,000
USA (contiguous)	13,000
Hawaii	28,100
Japan (Sendai)	28,400
Japan (Hiroshima and Nagasaki)	28,400
Finland	35,600
Belarus (Gomel)	11.3

Sources: Harach, et al. 1985; Table 5

Diagnosed, Undetected Thyroid Cancers

In normal populations, the incidence of clinically diagnosed thyroid cancers ranges from less than 0.5 per 100,000 men (in the United States and Central Europe) to 8 per 100,000 among Chinese and Filipinos living in Hawaii. The corresponding numbers for women are 1.0 (in Poland) and 24 (Filipinos in Hawaii) (Zatonski et al. 1996). The occult thyroid cancers, which are detected in autopsies by histological studies, occur in normal populations with an incidence that is thousands of times higher—ranging from 5,600 per 100,000 persons in Colombia to 35,000 per 100,000 persons in Finland (Table 7). In younger age groups (0 to 15 years), the incidence of occult cancers in Finland is lower (2,400 per 100,000).

These occult cancers are of the same papillary type as those found in Belarus, and show the same invasive growth pattern (Fransilla and Harach 1986). Thus, the potential for detection of "excess" thyroid cancers, after improving or intensifying the diagnostics, is enormous, and could lead to even greater incidence than those found in the highly contaminated region of Gomel in Belarus, where the incidence of 11.3 thyroid cancers per 100,000 children was reported to have been caused by Chernobyl radiation.

That undetected cancers and changes in diagnostics may dramatically influence the number of registered thyroid cancers, is indicated in the results of a screening study in the United States of people who had received radiation treatment for the head and neck. As Figure 4 shows, during the most active period of screening in 1974-1979, the incidence rate of malignant and other thyroid nodules was greater by 21-fold than the incidence of such disease before 1974. This increase is of the order of that seen in Belarus (Ron et al. 1992). Thus, the increased number of thyroid cancers registered in the former Soviet Union may be an effect of intensification and improvement of diagnostics, rather than a real effect of radiation.

Non-Radiation Effects

Nearly 5 million people in the former Soviet Union have been affected by severe psychological stress, leading to psychosomatic diseases (Filyushkin 1996). This real harm outweighs any hypothetical radiation risk caused by low-level radiation in contaminated areas.

The psychological stress was inflicted on inhabitants of contaminated areas by convincing them that it was fatally dangerous to live there, even though the radiation level in these areas was lower than natural radiation in many countries where people have lived since time immemorial, without any signs of detriment to their health.

Those responsible for bringing on these mass stress effects are the mass media in the Soviet Union and elsewhere, the ill-advised political decisions of the Soviet and post-Soviet governments, and the established system of radiation standards based on the linear no-threshold hypothesis developed by the International Committee on Radiation Protection. The medical profession also played an important role in this, based on a knowledge of radiation effects formed more by the mass media than university science curricula.

Many doctors interpreted the various symptoms of common diseases as the effects of Chernobyl irradiation. This was common in Poland and in other European countries outside the Soviet Union, where, because of incompetent medical advice, probably several hundred thousand abortions of "wanted" pregnancies were carried out in order to avoid nonexistent radiation damage to the fetus (Trichopolous et al. 1987; Spinelli and Osborn 1991, Czeizel 1994).

In the countries of the former Soviet Union, misdiagnosis reached such a catastrophic scale, that even a sore tooth or dryness of mouth was regarded as a Chernobyl effect (ICP 1991)! Further, an imaginary, nonexistent new disease was tailor-made there for the post-accident situation: "vegetative distonia," supposedly caused by Chernobyl radiation. This diagnosis, with no definitive diagnostic tests, was assigned by parents and doctors to account for various childhood complaints, and accepted by adults as an explanation for vague symptoms. At any one time, up to 1,000 children were hospitalized in Kiev alone, often for weeks, for treatment of this nonexistent "disease" (OECD 1996).

During the past 10 years, mass media and political figures of the former Soviet Union have tried their best to convince the people in contaminated regions of Belarus, Ukraine, and Russia that Chernobyl radiation endangers their health and life. More that 55 percent of inhabi-

PAP/CAF

Children in Poland taking stable iodine in a Lugol solution, after the Chernobyl accident, to prevent the thyroid from absorbing radioactive iodine. Stable iodine was administered to 18.5 million children and adults in Poland just after the accident in 1986.

tants of both contaminated, and non-contaminated, regions of Belarus believe that the Chernobyl accident causes their psychological stress (Ageeva 1996). This belief has led to increase of the incidence of psychosomatic sufferings *not* related to radiation, such as: diseases of endocrinological system, circulatory and gastrointestinal diseases, depression and other psychological disturbances, headaches, sleeping disturbances, difficulties in concentration, emotional instability, inability to work, and so on (ICP 1991; WHO 1995; Ivanov and Tsyb 1996).

Victim Creation

This problem was aggravated by the official declaration that millions of people should be categorized as "Chernobyl victims." Laws were passed and implemented to give these victims financial compensation, called by the locals a "coffin subsidy." In the Ukraine alone, this category encompassed about 3 million people, and the costs involved total one-sixth of the state budget (OECD 1996).

In the impoverished Belarus, such subsidies will total $86 billion (U.S.) by 2015 (Rolevich 1996). For millions of recipients of these subsidies, each time they sign a receipt for their monthly money, it confirms that they really are the "victims of Chernobyl." For who would pay them such funds if there were not a real health detriment being suffered, or if there were not a situation of radiation risk, which sooner or later will cause such detriment?

Nobody tells these "victims" that their small radiation doses (averaging 6 mSv to 60 mSv in various regions), or the higher doses of the "liquidators" (170 mSv in 1986) are below the level of 200 mSv at which an increase of cancer incidence was detected in Hiroshima and Nagasaki. Nor are they told that in these Japanese cities, irradiated survivors of nuclear attack live longer than the non-irradiated survivors, and that no increase of congenital diseases was detected in their offspring.

Unnecessary Relocation

The second important cause of non-radiation health effects is the legislation (currently in force) that prescribed relocation of 850,000 people, and implemented relocation of about 400,000 inhabitants of contaminated regions (Ilyin 1995; Anonymous 1996a; Filyushkin 1996). Relocation was continued even in 1992. It caused the destruction of family and community social networks and of workplaces, and exposed the relocated persons to resentment and ostracism in new localities, where old inhabitants treated them as privileged intruders.

In spite of these drawbacks, about 70 percent of the people living in contaminated areas wished to be relocated, probably influenced both by fear of radiation, and by the economic incentives and hopes for improved living standards that might result from relocation by the government (OECD 1996).

At first, relocation was performed in areas where the lifetime dose (that is, the dose received over a period of 70 years) might be higher than 350 mSv (about double the average natural radiation dose). Later, this lifetime limit was changed to 150 mSv (which corresponds to an annual dose of about 2.1 mSv), and then to 70 mSv (1 mSv per year). For a comparison: The average global natural radiation dose is 2.4 mSv per year. This relocation decision was taken in 1990 by the Supreme Soviet, under pressure from the pseudo-experts coming from ecological, populist, and nationalist groups (Ilyin 1995; Filyushkin 1996).

Relocation was a drastic measure, the declared aim of which was to protect health, and specifically to protect against DNA damages in somatic cells (which could induce cancers) or in genetic cells (which could increase congenital diseases). The facts are that irradiation of the human body with a dose of 1 mSv per year—the level at which relocation was started—causes in each cell about 0.2 damage of DNA per year, or 14 damages per 70 years. These radiation-induced DNA damages are of the same several types as spontaneous damages caused by other factors; only the proportion of particular types differs.

The number of spontaneous (natural) DNA damages, for example, caused by the body's thermodynamic processes and the action of free radicals (such as OH,

peroxides, and reactive oxygen species) is 70 million in one cell per year (Billen 1990). This number gives an indication of the power of DNA repair mechanisms, and other mechanisms of homeostasis, which in the flood of physical-chemical changes preserve the integrity of organisms both during the individual's life, and over thousands of generations.

"Nobody tells these 'victims' that their small radiation doses (averaging 6 mSv to 60 mSv in various regions), or the higher doses of the 'liquidators' (170 mSv in 1986) are below the level of 200 mSv at which an increase of cancer incidence was detected in Hiroshima and Nagasaki."

This also shows the absurdity of the mass relocation decision in the former Soviet Union. The aim was to defend the population against about 14 DNA damages per cell over 70 years, whereas in the same time period, as a result of natural causes, there would be 4.9 billion DNA damages per cell! The probability that these 14 DNA damages will cause a cancer—as opposed to a cancer being caused by one of the 4.9 billion spontaneous damages—is 1 in 350 million, which practically means: zero.

According to the linear no-threshold hypothesis, the limits of 350 mSv and 150 mSv, which were accepted for relocation, were supposed to spare the population from 1.75 percent and 0.75 percent increase in the incidence of cancers, respectively. These limits were in agreement with the ICRP recommendations for protection of the public in radiation accidents, which were published two years before the Chernobyl catastrophe (ICRP 1984). In this document, the ICRP recommended relocation in the intermediate phase of an accident, when individual whole-body radiation dose may reach 50 mSv in the first year. This, in the case of Chernobyl radiation, corresponds to a lifetime dose of about 150 mSv. The still-lower limit of 70 mSv was based on the ICRP dose limit of 1 mSv per year for the entire population (Filyushkin 1996).

These ICRP limits are lower by a factor of 4 to 40 than the natural lifetime doses in many inhabited regions of the world (for example, 1,500 mSv in Norway, 2,000 mSv in India, and 3,000 mSv in Iran). In the case of the Chernobyl accident, the implementation of the ICRP recommendations led to disastrous practical consequences: the unnecessary relocation of several hundred thousand people, the unnecessary introduction of an aggravated form of radiophobia with psychosomatic consequences in millions of people in the former Soviet Union.

I doubt, however, that the ICRP would be willing to accept responsibility for these practical consequences of its easy-chair, speculative recommendations.

Chernobyl in History

The initial fatalities caused by ionizing radiation from the Chernobyl accident, total 31 persons: 28 victims succumbed to acute radiation sickness; 3 more persons died during the first few weeks after the accident, as a result of non-radiation factors of the catastrophe. Over the next 10 years, 3 children died as a result of thyroid cancers, but it is not certain whether these 3 fatal cancers, and 679 other thyroid cancers registered through the end of 1995, were caused by the Chernobyl radiation. As noted above, meticulous studies of Swedish patients, in which no increase of thyroid cancers was found after average radiation doses from radioiodine higher than from Chernobyl fallout in the former Soviet Union, indicate that these cancers apparently were not caused by Chernobyl accident.

The average whole-body radiation doses from the Chernobyl fallout to populations of the former Soviet Union were slightly smaller than the average global natural lifetime dose, and smaller by a factor of 4 to 40 than in regions with high natural radioactivity. Even smaller doses were received in other countries. Therefore, it should not be surprising that no increase in the incidence of solid cancers, leukemias, or hereditary diseases that might be caused by the whole-body doses of Chernobyl radiation, was detected in the populations of the former Soviet Union and elsewhere.

Psychosomatic consequences, on the other hand, appeared in a great number of the inhabitants of contaminated regions in Belarus, Ukraine, and Russia. The cause of these psychosomatic consequences was not radiation, or any other physical factor, but hysterical radiophobia, induced by the mass media and improper regulatory policies, based on the linear no-threshold hypothesis and ICRP recommendations.

Apart from enormous economic losses in the former Soviet Union and in other countries, most of which were the result of unwise policy (Becker 1996), in terms of early and late fatalities, the Chernobyl catastrophe should be regarded as a minor one, in comparison with other industrial accidents of the 20th century.

For example, a river dam catastrophe at Vaiont, Italy, in 1963, destroyed five villages and killed 2,600 people. A release of 30 tons of toxic methyl isocyanide from a pesticide factory in Bhopal, India, caused the immediate deaths of 1,762 persons, and more than 15,000 fatalities in all, as of 1996. About 200,000 persons were injured and developed pathological symptoms such as lung and eye ailments, neurological and central nervous system disorders, including paralysis and gastrointestinal, cardiovascular, reproductive, and immunologic abnormalities (for references, see Jaworowski 1996).

It is striking that the two most famous disasters, which are permanently imprinted in the common public memory—Three Mile Island, and Chernobyl—are those with the lowest death tolls (In the case of Three Mile Island, the death toll is 0.) One of the causes of this imbalanced view is the linear no-threshold hypothesis of harm from radiation, which was also the most important factor responsible for starting, and perpetuating, the Chernobyl scare stories. In the coming decade, the refutation of the linear no-threshold hypothesis, should help in shaping a more rational approach to radiation protection of the public, and more realistic estimates of risks from the nuclear industry.

Chernobyl was the worst possible catastrophe of a badly constructed nuclear power reactor, with a complete core meltdown, followed by a free dispersion of radionuclides in the atmosphere. Nothing worse could happen. It resulted in a comparatively minute death toll, amounting to about half of that of each weekend's traffic in Poland. When the irrational rumble and emotions of Chernobyl finally settle down, in the centuries to come, this catastrophe will be seen as a proof that nuclear fission reac-

tors are a safe means of energy production.

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References

L.A. Ageeva, 19a96. "Socio-psychological consequences of the Chernobyl catastrophe for the population of Belarus, and their reduction" (in Russian), International Conference One Decade after Chernobyl: Summing up the Consequences of the Accident. Book of Extended Synopses. (Vienna: IAEA, p. 63-67).

Anonymous, 1996a. The International Conference: "One Decade after Chernobyl—Summing up the Consequences of the Accident," Summary of the Conference Results, IAEA Information Circular, INFCIRC/510, June 7, 1996.

Anonymous, 1996b. Working Material, International Conference: "One Decade after Chernobyl—Summing up the Consequences of the Accident," Environmental Impact and Prospects for the Future (Vienna: IAEA), IAEA/JI-CN-63.

S. Backe, H. Bjerke, A.L. Rudjord, and F. Ugleveit, 1986. "Nedfall av cesium i Norge etter Tschernobylulykken" (Oslo: National Institute of Radiation Hygiene, Report No. 1986-5).

M.I. Balonov, 1993. "Overview of doses to the Soviet population from the Chernobyl accident and the protective actions applied," In S.E. Mervin and M.I. Balonov (eds.), *The Chernobyl Papers. Doses to the Soviet Population and Early Effects Studies,* Vol. 1, pp. 23-45.

———, 1996. "Dose reconstruction for the populations of the former Soviet Union exposed to radioactive contamination as a result of the Chernobyl accident," *Proceedings of the 1995 Annual Meeting of the NCRP* (in press).

R.M. Barkhudarov, L.A. Buldakhov, and K.I. Gordeev, 1994. "Characterization of irradiation levels of the population in the controlled areas within the first four years after the Chernobyl NPP accident" (Moscow: Institute of Biophysics).

K. Becker, 1996. "Some economical, social and political consequences in Western Europe," International Conference One Decade after Chernobyl: Summing up the Consequences of the Accident, Book of Extended Synopses (Vienna: IAEA), pp. 300-301.

V. Beral and G. Reeves, 1992. "Childhood thyroid cancer in Belarus," *Nature,* Vol. 359, pp. 680-681.

D. Billen, 1990. "Spontaneous DNA damage and its significance for the 'negligible dose' controversy in radiation protection," *Radiation Research,* Vol. 124, pp. 242-245.

B. Bovonder, J.X. Kasperson, and R.E. Kasperson, 1985. "Avoiding future Bhopals," *Environment,* Vol. 27, No. 7, pp. 6-37.

L.A. Buldakov, 1993. "A method to reconstruct the radiation dose to the thyroid from incorporated ^{131}I," *Med. Radiol.,* Vol. 6, pp. 20-25.

W. Burkard, B. Grosche, and A. Schoetzau, 1997. "Down's syndrome clusters in Germany after the Chernobyl Accident," *Rad. Res.,* Vol. 147, pp. 321-328.

E. Cardis, L. Anspaugh, V.K. Ivanov, et al., 1996. "Estimated long-term health effects of the Chernobyl accident," International Conference: One Decade after Chernobyl—Summing up the Consequences of the Accident, April 8-12, 1996, Vienna.

Centrum Onkologii, 1979-1996. "Cancer in Poland," Annual reports of the Centrum Onkologii (Warsaw: The Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology).

A.E. Czeizel, 1994. Lecture at BfS/ISH Symposium on Ionizing Radiation in the Low-Level Range in Munich/Neuherberg, Nov. 23, 1994 (After: Becker 1996).

S.C. Darby, R. Doll, and S.K. Gill, 1987. "Long-term mortality after a single treatment course with X-rays in patients treated for ankylosing spondylitis," *British J. Cancer,* Vol. 55, pp. 179-190.

E.P. Demidchik, V.S. Kazakov, L.N. Astakhova, et al., 1994. "Thyroid cancer in children after the Chernobyl accident: Clinical and epidemiological evaluation of 251 cases in the Republic of Belarus," In S. Nagataki (ed.) *Nagasaki Symposium on Chernobyl: Update and Future* (Amsterdam: Elsevier), pp. 21-30.

P. De Wals, F. Bertrand, I. De la Mata, et al., 1988. "Chromosomal anomalies and Chernobyl," *Int.'l J. Epidemiol.,* Vol. 17, pp. 230-231.

I.V. Filyushkin, 1996. "The Chernobyl accident and the resultant long-term relocation of people," *Health Physics,* Vol. 71, pp. 4-8.

K.O. Fransilla and H.R. Harach, 1986. "Occult papillary carcinoma of the thyroid in children and young adults. A systematic study in Finland," *Cancer,* Vol. 58, pp. 715-719.

Yu. Gavrilin, V. Khrouch, S. Shinkarev, et. al, 1996. "Estimation of thyroid doses received by the population of Belarus as a result of the Chernobyl accident," In Eds. Karaglou, G. Desmet, G.N. Kelly, et al., *The Radiological Consequences of the Chernobyl Accident,* Proceedings of the First International Conference, Minsk, Belarus, March 1996. Report EUR-16544, pp. 1011-1020.

M. Goldman, R. Catlin, and L. Anspaugh, 1987. "Health and environmental consequences of the Chernobyl nuclear power plant accident," Report of the U.S. Department of Energy, DOE/ER-0332.

P. Hall, A. Mattsson, and J.D. Boice, Jr., 1996. "Thyroid cancer after diagnostic administration of iodine-131, *Radiation Research,* Vol. 145, pp. 86-92.

H.R. Harach, K.O. Fransilla, and V.M. Vasenius, 1985. "Occult papillary carcinoma of the thyroid. A 'normal' finding in Finland. A systematic autopsy study," *Cancer,* Vol. 56, pp. 531-538.

L.E. Holm, K.E. Wiklund, G.E. Lundell, et al., 1988. "Thyroid cancer after diagnostic doses of iodine-131: A retrospective cohort study," *J. Nat'l. Cancer Inst.,* Vol. 80, pp. 1132-1138.

L.E. Holm, P. Hall, K. Wiklund, et al., 1991. "Cancer risk after iodine-131 therapy for hyperthyroidism," *J. Nat'l. Cancer Inst.,* Vol. 83, pp. 1072-1077.

ICRP, 1959. "Recommendations of the International Commission on Radiological Protection" (Oxford: Pergamon Press), ICRP Publication No. 1.

———, 1984. "Protection of the Public in the Event of Major Radiation Accidents: Principles for Planning" (Oxford: Pergamon Press), ICRP Publication No. 40.

International Herald Tribune, 1996. Associated Press wire story, Nov. 27.

L.A. Ilyin, M.I. Balonov, L. Buldakov, et al., 1990. "Radiocontamination patterns and possible health consequences of the accident at the Chernobyl nuclear power station," *J. Radiol. Proc.,* Vol. 10, pp. 3-29.

L.A. Ilyin, 1995. *Chernobyl: Myth and Reality,* (Moscow: Megapolis).

IPC, 1991. "The International Chernobyl Project. Assessment of radiological consequences and evaluation of protective measures," International Advisory Committee. Technical Report (Vienna: IAEA).

V.K. Ivanov and A.F. Tsyb, 1996. "Morbidity, disability and mortality among persons affected by radiation as a result of the Chernobyl accident: radiation risks and prognosis," Fourth Symposium on Chernobyl-related Health Effects, Tokyo, December 1994.

E.P. Ivanov, G.V. Toloczko, L.P. Shumaeva, et al., 1996. "Childhood leukemia in Belarus before and after Chernobyl accident," *Radiat. Environ. Biophys.,* Vol. 35, pp. 75-80.

J. Jagielak, M. Biernacka, D. Grabowski and J. Henschke, 1996. "Changing environmental radioactivity in Poland during 10 years after Chernobyl accident," Panstwowa Inspekcja Ochrony Srodowiska, Biblioteka Monitoringu Srodowiska, Warsaw, p. 100 (in Polish).

Z. Jaworowski, 1996. "Chernobyl in Poland," In A. Bayer, A. Kaul, and C. Reiners (eds.) *Zehn Jahre nach Tschernobyl, eine Bilanz* (Stuttgart, Gustav Fisher, pp. 281-300).

———, 1997. "Beneficial ionizing radiation," In *What Risk?* (City: Butterworth-Heinemann), p. 151-172 (in press).

V.S. Kazakov, E.P. Demidchik, and L.N. Astakhova, 1992. "Thyroid cancer after Chernobyl," *Nature,* Vol. 359, p. 21.

P. Krajewski, 1991. "Estimate of thyroid committed dose equivalents in Polish population due to ^{131}I intake after the Chernobyl catastrophe. Determination of effectiveness of thyroid blocking with potassium iodide," *Polish J. Endocrinol.,* Vol. 2, No. 2, pp. 189-202 (in Polish).

I.A. Likhtarev, N.K. Shandala, G.M. Gulko, et al. 1993. "Ukrainian thyroid doses after the Chernobyl accident," *Health Physics,* Vol. 64, No. 6, pp. 594-699.

I.A. Likhtarev, G.M. Gulko, I.A. Kairo, et al., 1994. "Thyroid dose resulting from the Ukraine Chernobyl accident. Part I: Dose estimates for the population of Kiev," *Health Physics,* Vol. 66, pp. 137-146.

I.A. Likhtarev, B.G. Sobolev, I.A. Kairo, et al., 1995. "Thyroid cancers in the Ukraine," *Nature,* Vol. 375, p. 365.

J. Little, 1993. "Chernobyl accident, congenital anomalies and other reproductive outcomes," *Pediatr. Perinat. Epidemiol.,* Vol. 7, pp. 121-151.

V.A. Logachev, L.A. Mikhalina, and A.I. Tsvirbut, 1993. "Influence of radiation and non-radiation natural factors on the health of the population of the Mogilev district after the Chernobyl accident, *Medicinskaya Radiol.,* Vol. 6, pp. 19-24 (in Russian).

J. Michaelis, U. Kaletsch, W. Burkart, and B. Groscche, 1997. "Infant leukaemia after the Chernobyl accident," *Nature,* Vol. 387, p. 246.

E.V. Nilova, V.K. Ivanov, and A.F. Tsyb, 1995. "Study of the factors of radiation risk for participants of liquidation of the consequences of the Chernobyl accident," *Vestnik Akademii Medicinskikh Nauk* (in Russian).

OECD, 1996. "Chernobyl Ten Years On. Radiological and Health Impact. An Appraisal by the NEA Committee on Radiation Protection and Public Health" (Paris: Organization for Economic Cooperation and Development, Nuclear Energy Agency) p. 112.

N.D. Okladnikova, N.Ya. Kabasheva, and T.V. Azizova, 1992. "Short-term effects of low doses of radiation in participants in Chernobyl recovery work," Report of the Third All-Union Scientific-Technical Meeting on the Liquidation of Consequences of the Chernobyl Accident.

Vol. 3, Part 1. Zeleny Mys.
D.M. Parkin, D. Clayton, R.J. Black et al., 1996. "Childhood leukemia in Europe after Chernobyl: 5-year follow-up," *Br. J. Cancer,* Vol. 73, pp. 1006-1012.
E. Petridou, D. Trichopoulos, N. Dessypris, et al., 1996. "Infant leukaemia after *in utero* exposure to radiation from Chernobyl," *Nature,* Vol. 382, pp. 352-353.
A. Prisyazhniuk, O.A. Pjatak, V.A. Buzanov, et al., 1991. "Cancer in the Ukraine, post-Chernobyl," *Lancet,* Vol. 338, pp. 1334-1335.
C. Reiners, J. Biko, L. Geworski, M. Olthoff, et al., 1996. "Ergebnisse der therapie bei Kinder mit Schildrüsenkarzinomen aus hochkontaminierten weissrussischen Gebieten," In A. Bayer, A. Kaul, and C. Reiners (Eds.) *Zehn Jahre nach Tschernobyl, eine Bilanz* (Stuttgart: Gustav Fischer, pp. 385-400).
L.V. Remennik, V.V. Starinsky, V.I. Chissov, et al., 1996. "Malignant neoplasm of thyroid in children and in adults on the territories suffered from the Chernobyl accident," International Conference One Decade After Chernobyl: Summing up the Consequences of the Accident, Book of Extended Synopses (Vienna: IAEA, pp. 519-520).
I.V. Rolevich, I.A. Feniks, E.M. Baboshov, and G.M. Lych, 1996. "Social, economic, institutional and political impact of the Chernobyl accident in Belarus," National Statement of Belarus by the Head of Delegation, 6 Session. International Conference One Decade After Chernobyl: Summing up the Consequences of the accident (Vienna: IAEA).
E. Ron, J. Lubin, and A.B. Schneider, 1992. "Thyroid cancer incidence, *Nature,* Vol. 360, p. 113.
E. Ron, J.H. Lubin, R.E. Shore, et al., 1995. "Thyroid cancer after exposure to external radiation: A pooled analysis of seven studies," *Radiation Research,* Vol. 141, pp. 259-277.
A.V. Sevankaev, D.C. Lloyd, A.A. Edwards, et al., 1995. "High exposures to radiation received by workers inside the Chernobyl sarcophagus," *Radiation Protection Dosimetry,* Vol. 59, pp. 85-91.
A.V. Sevankaev, D.C. Lloyd, H. Braselmann, et al., 1995. "A survey of chromosomal aberrations in lymphocytes of Chernobyl liquidators," *Radiation Protection Dosimetry,* Vol. 58, pp. 85-91.
I. Shigematsu and J.W. Thiessen, 1992. "Childhood thyroid cancer in Belarus," *Nature,* Vol. 359, p. 681.
J.O. Snihs, 1996. "Contamination and radiation exposure evaluation and measures in the Nordic countries after the Chernobyl accident," In A. Bayer, A. Kaul, and C. Reiners (Eds.) *Zehn Jahre nach Tschernobyl, eine Bilanz* (Stuttgart: Gustav Fischer, pp. 232-279.
A. Spinelli and J.F. Osborn, 1991. "The effects of the Chernobyl explosion on induced abortion in Italy," *Biomed. Pharmacother,* Vol. 45, pp. 243-247.
V.F. Stepanenko, A.F. Tsyb, and E.M. Parshkov, 1996. "Dosimetric estimation of childhood thyroid cancer cases in Russia after Chernobyl accident," International Conference One Decade after Chernobyl: Summing up the Consequences of the Accident. Book of Synopses (Vienna: IAEA, pp. 210.211).
W. Sweet, 1996. "Chernobyl's stressful after-effects," *IEEE Spectrum,* (Nov.), pp. 27-34.
D. Trichopolous, X. Zavitsanos, C. Koutis, et al., 1987. "The victims of Chernobyl in Greece: Induced abortion after the accident," *British Medical Journal,* Vol. 295, p. 1100.
N. Tronko, et al., 1994. "Thyroid gland in children after the Chernobyl accident (yesterday and today)," In S. Nagataki (ed.) *Nagasaki Symposium on Chernobyl: Update and Future* (Amsterdam: Elsevier, pp. 31-46).
M.A. Tucker, P.H. Morris, J.D. Jones, et al., 1991. "Therapeutic radiation at a young age is linked to secondary thyroid cancer," *Cancer Research,* Vol. 51, pp. 2885-2888.
A.R. Tukov and L.G. Dzagoeva, 1993. "Morbidity among the employees of atomic industry in Russia, who took part in liquidation of the effects of Chernobyl accident," In *Medical aspects of Elimination of Consequences of Chernobyl Accident* (Moscow: Central Institute for Scientific Research, pp.97-99).
A.F. Tsyb, et al., 1992. "Epidemiological analysis of data on liquidators of the Chernobyl accident living in Russia," *Med. Radiol.,* Vol. 9/10, pp. 44-47.
UNSCEAR, 1982. "Ionizing Radiation: Sources and Biological Effects" (New York, United Nations: Scientific Committee on the Effects of Atomic Radiation. United Nations, 773 pp.).
UNSCEAR, 1988. "Sources, Effects, and Risks of Ionizing Radiation" (New York, United Nations: Scientific Committee on the Effects of Atomic Radiation. United Nations, 647 pp.).
UNSCEAR, 1994. "Sources and Effects of Ionizing Radiation" (New York, United Nations: Scientific Committee on the Effects of Atomic Radiation. United Nations).
G. Wagemaker, A.K. Guskova, V.G. Bebeshko, et al., 1996. "Clinically observed effects in individuals exposed to radiation as a result of the Chernobyl accident," Background Paper, Session 1, International Conference: One Decade after Chernobyl—Summing up the Consequences of the Accident, Vienna, Austria, April 8-12.
G. Walinder, 1995. "Has radiation protection become a health hazard?" Kärnkraftsäkerhet & Utbilding AB, Nyköping, 126 pp.
WHO, 1995. "Report of the international project for the health effects of the Chernobyl accident" (Geneva: World Health Organization).
E.D. Williams and N.D. Tronko (eds), 1996. *Molecular, cellular, biological characterization of childhood thyroid cancer,* Experimental collaboration project No. 8, Report of the European Commission EUR-16538.
E.D. Williams, D. Becker, E.P. Demidchik, et al., 1996. "Effects on the thyroid in populations exposed to radiation as a result of the Chernobyl accident," Background paper, Session 2, International Conference One Decade After Chernobyl: Summing up the Consequences of the Accident (Vienna: EC, IAEA, WHO).
W.A. Zatonski, 1993. *Malignant Neoplasms in Poland* (Warsaw: Centrum Onkologii) 206 pp. (in Polish).
W. Zatonski, M. Smans, J. Tyczynski, and P. Boyle, 1996. *Atlas of Cancer Mortality in Central Europe,* (Lyon: International Agency for Research on Cancer, IARC Scientific Publications No. 134), 175 pp.
I.A. Zvonova and M.I. Balonov, 1993. "Radioiodine dosimetry and predictions of consequences of thyroid exposure of the Russian population following the Chernobyl accident," In S.E. Mervin and I. Balonov (Eds.) *The Chernobyl Papers. Vol. I, Doses to the Soviet Population and Early Health Effects* (Richland, Wash.: Research Enterprises Inc., pp. 71-125).

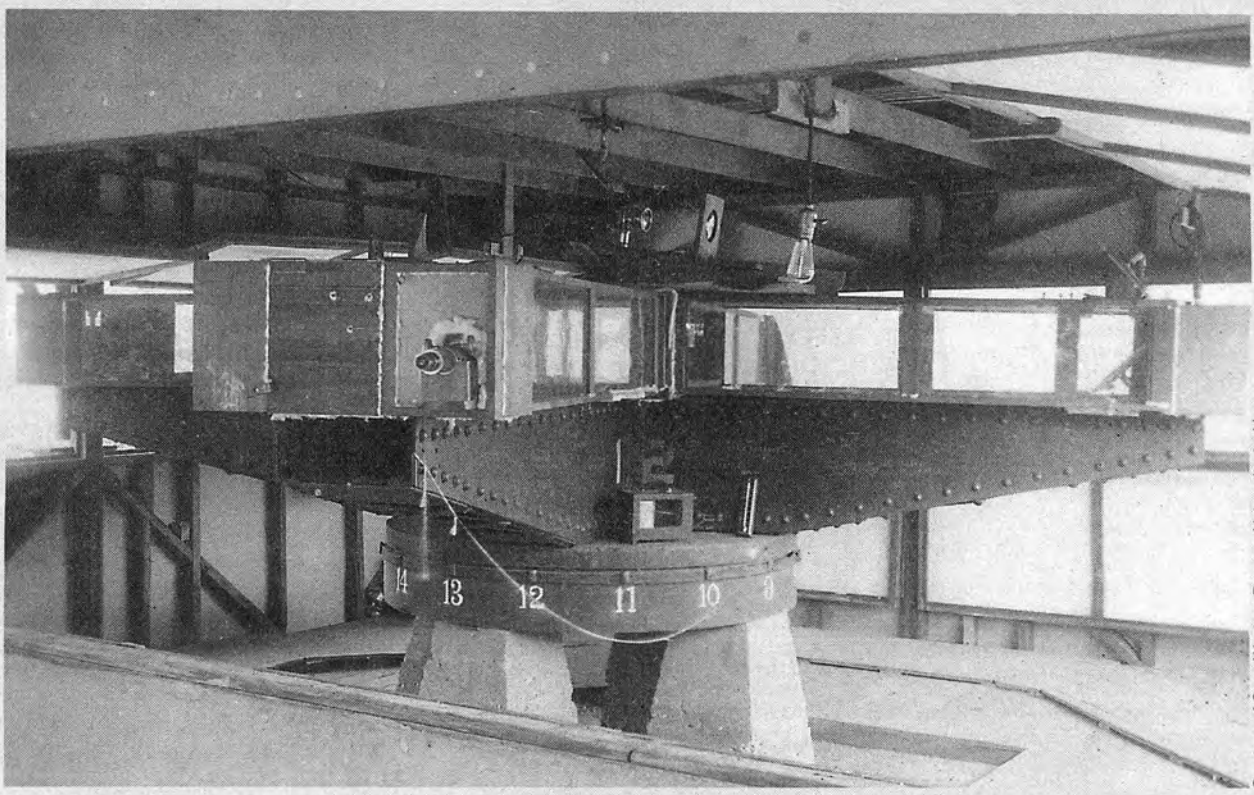
Notes

1. For criticism of the linear no-threshold hypothesis see, for example, T.D. Luckey, "The Evidence for Radiation Hormesis," *21st Century* Fall 1996, p. 12; Z. Jaworowski, "Hormesis: The Beneficial Effects of Radiation," *21st Century,* Fall 1994, p. 22).

Michelson-Morley-Miller: The Coverup

The Experiments of Dayton C. Miller (1925-1926) And the Theory of Relativity

by Maurice Allais



Courtesy of Case Western Reserve University Archives

The interferometer used by Dayton Miller between 1924 and 1926 at the Mt. Wilson Observatory in California.

Einstein's theories of special and general relativity rest on the allegedly null results of Michelson's interferometer experiment. Here, a French physicist and Nobel Laureate in economics, demonstrates that Michelson's results were not null, and that the interferometer experiments of the American scientist Dayton Miller produced positive results, thereby invalidating the foundation of the Theory of Relativity.

Summary: The interferometric observations of Dayton C. Miller in 1925-1926 reveal a very real internal coherence, independent of any spurious effect. They demonstrate that the velocity of light is not the same in all directions, and that it is possible to determine the motion of the Earth in its orbit from purely terrestrial experiments. Accordingly, Miller's experiments invalidate the very foundation of the Theory of Relativity.

1. The Genesis of the Theory of Relativity

In 1900, it was considered, as "well-established," that all attempts to detect, by purely terrestrial experiments, the motion of translation of the Earth had failed.

To explain this *negative* outcome, Lorentz presented *his hypotheses of the contraction of bodies according to their velocities and the local time,* and, following Lorentz, Einstein developed his Special Theory of Relativity (1905), and subsequently, his General Theory of Relativity (1916).

From the formulation of the Special Theory of Relativity stem both the impossibility of detecting the Earth's motion in its orbit, and the invariance of the velocity of light in all directions.

Today, it is everywhere admitted without reservation, *as postulates,* that the velocity of light is independent of its direction, and that no *purely terrestrial* experiment can detect the velocity of translation of the Earth, or even simply its position in its orbit.

2. The Reputedly 'Negative' Outcome of Michelson's Experiment and Miller's Experiments

The principle of Miller's experiments[1] is the same as for Michelson's experiments. According to this principle, the interferometer makes it possible to measure *the difference of the velocity of the light for two perpendicular directions.* In his 1933 paper, Miller presented his observations in the form of eight figures, *four for the azimuths and four for the velocities, in sidereal time, for four periods of continued observations during six or eight days* (Miller 1933, p. 229).

Any appreciation of the scope of Miller's observations boils down to three utterly fundamental questions:

First Question: Do Miller's observations result from mere disturbances (of temperature, for example), or do they *present a very real internal coherence?*

Second Question: Do they permit us to detect variations in the velocity of light according to its direction?

Third Question: Is it possible to deduce the Earth's position in its orbit from these observations?

3. The Very Remarkable Coherence Underlying Miller's Observations Excludes Any Spurious Effect

A very marked coherence appears when one considers the variations in the azimuths and velocities, not in civil time, *but in sidereal time.*

Figures 1 and 2 represent the fittings, with sinusoids *of a period of 24 hours,* of the curves representing velocities and azimuths *in sidereal time. They are on the whole very remarkable.*

1. Dayton C. Miller: "The Ether-Drift Experiment and the Determination of the Absolute Motion of the Earth," *Reviews of Modern Physics,* Vol. 5, July 1933, No. 3 pp. 203-42.

"It is startling that the findings published in Miller's paper in 1933 should have been ignored for 25 years. The outright pigeonholing of Miller's paper strikes me as one of the scandals of contemporary physics."

—Maurice Allais, "Should the Laws of Gravitation Be Reconsidered?," p. 55

The sidereal time θ^* for which the velocity is minimal, and the sidereal time θ^{**} for which the azimuth A is equal to its $\bar{A}$ mean value, and for which $dA/dt < 0$, are *very similar* for the four considered periods (Table 1).

The top parts of Figures 3 and 4 represent the hodographs of velocities for the four periods on the basis of the hourly values of velocities and azimuths *in sidereal time.* [A hodograph is the curve traced out in the course of time by the tip of a vector

Table 1
OBSERVATIONS OF MILLER: SINUSOIDAL FITTINGS WITH A 24-HOUR PERIOD

Velocities

	R	$1-R^2$
Feb. 8	0.361	0.869
April 1	0.981	0.0377
Aug. 1	0.882	0.223
Sept. 15	0.854	0.271

Azimuths

	R	$1-R^2$
Feb. 8	0.856	0.267
April 1	0.939	0.118
Aug. 1	0.970	0.0593
Sept. 15	0.927	0.141

Estimations of θ^* and θ^{**} (in sidereal time)

	θ^*	θ^{**}	$\theta^{**} - \theta^*$
Feb. 8	17.65	18.56	0.91
April 1	14.55	15.48	0.93
Aug. 1	16.50	15.83	−0.67
Sept. 15	17.59	17.78	0.29

R = correlation coefficient
θ^* = sidereal time of the velocity minimum
θ^{**} = sidereal time of the equality $A = \bar{A}$ with $dA/dt < 0$

Sources: Calculations of Figures 1 and 2. The correlations were calculated by this author in February 1996.

representing some physical quantity.] On each graph the $\bar{A}$ mean value is represented.

It is remarkable that on the whole the figures representing the hodographs are approximately *perpendicular* to the directions of the $\bar{A}$ mean azimuths.

The bottom parts of Figures 3 and 4 represent the hodographs deduced from the sinusoidal fittings of the velocities and azimuths. For the four periods, the *calculated* hodographs are *almost exactly perpendicular* to the mean $\bar{A}$ directions of the azimuths *and symmetrical relatively to those directions.* Indeed that is an *even more remarkable circumstance.*

Finally, the figures change gradually from one period to another. They attain their maximum dimensions around Sept. 21, which corresponds to the autumn equinox, and their minimum dimensions around March 21, corresponding to the spring equinox. *They are therefore dependent on the Earth's position in its orbit.*

All these properties, which indisputably correspond to a very marked coherence underlying Miller's observations, allow us to give an unquestionably affirmative answer to the first two fundamental questions of section (2) above.

It is therefore *absolutely wrong* to conclude that Michelson's experiment, as taken up by Miller, gives a negative outcome.

4. The Very Significant Correlation of Miller's Observations with the Earth's Position in Its Orbit

The most significant parameters characterizing Miller's eight fundamental figures are the maximum and minimum velocities V_M and V_m, the $\bar{A}$ mean values of the A azimuths, and the amplitudes A^*_M of their variations around their mean values.

Table 2 gives the direct estimations I made graphically of these parameters through the photographic enlargement of Miller's eight fundamental figures (original observations and running averages of Miller's figures), and that *quite indepen-*

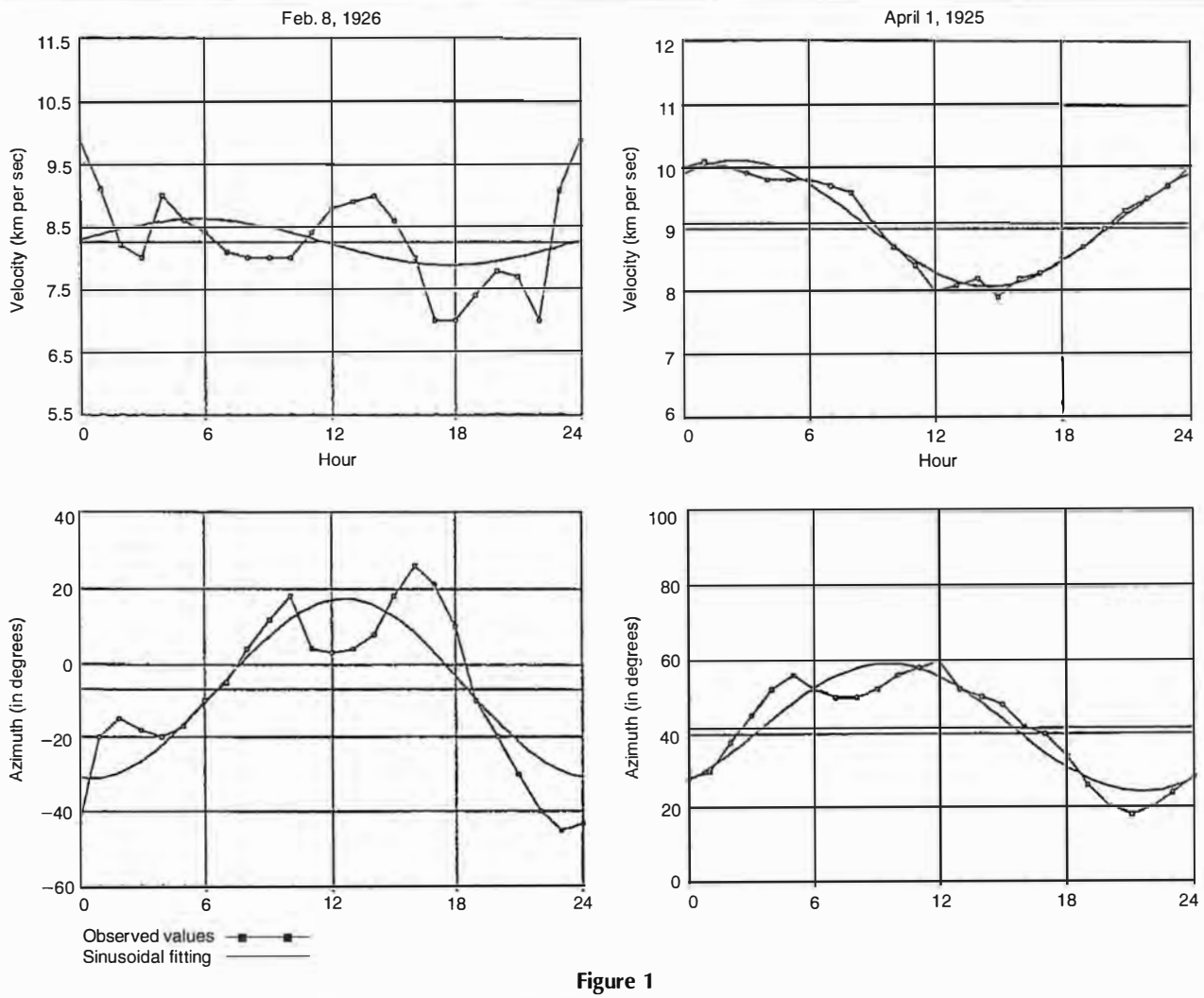


Figure 1
HOURLY OBSERVATIONS OF MILLER: DAILY VELOCITY AND AZIMUTH CURVES
(in sidereal time)

Sources: Hour-by-hour values of the running averages of Miller's figures (Miller 1933, p. 229). The fittings were calculated by this author in February 1996.

dently of any hypothesis or any theoretical interpretation whatsoever.

A thorough harmonic analysis of these parameters shows that *all have a marked semi-annual or annual periodical structure. The maximum and minimum values of the corresponding sinusoidal fittings all occur around the March 21 equinox.*

For lack of space, I must limit myself to commenting on the fittings of Table 3 of the observed data with sinusoids for a period of six or twelve months, *all having their maximum on March 21.*

Although each of the two groups of fittings corresponding to six- or twelve-month periods relates to *only one reference sinusoid with a maximum on March 21,* all the correlation coefficients are relatively high. They are all the more significant as the considered parameters do not

Table 2
FUNDAMENTAL FIGURES OF MILLER: GRAPHICAL ESTIMATIONS OF VELOCITIES AND AZIMUTHS

	Velocities (in km per sec)		Azimuths (in degrees)			
	V_M	V_m	A_M	A_m	$\bar{A}$	A^*_M
April 1, 1925	10	7.8	60	20	40	20
Aug. 1, 1925	11.6	6.5	45	−20	12.5	32.5
Sept. 15, 1925	9.8	4.2	90	20	55	35
Feb. 8, 1926	10	7.3	15	−40	−12.5	27.5

V_M and V_m: maximum and minimum values of velocities
A_M and A_m: maximum and minimum values of azimuths

$\bar{A} = (A_M + A_m)/2$
$A^*_M = (A_M - A_m)/2$
$A^* = A - \bar{A}$

Source: These estimations of V_M, V_m, A_M, and A_m were deduced *graphically* from photographic enlargements of Miller's figures (Miller 1933, p. 229), *independently of any hypothesis.* These estimations were made in June 1995, and have been used for all the calculations of Table 3.

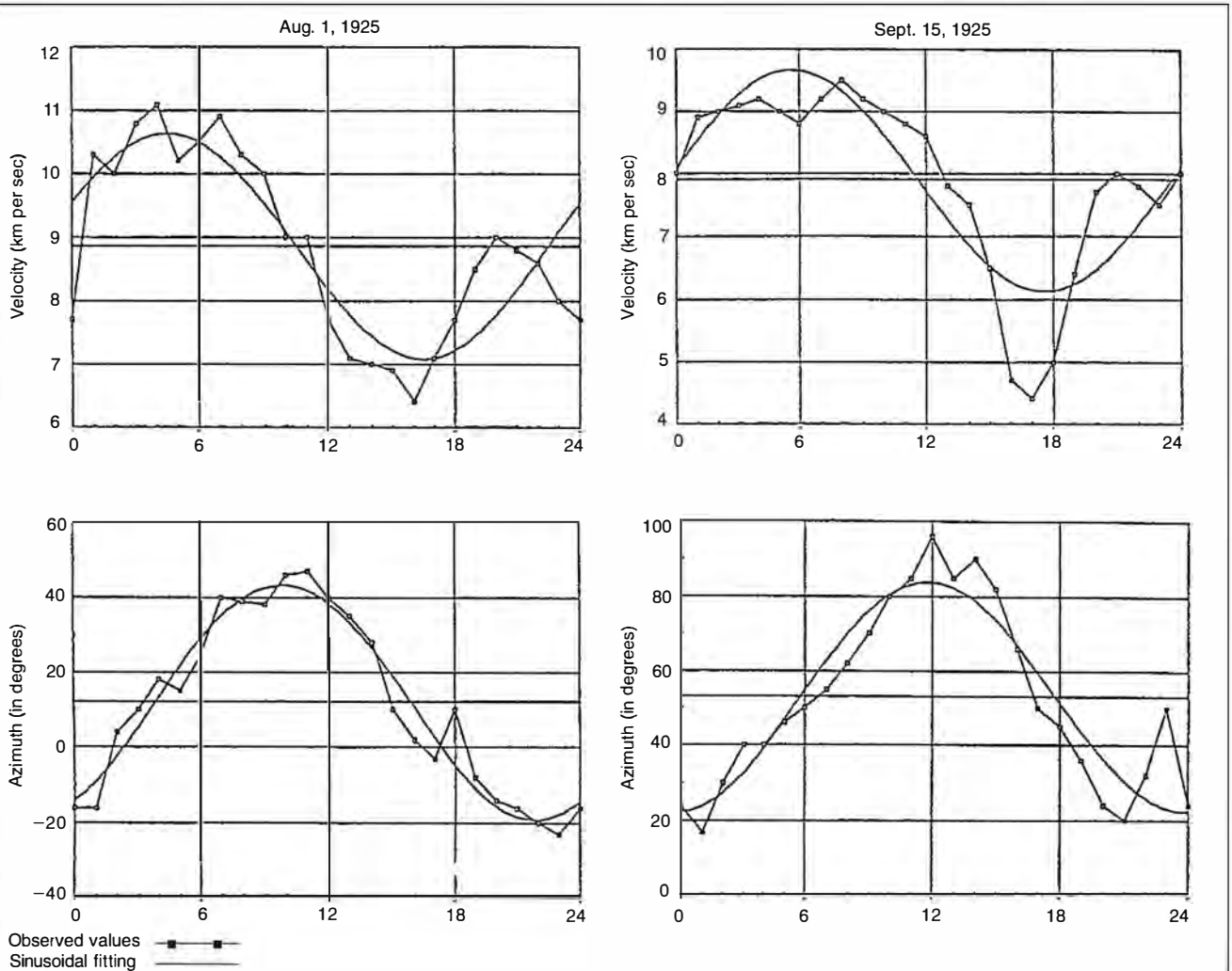


Figure 2
HOURLY OBSERVATIONS OF MILLER: DAILY VELOCITY AND AZIMUTH CURVES
(in sidereal time)

Sources: Hour-by-hour values of the running averages of Miller's figures (Miller 1933, p. 229). The fittings were calculated by this author in February 1996.

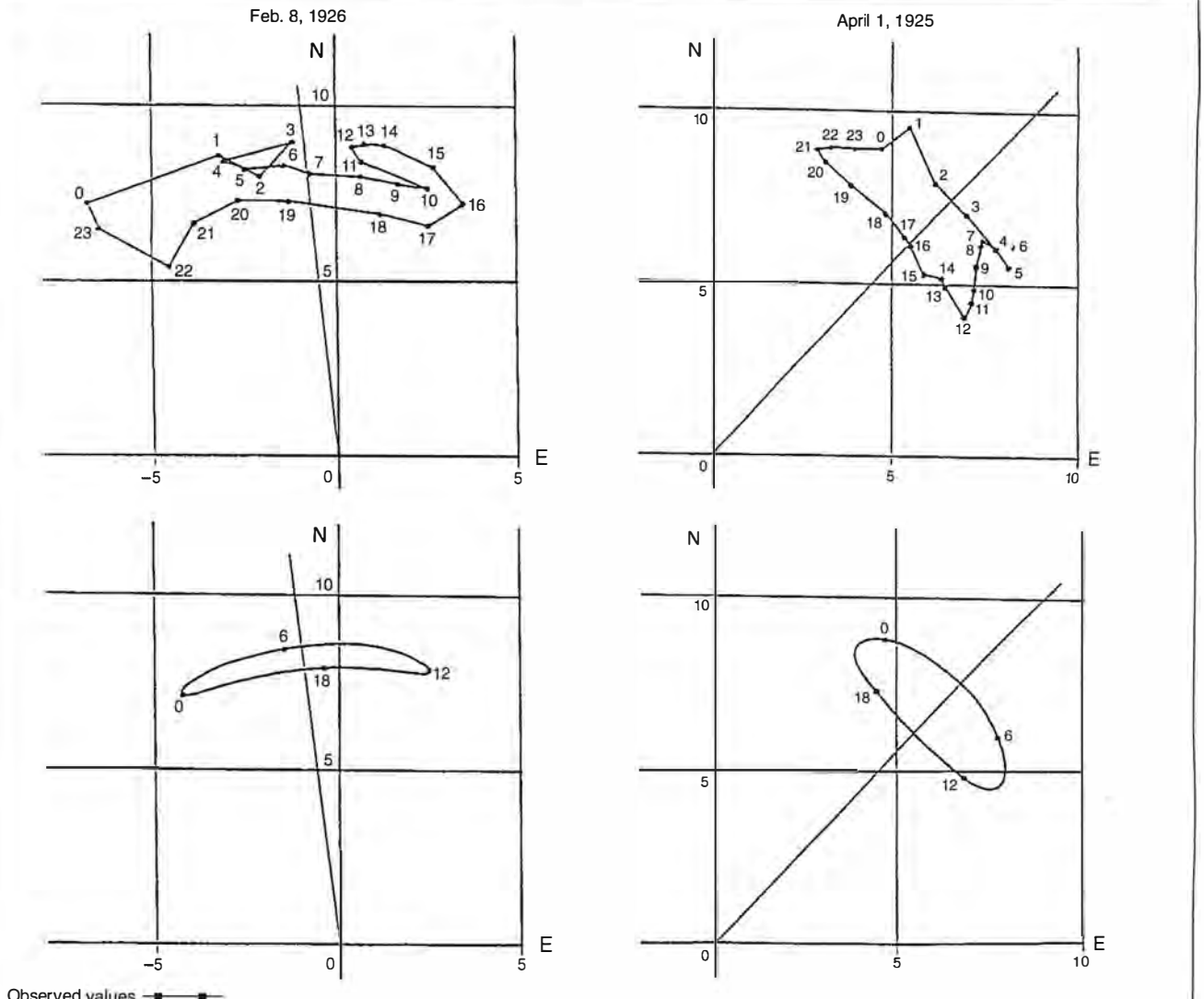


Figure 3
OBSERVATIONS OF MILLER: OBSERVED HODOGRAPHS OF HOURLY VALUES AND CALCULATED HODOGRAPHS DEDUCED FROM THE FITTINGS OF VELOCITIES AND AZIMUTHS

Source: Figure 1

correspond to isolated observations *but to the averages of very numerous observations*. The statistical significance *of the whole* of these results, for semi-annual or annual periods corresponding to fittings *to the same functions, is very high,* and amounts to a quasi-certainty.

Thus it may be considered as perfectly established that the observations corresponding to the four series of experiments have a semi-annual or annual periodicity centered on March 21, the date of the spring equinox, and that it is possible through purely terrestrial experiments, to determine the Earth's position in its orbit.

An affirmative answer must therefore be given, *in all certainty,* to the *third question* of section (2) above.

5. Interpretation of Miller's observations

The above analysis leads to a fourfold conclusion:

- First, there is *a considerable and absolutely indisputable coherence* between Miller's interferometric observations, and it *corresponds to a very real phenomenon.*
- Second, *it is quite impossible* to attribute this very marked coherence to fortuitous causes or to spurious effects (of temperature, for example).
- Third, *the velocity of the light is not invariant in all directions.*
- Fourth, all Miller's observations display *a very marked correlation* with the Earth's position in its orbit.

These conclusions are *independent* of any hypothesis and of any theoretical analysis whatsoever.

Most of the results, on which these conclusions are founded, particularly the most significant ones, *were not perceived by Miller.*

On the basis of his own analysis, Miller considered it possi-

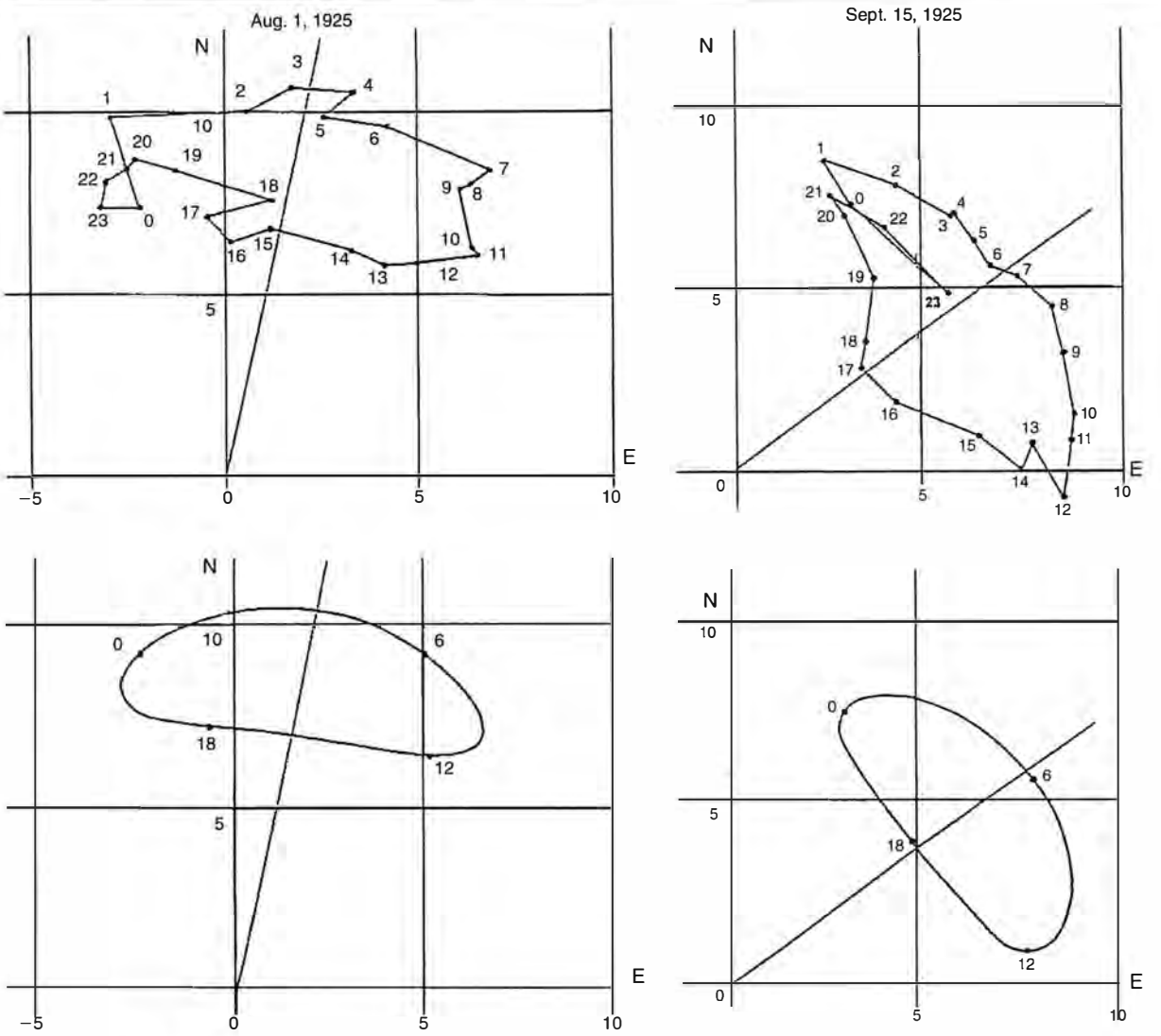


Figure 4
OBSERVATIONS OF MILLER: OBSERVED HODOGRAPHS OF HOURLY VALUES AND CALCULATED HODOGRAPHS DEDUCED FROM THE FITTINGS OF VELOCITIES AND AZIMUTHS

Source: Figure 2

ble to provide an estimation of the cosmic velocity of the Earth in relation to its orbital velocity (Miller 1933, pp. 230-237). *However, Miller's analysis only considers the A - $\bar{A}$ differences, and does not provide any explanation for the mean deviations $\bar{A}$ of the azimuths and their variations from one period to another* (Miller 1933, pp. 234-235).

Consequently, the interpretation given by Miller to his observations cannot be considered as valid.

In fact, it is possible to show that the observed velocities and azimuths can be explained by the conjunction of two effects:

- *an optical anisotropy of space in the* direction $\bar{A}$;
- *an effect proportional* to the total velocity of the Earth (orbital velocity + cosmic velocity toward the Hercules constellation).

6. The Significance and Scope of Miller's Observations

The very basis of the Special and General Relativity Theory rests on a triple postulate: the reputedly "negative" result of Michelson's experiment; the invariance of the speed of light in all directions; and the impossibility of detecting the absolute motion of the Earth, through any purely terrestrial experiment.

However, *with regard to the analysis above,* it is certain that *it is impossible* to maintain that interferometric experiments provide a *"negative"* outcome, that the velocity of the light is *invariant in all directions,* and that any purely terrestrial experiment *cannot determine* the motion of translation of the Earth.

Table 3
OBSERVATIONS OF MILLER: SEMI-ANNUAL OR ANNUAL DOMINANT PERIODICITIES

Fittings to a sinusoid of a period of 6 or 12 months with its maximum on March 21.

Series	Period in months	Correlation coefficient (R)	$1-R^2$
V_M	6	− 0.772	0.404
$(V_M + V_m)/2$	6	− 0.607	0.632
$\bar{A}$	6	+ 0.834	0.305
$\bar{A} + A^*_M$	6	+ 0.744	0.447
$\bar{A} - A^*_M$	6	+ 0.880	0.225
Averages:		$\overline{\lvert R \rvert} = 0.767$	$\overline{1-R^2} = 0.403$
V_m	12	+ 0.880	0.225
$V_M - V_m$	12	−0.9994	0.0012
V_m/V_M	12	+ 0.980	0.041
A^*_M	12	−0.924	0.145
Averages:		$\overline{\lvert R \rvert} = 0.946$	$\overline{1-R^2} = 0.103$
Overall averages:		$\overline{\lvert R \rvert} = 0.847$	$\overline{1-R^2} = 0.269$

Source: Estimations of Table 2

Consequently, the Special and General Theory of Relativity, resting on postulates invalidated by the observation data, cannot be considered as scientifically valid.

As Einstein himself wrote in 1925 in a review in *Science:* "If Dr. Miller's observations were confirmed, the Theory of Relativity would be at fault. Experience is the ultimate judge."

The *"positive"* outcome of Miller's experiments means that *there is no distinction to be made between the rotation of the Earth and its translation* as maintained by the *Theory of Relativity. Both* can be detected through purely terrestrial experiments.

Rejection of the Special and General Theory of Relativity as being incompatible with observational data *cannot in any way mean that all Einstein's contributions should be rejected.* It means only that *all* theoretical developments based on data invalidated by experimental data should be discarded *as such.*

Those contributions of Einstein *that appear to have been confirmed by experience* should naturally be preserved, *but, quite obviously, they must be given a theoretical justification other than that of the Theory of Relativity.*

A theory is only worth what its premises are worth. If the premises are wrong, the theory has no real scientific value. Indeed, the only scientific criterion of the scientific validity of a theory is its confrontation with experimental data.

References

Maurice Allais, 1959. "Should the Laws of Gravitation be Reconsidered?" *Aero-Space Engineering,* Sept., No. 9, pp. 46-52; Oct., No. 10, pp. 51-55; Nov., No. 11, p. 55.

Conference on the Michelson-Morley Experiment (Feb. 4-5), 1927. *Astrophysical Journal,* Vol. 68, (Dec.), pp. 341-402.

Albert Einstein, 1905. "Zur Elektrodynamik bewegter Körper," *Annalen der Physik,* Vol. 17, p. 891.

———, 1916. "Die Grundlage der Allgemeinen Relativistätstheorie," *Annalen der Physik,* Vol. 49, p. 765.

H.A. Lorentz, 1895. "Versuch einer Theorie des Elektrischen und Optischen Erscheinungen in bewegter Körperm," in (Leiden): *Enzyklop. d. math. Wiss., V.,* 1903, p. 2, Art. 14.

———, 1904. "Electromagnetic Phenomena in a System Moving with Any Velocity Smaller Than That of Light," in *Koninklijke Akademie van Wetenschappen te Amsterdam, Proceedings of the Section of Sciences,* Vol. VI, p. 809.

MAURICE ALLAIS

Richard Lomprez

On My Experiments in Physics, 1952-1960

EDITOR'S NOTE

These are excerpts from an autobiographical essay that Allais completed in 1988, the year he received the Nobel Prize in Economic Science. The 20-page essay, titled "My Life Philosophy," appeared in The American Economist, *Vol. 33, No. 2, Fall 1989.*

Allais was born in Paris in 1911, and graduated from the Ecole Polytechnique, first in his class in 1933. He began his professional career as an engineer in the national mining industry, simultaneously working on economics and history. From April 1948 on, he devoted his time to teaching, research, and writing, working in both physics and history. Although he retired in 1980, he has continued to work actively in all these areas.

Allais is the recipient of many awards, including 14 scientific prizes. As he notes in his essay: ". . .[O]ver the past 50 years, I have never stopped reflecting and working on the problems involved in the elaboration of a unified theory of physics."

Whatever the field of application, my whole life has been dominated by the thirst to know more, by the passion for research. I have felt this passion since my early youth; it has since formed the very foundation of my entire existence, and without any doubt, will remain so until the end. . . .

A. Michelson, 1881. "The Relative Motion of the Earth and the Luminiferous Aether," *The American Journal of Science*, Third Series, Vol. 22, Art. XXI, pp. 120-129.
A. Michelson and H. Gale, 1925. "The Effect of the Earth's Rotation on the Velocity of Light," *Astrophysical Journal*, (April), pp. 137-145.
A. Michelson and E. Morley, 1887. "On the Relative Motion of the Earth and the Luminiferous Aether," *The American Journal of Science*, Third Series, Vol. 24, No. 203, Art. XXXVI, pp. 333-345.
Dayton C. Miller, 1925. "The Ether-Drift Experiments at Mount Wilson," *Proceedings of the National Academy of Sciences*, Vol. 2, (April), pp. 306-314.
———, 1926. "Significance of the Ether-Drift Experiments of 1925 at Mount Wilson," *Science*, Vol. 63, No. 1635, (April), pp. 433-443.
———, 1933. "The Ether-Drift Experiment and the Determination of the Absolute Motion of the Earth," *Reviews of Modern Physics*, Vol. 5, No. 3, (July), pp. 203-242.

Research is a sort of adventure full of risks, but a fascinating adventure. When a researcher undertakes some research, he is never sure of success. Very often he fails: reality is contrary to his expectations; and if he carries out an analysis and discovers some new regularity, what he finds is generally not exactly what he was seeking for. . . .

In fact, there is hardly any greater satisfaction for the researcher than that which follows from the achievement of a vast synthesis between elements which at first seemed disparate or contradictory, or the display of new relationships between facts which seemed to have no connection, of regularities previously unrecognized, of invariant relationships in space and time. . . .

The Origin of My Physics Experiments

I believe it is very desirable to state explicitly what was the origin of all my experiments in physics.

I have always held the conviction that the propagation of the gravitational and electromagnetic actions implies the existence of an intermediate medium, the "ether" of Fresnel and the 19th century physicists, but without there being grounds to believe, as was generally considered in the 19th century, that all the parts of that medium are perfectly motionless in relation to fixed stars.

This conviction led me to consider that a magnetic field corresponds to a local rotation of this intermediate medium.

From this, I inferred that a link could be established between magnetism and gravitation by observing the effect of a magnetic field on the movement of a pendulum consisting of a glass ball suspended on a thread of a length of approximately 2 meters.

In order to detect such an effect I began by observing the movement of such a pendulum in the absence of any magnetic field other than that of the Earth. *To my great surprise,* I found out that this movement did not reduce itself to the Foucault effect, but displayed *very significant anomalies* in relation to this effect. It was these *totally unexpected anomalies* which made up the essential object of my experiments from 1953 to 1960.

Of all the *very limited number* of observations made in 1952 and 1953 of the movement of a glass ball oscillating in a magnetic field of the order of a few hundred gauss, *I was not able to draw any definitive conclusion.* With certain experimental devices, I found positive effects, while with others, I obtained no effect whatsoever.

However great, *indeed very crucial,* the importance of these experiments, I was led, given the difficulties to realize a much stronger magnetic field, to interrupt them in order to devote all the resources at my disposal to the study of the anomalies in the movement of a short pendulum, the existence of which had been demonstrated *indisputably* in 1952 and 1953.

Paraconical Pendulum Experiments

In order to study the anomalies detected in the movement of a short pendulum, I made use mainly of a paraconical pendulum, approximately 1 meter in length, consisting of a vertical bronze disc attached to a bronze rod suspended from a stirrup resting on a steel ball.

Indeed, outside any magnetic field other than the Earth's magnetic field, I observed, on the basis of *uninterrupted* observations realized over periods of a month between 1954 and 1960, *very remarkable* anomalies in the movement of the paraconical pendulum. A key finding was the existence of a significant periodicity of the order of 24h 50 min.

Identical results were found in June and July 1958 in two laboratories some 6 km away from each other, one in a basement at Saint-Germain, the other in an underground quarry at Bougival, 57 meters below ground.

Indeed, such a periodic *lunisolar* effect is quite *inexplicable within the framework of the currently accepted theories.*

Optical Sightings

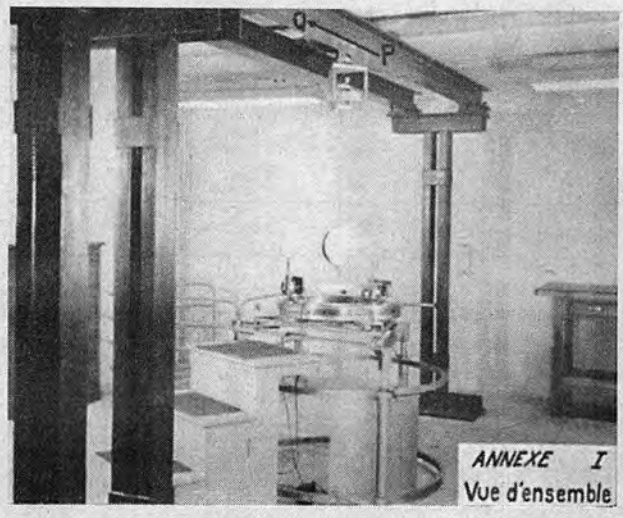
The existence of the anomalies observed in the precision levelling and triangulation operations, compared with the anomalies observed in the movement of the paraconical pendulum, led me to realize, in parallel with my pendulum experiments at Saint-Germain and Bougival in 1958, a series of North-South and South-North optical sightings on fixed sighting-marks. As a result of technical difficulties, it was not possible to realize these optical sightings satisfactorily until the second half of July 1958.

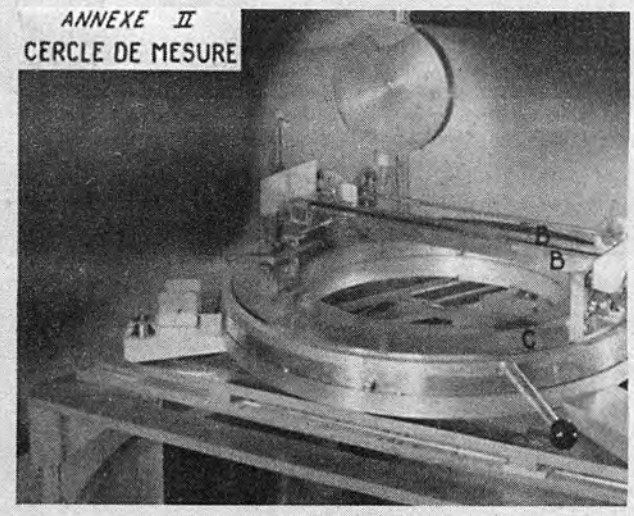
Indeed, I found, in the second half of July 1958, a *remarkable correspondence* between the anomalies of the paraconical pendulum and the anomalies corresponding to reciprocal optical sightings of two theodolites on two sighting-marks borne on the same supports as the theodolites. In any case, these optical anomalies, considered in themselves, are *inexplicable within the framework of the currently accepted theories.*

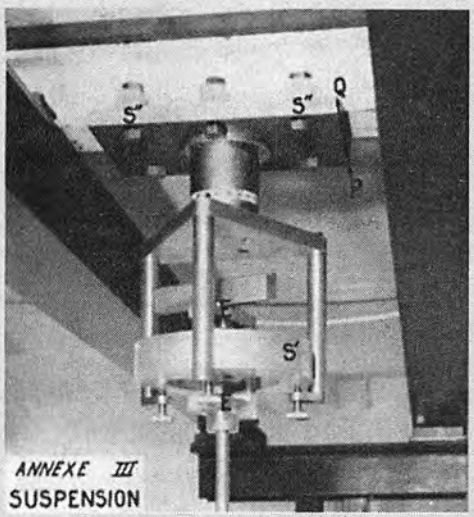
Effects of the Total Eclipse

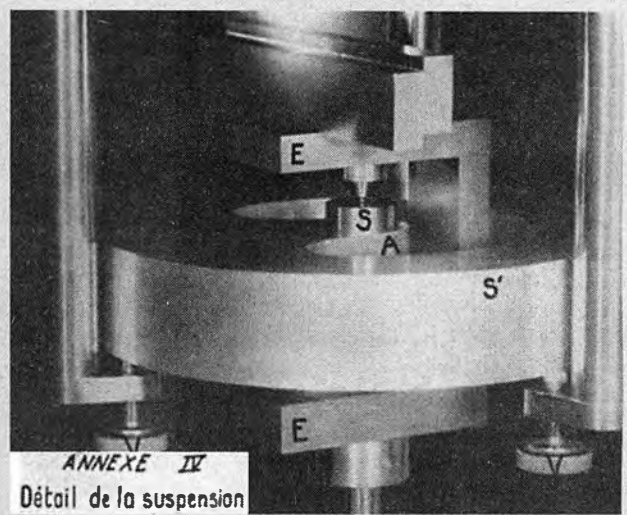
Finally, during the total eclipse of the Sun on June 30, 1954, a remarkable deviation of the plane of oscillation of the paraconical pendulum was observed. This deviation is *quite inexplicable within the framework of the currently accepted theories.* An entirely *similar* deviation was observed once again during the total eclipse of the Sun on Oct. 2, 1959.

These various anomalies appeared to me to be closely connected to the very many anomalies observed during the 19th and 20th centuries in mechanical, optical, and electro-









The paraconical pendulum used by Allais. Clockwise from top left: The entire apparatus; the measuring device; a closeup of the suspension; and the suspension system. Small ball bearing at S supports weight of pendulum.

magnetic experiments, which have remained *unexplained,* and of which I presented an overall analysis in a paper in 1958 (published in English in 1959) [see References].

To conclude this very brief survey of my experiments, I believe I can make a prediction. If, *without interruption, for at least a month, at the same place and simultaneously,* observations were made of the movement of the paraconical pendulum, together with optical sightings such as those I made in 1958, and a repetition of the experiments of Michelson-Morley (1887) and Miller (1925), the purpose of which was to display the movement of the Earth relatively to the ether, it would be found that the effects observed by Miller in 1925 correspond to the anomalies of the movement of the paraconical pendulum and the anomalies of the optical sightings observed in July 1958.

References

References for my main works can be found in *Maurice Allais. Principaux Ouvrages et Memoires, 1943-1984* (about 300 titles) as well as some "Données Biographiques" in the collective volume *Marchés, Capital et Incertitude. Essais en l'honneur de Maurice Allais*, Marcel Boiteux, Thierry de Montbrial, Bertrand Munier, eds., *Economica*, 1986 (pp. 225-257). This book also contains a general presentation of my work by the editors (pp. 5-44).

An English version of this book has been published by Kluwer Academic Publishers, Dordrecht, Netherlands, under the title *Markets and Risk: Essays in honor of Maurice Allais* edit. Bertrand Munier, 1995.

The main references to my experiments in physics are given in Boiteux, Munier, and Montbrial, *op. cit.*, pp. 253-254). See especially: Allais, 1959, "*Doit-on reconsidérer les lois de la gravitation;* and Allais, 1959, "*Should the laws of gravitation be reconsidered*" (*Aero-Space Engineering,* Sept. 1959, No. 9, pp. 46-52; Oct. 1959, no. 10, pp. 51-55; and Nov. 1959, No. 11, p. 55).

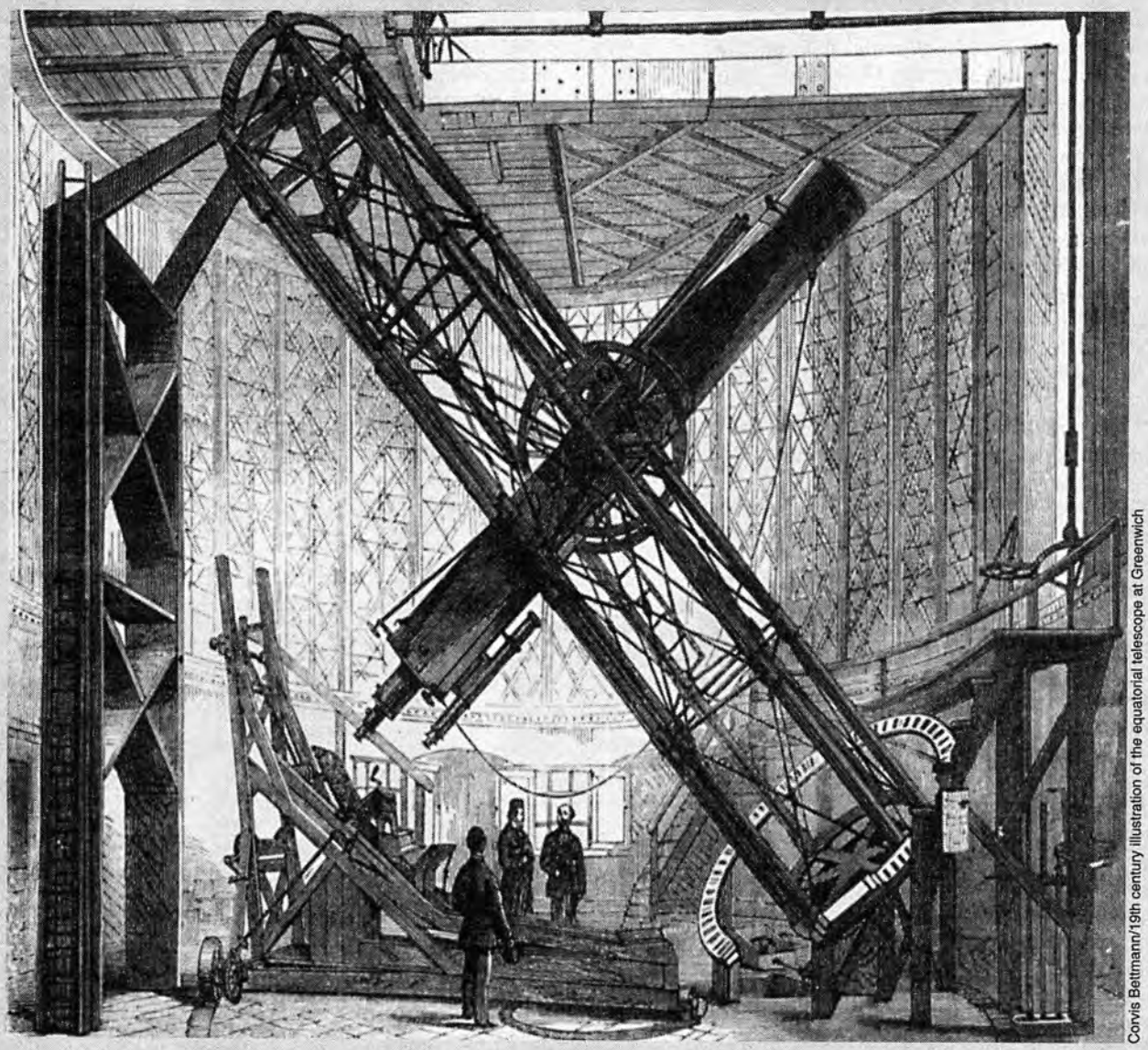
The references of my main works can also be found in "Les Prix Nobel (The Nobel Prizes), 1988", (Stockholm: Almquist and Wiksell International).

[A more recent (French-language) publication by Allais is *The Anisotropy of Space: A Necessary Reappraisal of Certain Postulates of Contemporary Theories, Observation Data* (Paris: Editions Clément Juglar, 1997). Here, Allais presents a comparative analysis of the anomalies of the motion of the paraconical pendulum, the anomalies of optical sightings on sighting marks, the anomalies of optical sightings of Esclangon, and the interferometric anomalies of Miller, and their links, particularly in regard to their periodic structure, and their correlation with the movement of the Earth in its orbit.]

Michelson-Morley-Miller: The Coverup

Optical Theory in the 19th Century and the Truth about Michelson-Morley-Miller

by Laurence Hecht



Corvis Bettmann/19th century illustration of the equatorial telescope at Greenwich

To understand the ground-breaking significance of Dayton Miller's ether drift measurements, one must go back to the original discoveries of Fresnel on the wave theory of light and its subsequent development in the 19th century.

The accompanying article by French physicist Maurice Allais (who is also the winner of the 1988 Nobel Prize in economics), presumes a familiarity with the classic experiments of American physicist Dayton C. Miller (1866-1941). For the reader unfamiliar with this important work, carried out during the first three decades of this century, and with the physical theory on which it is premised, we provide this summary review. Our interpretations may not, of course, agree in all cases with those of M. Allais.

1. Origin of the Wave Theory of Light

By the time of the death of Augustin Jean Fresnel in 1827, at the early age of 39, Isaac Newton's theory of light, which had prevailed for the entirety of the previous century, was dead and all but buried. The assault on Newton's *Optics* had originated in England itself with the work of the highly controversial genius Thomas Young; it was brought to a decisive conclusion by the Ecole Polytechnique's Augustin Fresnel, through an experimental-theoretical effort, lasting approximately 12 years, from 1814 to his untimely death.

Newton had argued that the principal phenomena in optics, such as the refraction (bending) of a ray of light when passing from one medium into another, or its diffraction (apparent bending around small objects), could be explained on the basis of a theory of attraction, consistent with his hypothesis of universal gravitation. In Newton's view, light rays consisted of trains of very small corpuscles, which, on encountering objects, are attracted to them in proportion to their mass. It is a consequence of this theory that light would travel at a greater velocity in denser substances, such as glass or water, than in air. Not until the middle of the 19th century was it possible to definitively prove that the opposite is the case.

Well before that time, Young and Fresnel had proved the invalidity of Newton's optics by focussing their efforts on the more subtle phenomenon of diffraction.

When a pencil of light of one color is directed at a very narrow object, such as a hair, or the edge of a knife, or is caused to pass through a small aperture or slit, and is then projected onto a screen, close examination with a magnifying lens reveals the presence, on the white screen, of parallel bands of alternating light and darkness. Young explained these *interference fringes,* as they came to be known, by reviving the wave theory of light, last propounded by Gottfried Leibniz's famous teacher and collaborator, Christiaan Huygens, in his 1678 *Treatise on Light.*

According to Huygens, a substance, known as the *ether,* consisting perhaps of invisibly small particles, must pervade all space, and the matter contained within it. The propagation of light, in this theory, consists of a wave-like disturbance of this ether, somewhat analogous to the passage of a wave on the surface of water. (The analogy of light, and sound, to water waves, which exhibit the phenomenon of interference, was first proposed by Leonardo da Vinci.) In Huygens's theory, an unobstructed light source sends out light in all directions, forming a spherical wave-front of expanding concentric spheres.

Young explained the alternating light and dark fringes, as seen on a screen placed behind a knife edge, for example, as places where light waves proceeding directly from the source to the screen, were meeting up with light waves that had been slightly deflected by the edge of the blade. Having thus travelled a slightly longer path, the deflected *(diffracted)* rays should be in a different *phase* than those which proceeded directly to the screen. (The concept of *phase* is best understood by analogy to water waves. If two water waves, as from the wakes of passing motor boats, cross each other when *both* are at their peak, or crest, the resultant wave formed by their momentary combination is larger than either of the two components. Alternatively, if the two waves cross when one is at its peak and the other in its trough, their momentary combination cancels the effect of either, producing a smooth surface on the water. The results are known, respectively, as *constructive* or *destructive* interference.)

By careful experimentation, Young was able to estimate the length of a light wave, with considerable accuracy, and to explain in great detail a variety of diffraction phenomena, including the fringes produced by thin plates separated by air or clear liquids. His success in developing the wave theory to take account of these complex phenomena was remarkable, especially considering that he worked almost alone, in a country fanatically committed to defending Newton's system. After the publication of his early papers critical of Newton, Young became the object of a fierce attack by Henry Brougham, later Lord Chancellor of England, in the *Edinburgh Review,* an at-

After a portrait by Tardieu, Frontispiece from Vol. II of Fresnel's works

Augustin Fresnel (1788-1827)

Archives Center, National Museum of American History, Negative number 46838-E

Thomas Young (1773-1829)

Young and Fresnel proved the invalidity of Newton's optics by focussing their efforts on the more subtle phenomenon of diffraction, the disturbance in a wave front caused by a small obstacle.

tack that was so successful that when Young attempted to reply by pamphlet, Young's work sold only one copy.

The son of a wealthy Quaker business family from Somersetshire, Young was a precocious polymath. He mastered eight languages by early adolescence, and later was said to be able to play every instrument in the orchestra with proficiency. He studied a year at Göttingen University in 1795, and returned to England to take a degree in medicine. His first study brought him into controversy with the leading authorities in the field, over the function of the crystalline lens in the eye in accommodation. He authored monographs in mechanics, geometry, natural history, and machine design, and took up the decipherment of Egyptian hieroglyphics, making important early contributions to the field.

Fresnel Revives Huygens's Principle

In 1814-1818, the further development of the wave theory shifted ground to France, where the superior resources of the Ecole Polytechnique, and a 150-year tradition of Leibnizian science would be brought to bear on it. Augustin Fresnel, already by then in intimate dialogue with André-Marie Ampère on matters of theology and natural philosophy, began his attack on the problem in 1814.

Fresnel was born May 10, 1788, at Broglie in Normandy. The revolution having interrupted his father's work as an architect on the harbor at Cherbourg, the family moved to a small town near Caen, where young Fresnel was raised and schooled. He showed no taste for languages, and was an undistinguished student in his early years. But his scientific talents bloomed early; he designed toy bows of such power, for use in childhood war games, that the neighborhood parents had to confiscate them. His childhood friends called him "the genius."

Fresnel entered the Ecole Polytechnique in Paris at age 16, in poor health, but so distinguished himself in geometry as to win public praise from the famed Legendre. He worked for 10 years in a modest position as a civil engineer in the department of *ponts et chaussées* (bridges and roads). His work in optics began in 1814, the same year he allied himself to the cause of the Bourbon restoration. He so vehemently opposed the brief return of Napoleon in 1815, that he was deprived of his office during the Hundred Days, although he was allowed to live in Paris. Between then and 1824, amid intermittent bouts of ill health, he revolutionized physical science with his work in optics. Poor health in 1824 forced him to abandon all scientific research, except for a successful project to design a new type of lens for lighthouses. He died in 1827, barely 39 years old.

In 1816, François Arago, then in experimental collaboration with Fresnel, visited Young in England to discuss the interpretation of polarization. By 1818, Fresnel had made a discovery that brought the wave theory beyond the point achieved by Young. To do so, he reintroduced a hypothesis concerning the propagation of light which had first been proposed by Huygens more than a century earlier, and whose broader implications are yet to be explored.

In examining more closely the conditions under which interference fringes are produced, by the interposition of a slit or narrow object into the light path, Fresnel saw that it was insufficient to suppose that the fringes resulted merely from the interaction of the direct rays from the source, with rays deflected by the small obstruction. Rather, it was necessary to suppose that every point of the advancing wave front acts like an independent source of reproduction of the initial disturbance, which we call light. Thus, from each point in the space surrounding a light source, new spherical wave fronts are being generated. If no obstruction is encountered, the light from these new spherical sources will continue onward on the same outwardly directed radial lines, while the backward-directed rays will be cancelled as a result of interference effects.

Suppose, however, that the spherical wave front should pass through a small aperture in a screen as in Figure 1. Let *AG* be the small aperture through which the light from *C* passes. Let *P* represent the darkest point in the darkest band of the interference fringe formed on the screen *BD*. According to the earlier interpretation of Young, the darkness is produced by the meeting of the two extreme rays, *AP* and *GP*, whose difference in length corresponds to one-half wavelength (that is, to a maximum difference in phase, where, by analogy to water waves, crest meets trough).

But, careful experimentation showed Fresnel that the darkest point in the darkest band occurred where the difference in length between the extreme rays, *AP* and *GP*, corresponded to one whole wavelength. If the two extreme rays, *AP* and *GP*, were alone responsible, they would interfere constructively to produce here a maximum illumination. By careful consideration of this paradox, Fresnel was led to a new hypothesis, combining the principle of interference with Huygens's Principle of propagation.

The light passing through the aperture *AG* constitutes a very small segment of the spherical wave front emanating from *C*.

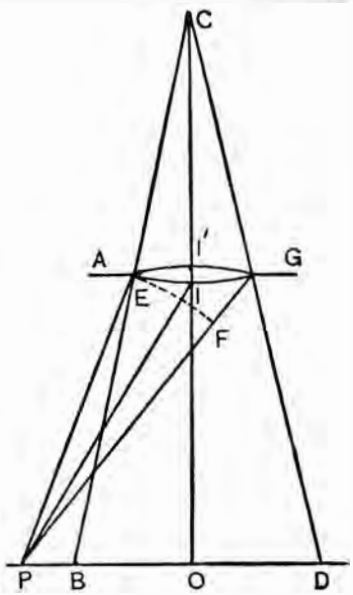


Figure 1
FRESNEL APPLICATION OF HUYGENS'S WAVE THEORY TO INTERFERENCE

Light of one color, originating at C and passing through the small aperture AG will form dark and light bands, known as interference fringes, on the screen PBOD. Augustin Fresnel (1788-1827) applied Huygens's Principle of continuous re-propagation of light to explain the phenomenon.

At each point along this segment *AG,* according to Huygens's Principle, new, secondary waves are being generated, whose effect at the point *P* cannot be ignored. Fresnel shows that it is the action of these secondary waves which produces the destructive interference, hence darkness, at *P.*

To see how, Fresnel asks us to imagine another ray, *PI,* drawn to meet the center of the arc *AG*. Because of its marked inclination to the arc (when *P* falls close to the center *O,* the interference patterns disappear), the ray *PI* is almost exactly the mean between *GP* and *AP*. As these differ by one whole wavelength, *PI* must be in exactly opposite phase with either of them. The result of its interaction with either is destructive interference at *P,* and the same is true of corresponding pairs of secondary rays coming from the two halves of the arc. As Fresnel describes it in the report of his experimental *tour de force:*

> We now have the arc divided into two parts, whose corresponding elements are almost exactly equal, and send to the point *P* vibrations in exactly opposite phases, so that these must annul each other.[1]

In later investigations, Fresnel worked out the theory of reflection and refraction, polarization, and the transverse nature of light vibrations, showing all to be in accord with his wave conception. His treatment of the phenomenon of double refraction, occurring in certain types of crystals, where two rays, refracted at different angles, an *ordinary* and *extraordinary* ray, are produced from a single pencil of light, drew much attention. His solution required the construction of a geometrical surface of the fourth order to describe the hypothesized density distribution of the ether within a certain type of such crystals, known as biaxial. In 1832, the Irish mathematician William Rowan Hamilton noted that points of discontinuity in Fresnel's surface should give rise to physical singularities in the propagation of light rays passing through them, which results were verified in the course of subsequent decades, establishing the validity of Fresnel's theory with great certainty.

The second half of the 19th century saw an explosion of attempts to provide what came to be known as a *dynamical* model of Fresnel's ether. By this was meant, essentially, a mechanical analogy (such as, for example, the supposition that the ether is an elastic solid like a crystal), from which the equations describing the behavior of light could be deduced with mathematical consistency.

The essential flaw in such an approach was the unquestioned assumption that processes in the universe could fit a simple mechanical analogy. Fresnel had to battle early efforts along these lines by his rival Siméon Denis Poisson (1781-1840). Poisson's ether, Fresnel remarked in correspondence with Poisson, was only "a mathematical abstraction," not the real thing. Or, to put the matter on broader foundation, one might ask: why should God have so constructed the universe that the propagation of light be explicable by analogy either to a fluid, or to a simple mineral crystal? To Fresnel and his philosophical allies, such as Ampère, as to Carl F. Gauss and Wilhelm Weber in Germany, whose parallel researches in magnetism and electricity were leading to similar paradoxes,[2] such reductionism was not acceptable. But, among the leading scientists of the generation following Fresnel, only Bernhard Riemann at Göttingen University dared a full-scale assault on the reductionist prejudices then engulfing scientific discourse. In a bold effort, Riemann attempted to construct a new physics in which the principle of operation of the human mind in generating new thoughts, rather than a simpler, mechanical analogy, or formal mathematical representation thereof, was to be the foundation.[3]

Unfortunately, the work of Riemann and a small circle of associates was effectively contained, with the result that the main line of experimental development in optics proceeded from the far more restricted framework established by James Clerk Maxwell, beginning about 1858. This is the standpoint sometimes referred to as the English school, although it originated with the leading French opponents of Fresnel and Ampère—namely, Pierre Simon Laplace, Poisson, Augustin Louis Cauchy, and Jean Baptiste Biot.[4]

2. The Question of Relative Motion

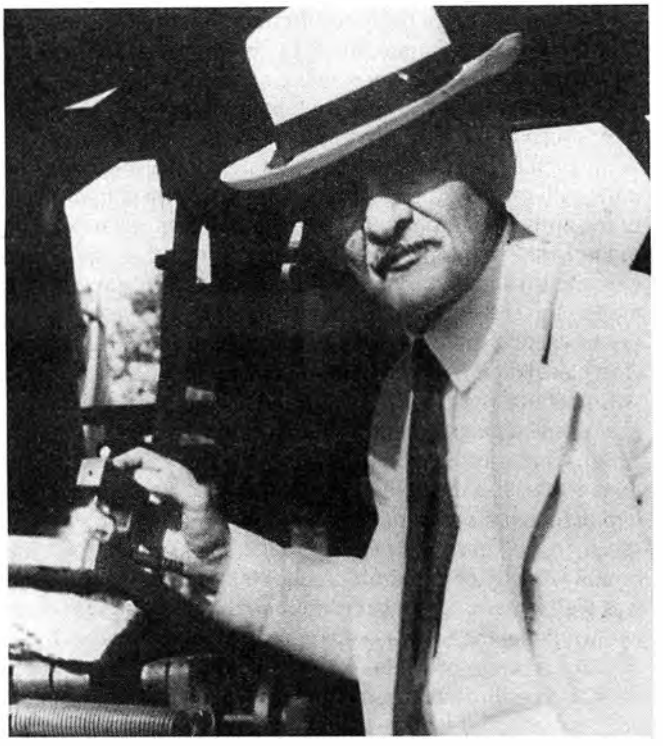
The paradox that consistently arose to explode all efforts at constructing a self-consistent theory of the propagation of light, centered on the question of the effect of the relative motion of the medium on the velocity of light. To best understand this paradox, we go back to the discovery of the phenomenon known as *aberration.*

The Danish astronomer Ole Rømer first suggested the existence of aberration, in a 1677 letter to Huygens. In 1728, the English astronomer James Bradley reported on observations confirming the presence of such a phenomenon as the result of the retarded rate of propagation of light.[5] From Bradley's standpoint, which was that of the corpuscular theory of light, aberration could be explained in the following way.

Imagine that you are trying to land a drop of water from an eye dropper directly onto the bottom of a narrow test tube, which is attached to the outside of a revolving turntable. If the opening of the test tube is pointed directly up at the eye dropper, the water droplet will clearly hit the side of the test tube before striking the bottom. The problem is that in the time the droplet falls from its entry into the mouth of the tube, the side of the test tube moves forward to meet it. This problem can be overcome by inclining the test tube forward, in the direction of its motion. If the angle is correct, a drop of water entering the mouth of the test tube, will fall to the bottom, never touching the side of the tube. The proper angle of inclination will depend on the ratio of the velocity of the turntable to the velocity of the falling water droplet.

Now, substitute for the test tube, the tube of a telescope; for the turntable, the Earth's motion in its orbit; and, for the velocity of fall of the water droplet, the velocity of light. The latter two quantities are, respectively, 30 and 300,000 kilometers per second. This leads to a desired angle of inclination of a telescope tube of a little more than 20 seconds of arc (about 1/180th of a degree) in the direction of the Earth's orbital motion, when viewing a star whose actual position is directly overhead. The figure of roughly 20.5 seconds of arc is known as the *constant of aberration.*

The same explanation applies on the assumption that the light consists of a wave, or a train of waves, traveling down the telescope tube, as the tube is propelled through space. One must, however, assume that the ether inside the telescope tube is not carried along with it (if it were, there would be no aberration); rather, that the Earth, and the telescope tube, move



Courtesy of Case Western Reserve University Archives

Albert Michelson with his interferometer in the 1920s.

freely through the ethereal medium, which must be at rest with respect to the Earth's motion. Notice that we are considering two media here: the air in the telescope tube, which we assume to be carried along with the tube, and the luminiferous ether, which we suppose passes through the pores of matter "as freely as the wind through a grove of trees" (Young).

Suppose, now, that instead of air, we fill the telescope tube with water. We know precisely the rate at which the velocity of light is slowed in water , as compared to air. Looking at our example of the water drop and test tube, we should have the case now, in which the drop falls more slowly, and thus the tube would need to be more inclined—that is, a greater constant of aberration. But experiments by the English astronomer G.B. Airy, in 1871, showed that there was no change in the constant of aberration using a water-filled telescope.

This was precisely the result anticipated by Fresnel a half a century earlier, when he formulated his theory to explain the results of experiments by the French astronomer Arago, which had shown that the motion of the Earth does not change the refraction of starlight by the Earth's atmosphere. To explain the lack of change in the constant of aberration, when the transmitting medium is changed, Fresnel introduced the hypothesis that the ether is carried along, or convected (*entrainé*), inside the telescope tube. To explain the variations in index of refraction between different transparent media, his predecessor, Young, had already supposed that the ether is more compressed inside of substances with a higher refractive index. In an 1818 letter to Arago, Fresnel added to this, the assumption that the ether inside a moving body is partially carried along with it. Thus, if a rectangular glass prism is moved through the air, for example, it takes in less dense ether through the front surface, condenses it, and expels it out the trailing surface, somewhat like a ramjet. But a part of the denser ether is carried along with it, the more so, the greater the index of refraction.

To understand the non-change of the aberration constant when the telescope tube is filled with water, we have, now, the following: The telescope is inclined forward in the direction of orbital motion of the Earth, so that when the wave front, were it moving through air, reaches the eyepiece of the telescope at the bottom of the tube, the eyepiece has moved forward the requisite amount to "catch" the wave front. But, because we have now filled the tube with water, the wave front, which travels more slowly in water than in air, should be arriving at the eyepiece too late. However, because the more condensed ether within the water is partially carried along with the telescope tube in the direction of the Earth's motion, the wave front is advanced along with the ether, just enough so as to arrive at the eyepiece in time to be seen.

So, with two crucial hypotheses, Fresnel was able to give a complete explanation of aberration. As summarized later by his famous American successor, A.A. Michelson, these two hypotheses were: *first,* that the ether is at absolute rest, excepting, *second,* in the interior of transparent media, where the ether moves with a velocity less than the velocity of the medium in the ratio $(n^2 - 1)/n^2$ (where n is the index of refraction). These were considered as fully confirmed by later experiments, of which an 1851 effort by French physicist A.H. Fizeau was the most famous.

3. The Interferometry Experiments

It was the first hypothesis of Fresnel, which American physicist Albert Abraham Michelson (1852-1931) set out to test in his famous interferometry experiment, first in 1881 in Berlin, then, in 1887, with an improved apparatus, at the Case School of Applied Science in Cleveland, and several times thereafter in the decade of the 1920s. But his results also called into question the validity of the second hypothesis by which Fresnel had explained aberration.

A.A. Michelson was born in 1852 in Strelno, Prussia (now Poland), to a German-Jewish family, which emigrated to the United States in 1854. After temporary employment in New York as a jeweler, his father took the family to San Francisco, where he established a small dry goods business serving the gold rush miners in northern California, moving later to Virginia City, Nevada. Young Michelson was educated at Boy's High School in San Francisco, where headmaster Theodore Bradley encouraged him on a career in science. He tied for first place with two other boys from his state in the examination for scholarship to the U.S. Naval Academy. When he did not get the appointment, he travelled overland to Washington, with a letter from his congressman, seeking an audience with President Ulysses S. Grant. The President told him that the last of the 10 special appointments-at-large had been filled, but advised him to go to Annapolis to see the Commandant of the Naval Academy, who created an additional opening for him.

In 1877, while an instructor in physics and chemistry at the Naval Academy, Michelson conceived of an improvement in the French physicist J.B.R.Foucault's apparatus for determining the velocity of light. Using a $2,000 subsidy from his father-in-law, the wealthy New York businessman Heminway, he determined the velocity of light to be 186,508 miles per second, with an estimated error of one part in 10,000. It was the fourth

terrestrial measurement of the speed of light, the other three having been carried out in France by Fizeau, Foucault, and A. Cornu.

In 1880, Michelson traveled to Europe for post-graduate study under Naval sponsorship. While in Berlin, he conceived of a means to measure the relative motion of the Earth with respect to the ether, in defiance of the assessment of leading British scientist James Clerk Maxwell (1831-1879), who had recently asserted the impossibility of such a measurement.[6]

Drawing on a fund established by Alexander Graham Bell with the Berlin instrument-making firm Schmidt & Haensch, Michelson had an apparatus constructed, which he put to the experimental test in 1881 at Berlin and Potsdam. His idea was to use the phenomenon of interference to detect very small differences in path length between two pencils of light, one travelling back and forth in the direction of the Earth's orbital motion through the hypothesized stationary ether, and the other perpendicular to it. The apparatus, which came to be known around the world as the Michelson interferometer, consisted of two perpendicular brass arms of equal length (about 1 meter), each with a mirror on the end (Figure 2). A source of light at *a* projects its rays to a piece of plate glass, located at *b,* and angled at 45 degrees to the direction of the ray. A thin coating of silver allows approximately half the light to pass through the glass, and down the arm to the mirror at *c*. The remaining half is reflected by the silver coating at a right angle at *b*, down the other arm to the mirror at *d*.

On the return trip, half the rays from *c* are reflected from the silvered back side of *b* into the tube of the telescope at *e*. Half the rays reflected from the end of the other arm at *d* pass through the partially silvered glass *b,* and also enter the telescope at *e*. (At *g* a plate of glass of the same thickness as *b* is interposed to compensate for the fact that the ray along the arm *bd* is refracted three times, by the thickness of the glass, and that along *bc* only once, in their passage to *e*.)

The apparatus is adjusted so that an interference fringe pattern is seen in the eyepiece of the telescope. Any slight change in the path length or time of travel of light traversing one of the arms, will produce a shift in the observed fringe pattern. If one of the arms of the apparatus were then placed in the direction of the Earth's motion through the ether (presumed stationary), calculation showed that it would take the light ray a longer time to travel the round trip down this arm and back, than the ray traversing the other arm in the perpendicular direction. (The calculation is akin to that of comparing the time it takes a swimmer in a river to swim upstream and back down again, as against swimming across the current.[7])

But, what was the motion of the Earth with respect to the stationary ether? At the time of the 1881 experiment, astronomers had detected a motion of the solar system, of undetermined speed, in the direction of the constellation Hercules. The mean orbital velocity of the Earth, about 30 kilometers per second, was well known. Michelson assumed that the resultant of the two would be the Earth's absolute, or cosmical, motion. By estimating a range of values for the velocity toward Hercules, Michelson estimated an expected displacement of the interference pattern of at least 1/10 of a fringe. His apparatus, which was capable of detecting shifts an order of magnitude smaller, could find no such positive results.

Michelson's first interferometer was plagued with problems. Its sensitivity to vibration meant that it could not be used during the day in Berlin, and at night only with difficulty. The brass arms were subject to differential expansion as a result of temperature changes, and to bending when rotated. Alter-

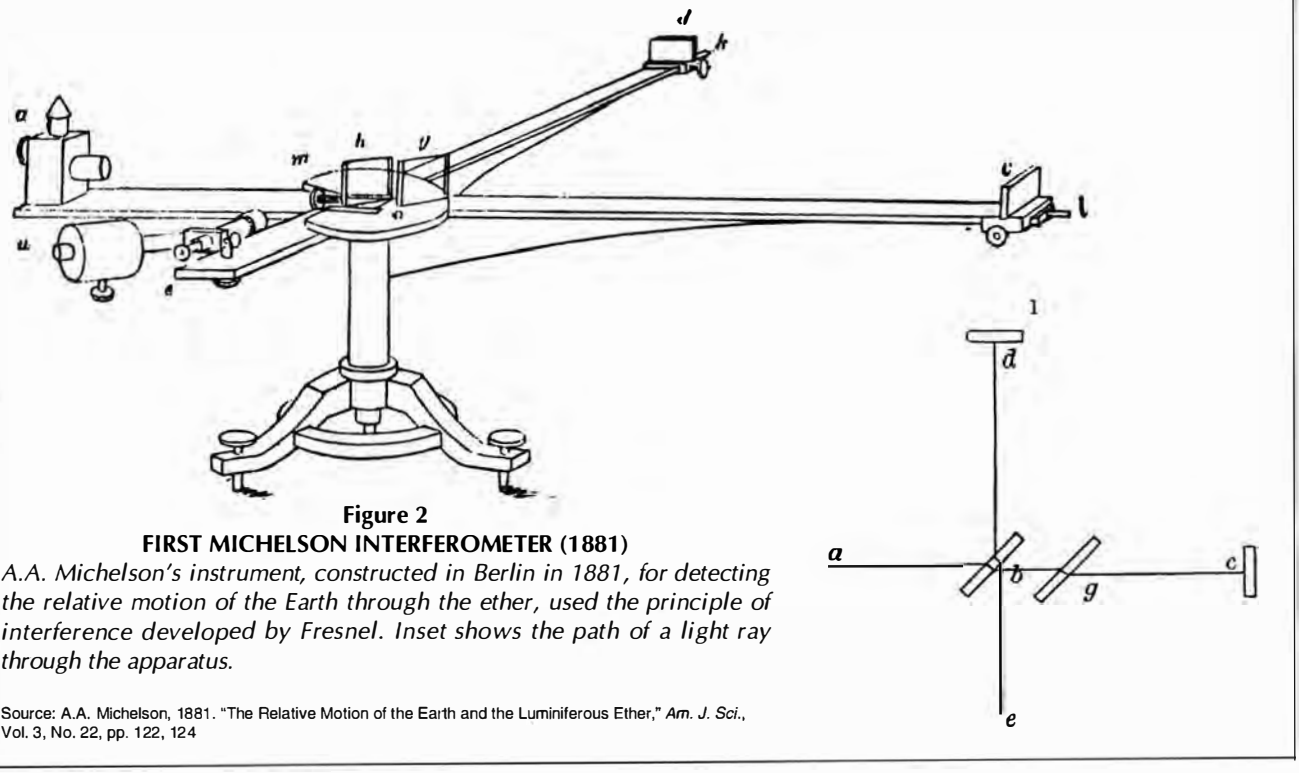
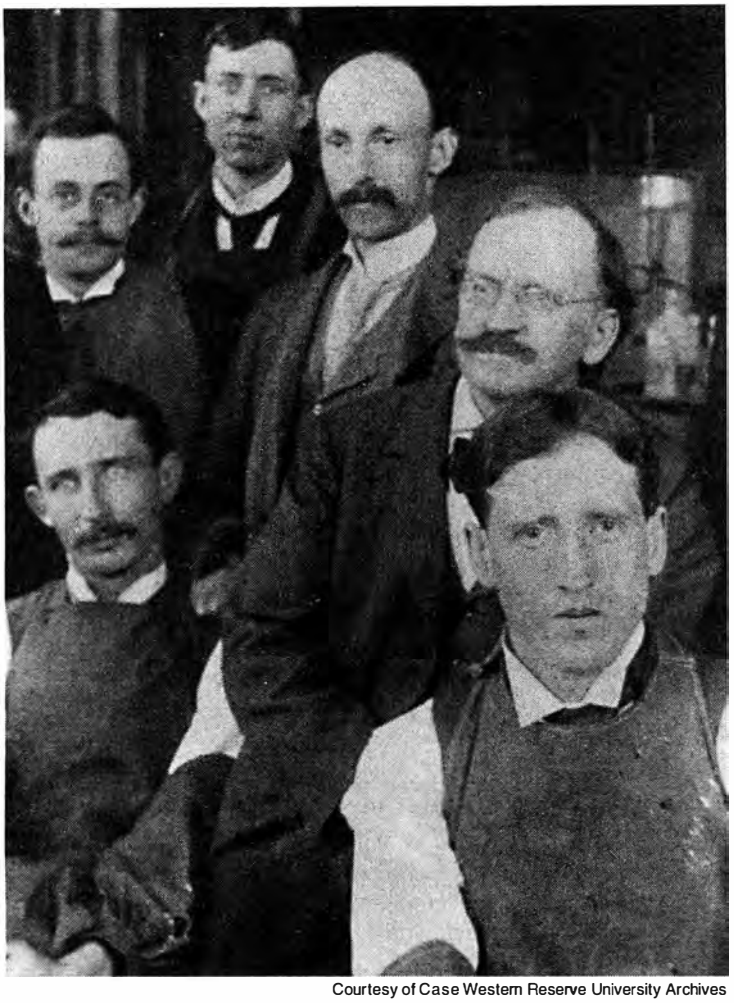


Figure 2
FIRST MICHELSON INTERFEROMETER (1881)

A.A. Michelson's instrument, constructed in Berlin in 1881, for detecting the relative motion of the Earth through the ether, used the principle of interference developed by Fresnel. Inset shows the path of a light ray through the apparatus.

Source: A.A. Michelson, 1881. "The Relative Motion of the Earth and the Luminiferous Ether," *Am. J. Sci.*, Vol. 3, No. 22, pp. 122, 124



Courtesy of Case Western Reserve University Archives

Edward W. Morley, (upper right), with chemistry students at Western Reserve University, 1896. Although trained as a theologian, Morley became a gifted experimenter in chemistry; he precisely determined the ratio of the densities of oxygen and hydrogen, and the atomic weight of oxygen. Born in New Jersey in 1838, Morley attended Williams College and Andover Theological Seminary. He was the president of the American Association for the Advancement of Science in 1895, and of the American Chemical Society in 1899.

ations were made, and the instrument was removed to the less-trafficked locale of the Astrophysical Observatory in Potsdam, and finally to a stone cellar in the vicinity.

> Here, the fringes under ordinary circumstances were sufficiently quiet to measure, but so extraordinarily sensitive was the instrument that the stamping of the pavement about 100 meters from the observatory, made the fringes disappear entirely! [Michelson 1881, p. 124]

From four series of observations made in April 1881, no significant evidence of a relative motion through the ether could be found. Michelson concluded:

> The interpretation of these results is that there is no displacement of the interference bands. The result of the hypothesis of a stationary ether is thus shown to be incorrect, and the necessary conclusion follows that the hypothesis is erroneous.
>
> This conclusion directly contradicts the explanation of aberration which has been hitherto generally accepted, and which presupposes that the earth moves through the ether, the latter remaining at rest [Michelson 1881, p. 128; the hypothesis he refers to is Fresnel's].

After his return from Europe in 1882, Michelson took the position of Professor of Physics at the newly organized Case School of Applied Science in Cleveland, Ohio. Here he met Edward W. Morley, professor of chemistry at the neighboring Western Reserve University, who had ideas for improvements in the interferometer, particularly respecting the stability of its base. Apart from the hyper-sensitivity of the Berlin-made instrument, a small error in experimental conception had been pointed out to Michelson by M.A. Potier of Paris in the winter of 1881, and later in a published analysis of the experiment by H.A. Lorentz.

With money from the Bache Fund of the National Academy of Sciences, an entirely new instrument was constructed and put into operation in 1887, in the basement of the main building of Western Reserve's Adelbert College in Cleveland. It consisted of a solid block of sandstone 1.5 m square and 30 cm thick, on which was mounted the optical apparatus. To reduce vibrations, the sandstone block rested on a wooden disk, which floated on mercury contained in a circular cast iron tank, the tank resting on a brick pier. This made it possible to rotate the sandstone block holding the optics through 360 degrees, with almost no vibration (Figure 3).

The optical apparatus, built by John A. Brashear of Pittsburgh, was in principle the same as that used in Michelson's Berlin instrument. However, the effective light path was increased by reflecting the light back and forth with four mirrors at each corner, so that it traversed the diagonal of the stone block eight times. This was equivalent to using an interferometer arm 11 m long. On the theory of a stationary ether, pointing one arm of the apparatus in the direction of a velocity equal to that of the Earth in its orbit would produce a displacement in the interference pattern of 0.4 of a fringe width.

Michelson and Morley conducted observations with the apparatus for one hour at noon on July 8, 9, and 11, and one hour in the evening of July 8, 9, and 12 of 1887, the entire series of observations lasting six hours. In each observational session the apparatus was slowly turned through 36 rotations. An observer walked around the instrument, keeping the telescopic image of the interference fringe in his field of view. Every 16th of a circular "turn," the observer read off his estimate of the fringe displacement along graduated markings that were visible in the eyepiece; these were recorded by an assistant.

No 'Null Effect'

The observations did not produce the 0.4 of a fringe width displacement that the motion of the Earth in its orbit would

produce, given the theory of a stationary ether. To this day, most popular treatments, textbooks, and even advanced reference works report that the 1887 Michelson-Morley experiment yielded a *null* result. However, as Dayton C. Miller, who began experiments with Morley with an improved form of the original apparatus in 1902, later noted:

> *[T]he indicated effect was not zero;* the sensitivity of the apparatus was such that the conclusions, published in 1887, stated that the observed relative motion of the earth and ether did not exceed one-fourth of the earth's orbital velocity. This is quite different from a null effect now so frequently imputed to this experiment by writers on Relativity [Miller 1933, p. 206; emphasis in original].

We will return to Miller's work and the implications for the Special Theory of Relativity, shortly. Michelson's own evaluation of the experiment does not contradict the words of Miller, although the flavor may be different. We cite it for comparison:

> Considering the motion of the earth in its orbit only, this displacement [of the fringes] should be $2D\ v^2/V^2 = 2D \times 10^{-8}$. The distance D was about eleven meters, or 2×10^7 wave-lengths of yellow light; hence the displacement to be expected was 0.4 fringe. The actual displacement was certainly less than the twentieth part of this, and probably less than the fortieth part. But since the displacement is proportional to the square of the velocity, the relative velocity of the earth and the ether is probably less than one-sixth the earth's orbital velocity, and certainly less than one-fourth [Michelson and Morley, 1887, p. 341].

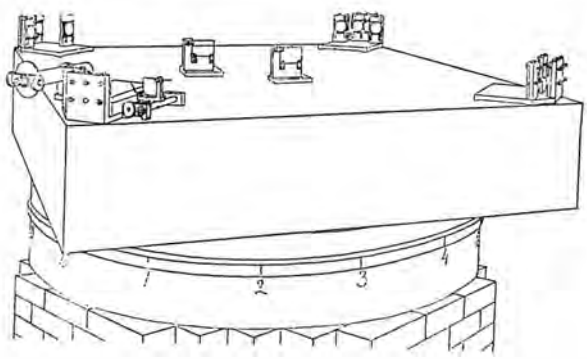
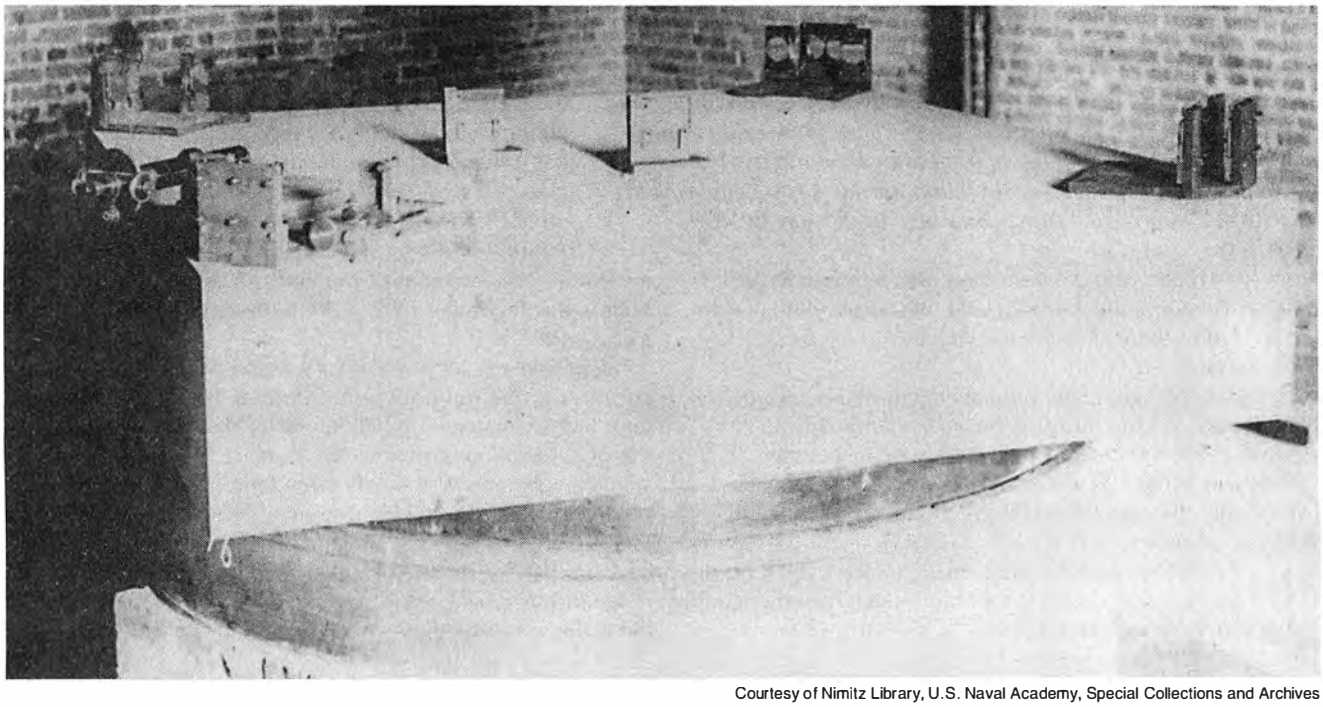


Figure 3
MICHELSON-MORLEY INTERFEROMETER (1887)
Edward W. Morley, chemistry professor at Western Reserve University, conceived of this design for greatly reducing the sensitivity of the interferometer to vibration. The optical apparatus is placed on a 30-cm-thick stone slab, which floats on a circular tank of mercury, allowing the optics to be rotated through 360 degrees.

Source: Illustration from *American Journal of Science*, Vol. 34, No. 203 (Nov. 1887), p. 337, courtesy of Nimitz Library, U.S. Naval Academy, Special Collections and Archives.

Michelson then adds the following important qualification:

> In what precedes, only the orbital motion of the earth is considered. If this is combined with the motion of the solar system, concerning which but little is known with certainty, the result would have to be modified; and it is just possible that the resultant velocity at the time of



Courtesy of Nimitz Library, U.S. Naval Academy, Special Collections and Archives

The Michelson-Morley experiment of 1887, set up in the basement of Adelbert Hall, Western Reserve University. Results were smaller than expected, but not null!

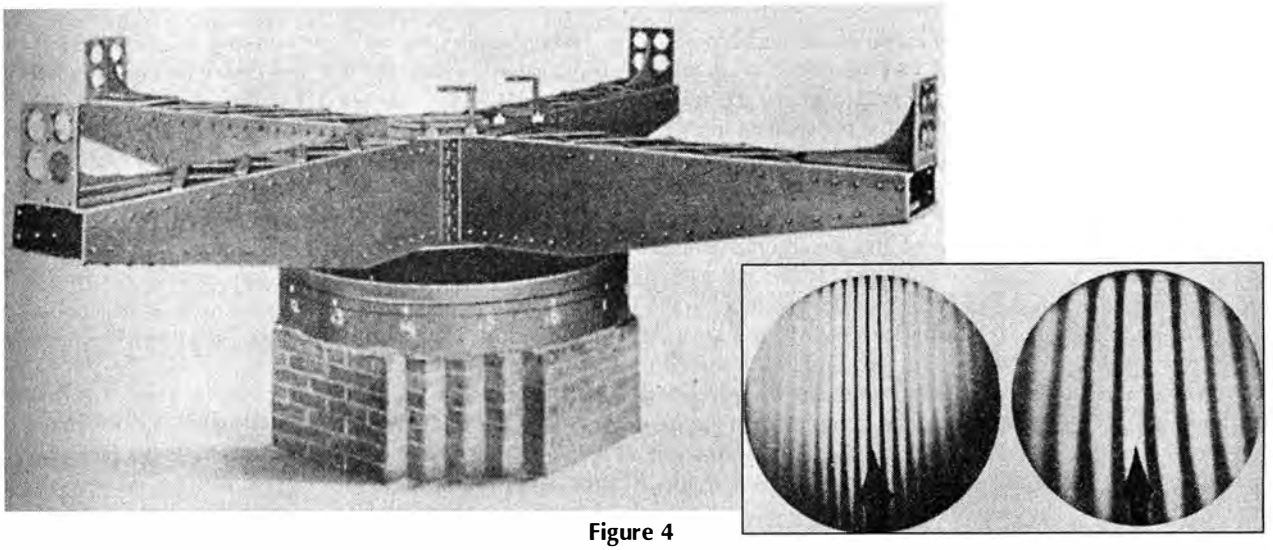


Figure 4
MORLEY-MILLER INTERFEROMETER (1903)

Dayton C. Miller joined Morley in designing a new apparatus, more stable, and, at the same time, more sensitive, than that used by Michelson-Morley in 1887. Structural steel girders forming the arms floated on the original mercury tank. New optics with four mirrors at the end of each arm formed a 32-m effective light path. The instrument is shown almost completed, but without the optics, in 1903, Inset shows the fringe pattern, as seen through the telescope of the interferometer on narrow and broad magnification. The observer estimated the fringe position with respect to the pointer at bottom, in tenths of a fringe width.

Source: E.W. Morley and D.C. Miller, 1905."Report of an Experiment to Detect the FitzGerald-Lorentz Effect," *Philosophical Magazine*, Ser. 6, Vol. 9 (May), Plate X; D.C. Miller, 1933. "The Ether-Drift and the Determination of the Absolute Motion of the Earth," *Rev. Modern Phys.*, Vol. 5, p. 211 (July).

observations was small though the chances are much against it. The experiment will therefore be repeated at intervals of three months, and thus all uncertainty will be avoided [Michelson and Morley, 1887, p. 341].

Unfortunately, Michelson did not have the opportunity to make such repeated observations. In 1889, he left the Case School for a brief position at Clark University, and then moved on to the University of Chicago, where he taught for 38 years. His work in the next decade centered on using interferometry to determine the standard of length, for which he became world famous.

But the anomaly in the Fresnel theory of aberration, which Michelson's apparatus had detected, remained, and soon became a topic of worldwide discussion among physicists. In 1891, physicist G.F. FitzGerald of Dublin proposed that the smaller than expected results of the Michelson-Morley experiment might be caused by a shortening of the stone base of the interferometer in the direction of motion of the instrument through the ether, owing to a change in intermolecular forces effected by relative motion through the ether. If the effective light path became shorter in that direction, it could reduce or annul the results expected with the Fresnel hypothesis. British physicist Sir Oliver Lodge promoted the FitzGerald contraction hypothesis in an 1892 address to the British Royal Society.

In 1895, the Dutch physicist H.A. Lorentz, who was engaged in an effort at modifying Wilhelm Weber's electrodynamics to address new experimental results, adopted and elaborated on the FitzGerald hypothesis. He suggested, that the motion through the ether of the electrically charged particles constituting a body, would generate a magnetic effect that would increase the interatomic attractive forces, resulting in a contraction in the direction of motion. If Lorentz's supposition were true, the amount of the contraction would depend on the physical properties of the solid; a change in the material separating the ends of the interferometer ought to produce a change in the amount of shifting of the interference fringes.

Enter Dayton C. Miller

In 1890, the young American physicist Dayton C. Miller joined the faculty at the Case School, which Michelson had recently left, and soon became a close friend of Professor Morley. While the names of Michelson and Morley have become world famous, thanks to the popularity of the Theory of Relativity, that of Miller is less well known. This is unfortunate, because Miller's investigations with the instrument invented by Michelson to detect the relative velocity of the Earth through the ether, were far more extensive than those of either his predecessor, Michelson, or their joint collaborator, Morley.

Dayton Clarence Miller (1866-1941) was born in Strongsville, Ohio. He graduated from Baldwin-Wallace College, and earned a doctorate in science from Princeton University in 1890, working under astrophysicist Charles A. Young. He was president of the American Physical Society during 1925-1926, chairman of the National Research Council's Division of Physical Sciences from 1927 to 1930, and president of the Acoustical Society of America from 1913 to 1933. Apart

from his extended work on the ether-drift experiment, Miller had a lifelong interest in music and acoustics. His mother a church organist, his father a choir member, Miller became an accomplished flutist. In 1908, he invented an instrument he called the phonodeik, to photographically record sound patterns, and with which he established the physical characteristics of the vowels in speech and music. As an expert on architectural acoustics, he was consulted on the design of a number of college chapels, and of Severance Hall in Cleveland.

The Michelson-Morley experiment and the Lorentz contraction hypothesis were a subject of much discussion at the International Congress of Physics in Paris in 1900, at which Professors Miller and Morley were both present. At the urging of William Thomson (Lord Kelvin), the two undertook the construction of a more powerful apparatus to repeat the ether-drift experiment of 1887. By 1902, they had completed an interferometer designed to test the Lorentz-FitzGerald contraction. The base was constructed of planks of white pine 4.3 m long, arranged in a cross. The optical apparatus was the same as the 1887 experiment, but the effective light path was more than three times longer. In observations made in 1902 and 1903, a small positive effect was observed, but the wooden support was so sensitive to changes in temperature and humidity that the apparatus was abandoned.

With an appropriation from the American Academy of Arts and Sciences, a new interferometer was completed by 1904 (Figure 4). Its arms, about 4.3 m long, were made of structural steel girders. It was floated on mercury in the same cast iron trough used in the 1887 experiment. New optical parts made by O.L. Petitdidier of Chicago were used. Four mirrors at the ends of each arm produced an effective light path equivalent to an interferometer arm 32 m long, almost three times that of the 1887 apparatus. This same apparatus was used by Miller in numerous observational sessions over the course of more than 25 years, and in several locations, including atop Mount Wilson in California.

In the first test of the new Morley-Miller apparatus, the distance between mirrors at the ends of the interferometer arms was made to depend on pine wood rods, in hopes of testing the Lorentz contraction. Results of the observations were inconclusive:

> If pine is affected at all as has been suggested, it is affected to the same amount as is sandstone. Some have thought that this experiment only proves that the ether in a certain basement room is carried along with it. We desire, therefore, to place the apparatus on a hill to see if an effect can be there detected.

So reads the conclusion of Morley and Miller's 1905 report on the experiment (cited in Miller 1933, p. 216).

In 1905, the interferometer was moved to a hut, on an unobstructed site on a hill in Cleveland Heights, at an altitude of about 285 m. The pine rods were removed, and the mirrors fastened directly to the steel base of the instrument. The hut and wooden covering of the instrument were provided with glass windows, to prevent possible obstruction of the ether flow. Observations were made in July, October, and November, consisting of 230 turns (rotations) of the apparatus in three sets. These showed a very definite positive effect (displacement of the fringes in certain directions), but too small to be reconciled with the Fresnel theory.

When Miller returned from summer vacation the next year, the property where the interferometer was housed had been sold, and the new owner demanded its immediate removal. The retirement of Professor Morley, and other circumstances, contributed to a long delay in Miller's interferometry work.

The Theory of Relativity

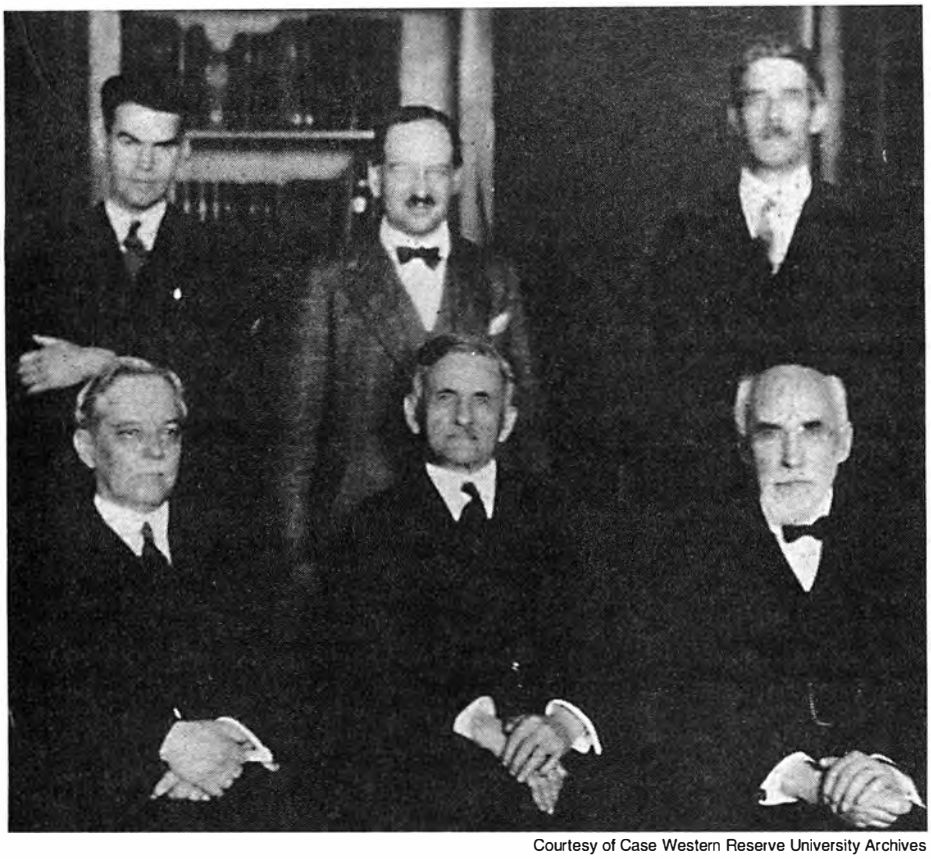
It was not until 1921 that Miller resumed experimentation with the interferometer. By that time, Einstein's Theory of Relativity had gained support among some scientists, and a great deal of publicity. Neither Michelson nor Miller could be counted among its adherents.

When Einstein developed the Special Theory of Relativity, in 1905, the interferometry experiments of Michelson, Morley, and Miller were not much in his thoughts. The title of his first paper on the subject, *Zur Elektrodynamik bewegter Körper* ("Toward the Electrodynamics of Moving Bodies"), indicates the direction of his thoughts. The problem he addressed in physics had its roots in Wilhelm Weber's formulation of the fundamental law of electrodynamics, which he had developed in conjunction with Carl Friedrich Gauss in 1845. Weber had determined, by an experimental proof of the validity of the Ampère angular force, that the force between two moving electrical particles would be dependent on the relative velocities and accelerations of the particles, and on a constant, which was determined in 1854 to be equal to the square root of 2 times the speed of light. Some important derivatives of Weber's work included an electrodynamic determination of the cause of the advance of the perihelion of Mercury,[8] the determination of a limit on relative velocities, and a theoretical determination of the classical electron radius, several decades before its experimental validation.[9]

What remained to be done after Weber's work, was to construct an intelligible representation of the deeper relationship among the phenomena of gravity, electrodynamics, and optics. This was the stumbling block already addressed by Gauss in his correspondence with Weber in 1845.[10]

Einstein's imaginative attempt at a solution centered on his recognition of the physical significance of a philosophical problem which he called the *paradox of simultaneity.* The determination of the simultaneity of two events depends on the position and relative velocity of the observer. Depending on the arrangement of these two variables, the same two events can occur before, after, or simultaneous with another. The implication for physics is an interdependency between the measures of length and time (and therefore, by the system of units which Gauss had established in 1832, of *mass,* as well,[11]) an interdependency whose implications were most thoroughly explored by Gauss's prized student, Bernhard Riemann, in his 1854 Habilitation dissertation.

However, Einstein introduced into his system some additional assumptions, principal among which were (1) the requirement that the velocity of light be invariant, regardless of the velocity of the emitting source, and (2) the non-existence of an ether at absolute rest. Thus, for the theory of relativity to be valid, it was necessary that the results of measurements with the Michelson interferometer be *absolutely zero,* or *null.* Unfortunately, the experimental evidence did not satisfy this re-



Courtesy of Case Western Reserve University Archives

Front row, from left: Dayton Miller, Albert Michelson, and H.A. Lorentz.

The Morley-Miller steel interferometer with its large cast iron tank for mercury was transported across the continent to the grounds of the Mount Wilson Observatory in California, and set up in March 1921, with the intention of measuring the ether-drift at the higher altitude there (1,750 m). Sixty-seven sets of observations produced a positive effect, corresponding to a relative motion of Earth and ether of 10 kilometers per second. Tests were made on the instrument to isolate the effects of radiant heat. A concrete base was tried in place of the steel girders, still producing positive results.

The apparatus was returned to Cleveland and experiments were made under various controlled conditions, between 1922 and 1924. Artificial light sources were tried, and the results found not to differ with those obtained with sunlight. (From then on, the acetylene headlamp, used at that time on automobiles, became the standard light source.) Extended tests were made of the effect of heat variations on different parts of the instrument.

quirement. A small, but persistent positive result kept cropping up in the most carefully conducted experimental trials with the most powerful interferometry apparatus available.

In 1919, the General Theory of Relativity gained notoriety after an astronomical expedition to equatorial Africa, led by Sir Arthur Eddington, photographed the light from a star occulted by the Sun during a total solar eclipse. Examination of the photographs seemed to suggest a slight bending of the path of the starlight around the Sun, consistent with Einstein's theory. The scant physical evidence was somewhat out of proportion to the worldwide publicity blitz that followed its announcement.

First Mt. Wilson Experiment

This was the context for Dayton C. Miller's return to his earlier experiments in interferometry, as he describes in a 1933 review of his efforts:

> Since the Theory of Relativity postulates an exact null effect from the ether-drift experiment which had never been obtained in fact, the writer felt impelled to repeat that experiment in order to secure a definitive result. An elaborate program was prepared and ample funds to cover the very considerable expense involved were very generously provided by Mr. Eckstein Case of Cleveland [Miller 1933, p. 217].

Albert Einstein visited Miller at Case on May 25, 1921, and urged further experimentation.

Miller's New Hypothesis

The interferometer was moved again to Mount Wilson in 1924, and set up in August at a new site, less exposed to the wind. A series of observations was made in September 1924, and in March-April 1925. While positive results were again obtained, a new paradox in their interpretation arose, the solution of which led Miller to his final theory of the ether-drift experiment. Calculations based on the effects of the orbital motion and apparent motion toward Hercules, predicted maximal variations in magnitude and azimuth to occur between September and April. These were not detected.

Miller realized that an assumption underlying all previous experiments with the interferometer might be invalid. It had previously been assumed that the Earth's velocity through the ether was known; namely, that it was the resultant of the orbital motion, combined with the motion of the solar system toward Hercules. What if, instead, the assumption were made that we do not know all of the motions which combine to produce the Earth's absolute motion through the ether? As we do know the results observed by the interferometer, however, we may take these as the primary data for the purpose of adducing the magnitude and direction of the Earth's absolute motion through the ether.

Why had no one thought of this approach before, Miller wondered? He wrote:

> The answer is, in part, the fact already stated that the purpose [of previous experiments] had been the verification of certain predictions of the so-called classical

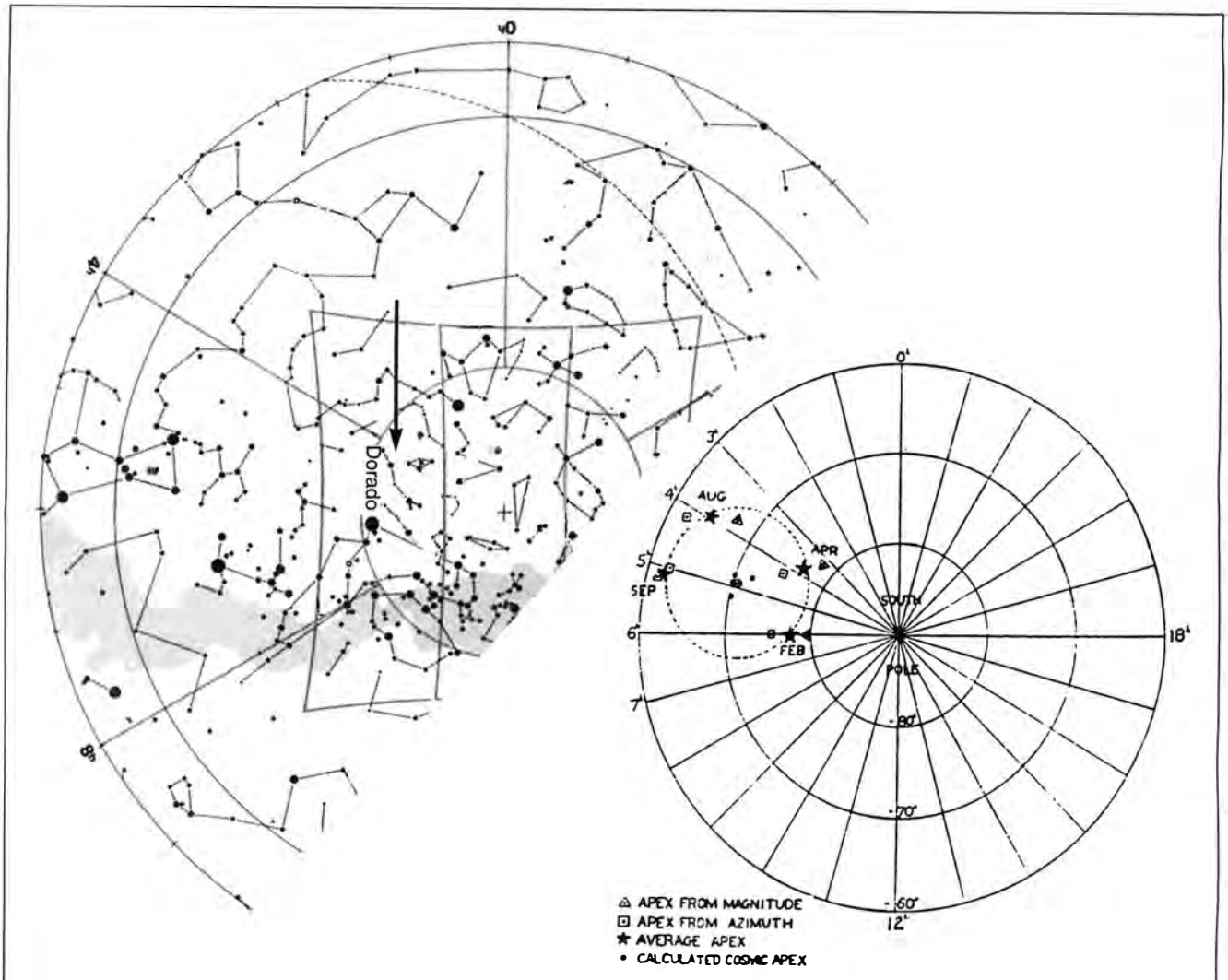


Figure 5
MILLER'S CHART OF THE APEX OF EARTH'S COSMICAL MOTION (1933)

Miller's analysis of the 1925-1926 observations at Mount Wilson, showed the Earth was moving in space at 208 km per second, toward a point in the southern celestial hemisphere in the constellation Dorado. The calculated apex of motion is at the center of the dotted circle. Starred points indicate the calculated apex of motion at each of the four epochs when observations were made. The accompanying stellar map shows the position of Dorado.

Source: D.C. Miller, 1933. "The Ether-Drift and the Determination of the Absolute Motion of the Earth," *Rev. Modern Phys.*, Vol. 5, p. 232 (July).

theories; and, in part, that it is not easy to develop a new hypothesis, however simple, in the absence of direct indication. Probably a considerable reason for the failure is the great difficulty involved in making the observations at all times of day at any one epoch. Very few, if any, scientific experiments require the taking of so many and continuous observations of such extreme difficulty; it requires greater concentration than any other known experiment. . . [Miller 1933, p. 222].

Results from Mount Wilson 1925-1926

The observations at Mount Wilson of April, August, and September 1925, and of February 1926 were conducted under the new hypothesis.

The reduction of the data from this cycle of observations was an enormous effort. The records consisted of 316 pages of readings, showing the fringe displacement at each of the 16 circular positions (azimuths) of the interferometer on each turn. A number of ingenious geometric models were constructed to aid in the visualization and computation of the effect. Altogether, 250,000 distinct observations were involved.

Miller presented a preliminary solution on Dec. 29, 1925, in his address as president of the American Physical Society to its Kansas City convention. The point on the celestial sphere toward which the Earth moves because of its absolute motion is defined as its *apex of motion.* Based on observations through Sept. 15, 1925, Miller and assistants calculated an

apex of motion in the northern celestial hemisphere of right ascension 17 hours and declination +65°.

Following a fourth observational series, made on Feb. 8, 1926, all of the data were subjected to an elaborate reexamination. The results, presented to the Pasadena Ether-Drift Conference, Feb. 4-5, 1927, showed an apex of motion of right ascension 17 hours and declination +68°—close to the 1925 results.

Miller's Final Results

Miller undertook a new study of the Mount Wilson series of observations in 1932. The possibility that the apex of motion was on the same line, but in the opposite direction, was examined, and found to be the more probable. The apex finally determined was in the southern celestial hemisphere at right ascension 4 hours 54 minutes and declination −70°33′. It lies in the constellation Dorado (Sword Fish) in the great Magellanic Cloud.

The calculations connected with the 1932 re-analysis also permitted, for the first time, an estimate of the Earth's cosmic speed. For each of the four epochs (Feb. 8, April 1, Aug. 1, and Sept. 15), an apex of motion was calculated, once from the data for the magnitude of fringe displacement (*velocity*), and once from the record of *azimuth* of the interferometer. From the two apices, which lay close to each other in each case, a mean apex was derived for each of the four epochs. These were found to lie on a small circle on the celestial sphere (Figure 5), whose center was taken to be the already reported apex of cosmic motion.

Courtesy of Case Western Reserve University Archives

Dayton Miller at the Case School, with the Henrici harmonic analyzer, which he used earlier for sound and later for interpretation of interferometer data.

The model in Figure 6 indicates how the estimation of speed was made. Depicted are the orbital position of the Earth, at each of the four epochs when interferometer observations were made. The diagonal of each parallelogram points to the mean apex for that epoch; the long side points to the calculated apex of motion (the center of the circle). The short side of the parallelogram represents the known orbital velocity of the Earth, of about 30 kilometers per second. Knowing the direction of three sides of a triangle, and the magnitude of one side, allows a simple determination of the magnitude of the other sides. By such means, an estimated velocity of 208 kilometers per second toward the southern constellation Dorado was obtained. That is Miller's estimate of the absolute motion of the Earth through the ether.

The direction of motion is within 6 degrees of being perpendicular to the plane of the ecliptic (the plane in which the elliptical motion of the planets occurs), from which Miller conjectures:

> This suggests that the solar system might be thought of as a dynamic disk which is being pulled through a resisting medium, and which therefore sets itself perpendicular to the line of motion.
>
> The fact that the sun is moving towards the southern apex with a velocity of 208 kilometers per second and at the same time is apparently moving, with respect to the near-by stars, in the opposite direction towards the constellation Hercules with a velocity of 19 kilometers per second, indicates that the group of stars as a whole is moving towards the southern apex with a velocity of 227 kilometers per second [Miller 1933, p. 234].

A new paradox now arises. By the methods just described, Miller found a velocity of approximately 200 kilometers per second for each of the four epochs. However, the velocities adduced from direct observation of the fringe displacements are smaller by about a factor of 20. Some additional physical assumption is necessary, as Miller notes, to account for the reduction in observed velocity. Perhaps this is to be explained by an additional "drag" on the ether at the Earth's surface, or, perhaps, by an entirely different hypothesis. The question is left open.

An extraordinary coincidence of phase, in both the velocity (fringe displacement) and azimuth curves for all four epochs, when they are plotted against sidereal time, was noted by Miller. The minima of the velocity curves occur at about 17 hours for all four epochs. These can be seen in Miller's graphs, reproduced as Figures 1 and 2 in the accompanying article by Maurice Allais (p. 26). The same coincidence of phase among

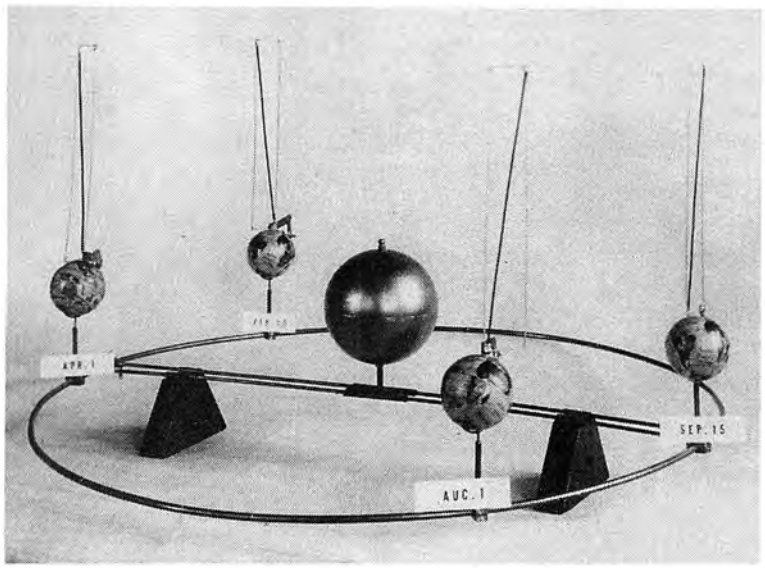


Figure 6
MODEL USED TO CALCULATE THE EARTH'S ABSOLUTE VELOCITY

Miller's model shows the Earth's orbital position at each of the four epochs in 1925-1926, when interferometer observations were made at Mount Wilson. The parallelograms indicate the Earth's orbital velocity (horizontal leg), and velocity of cosmical motion. The direction of motion is south, or downward.

Source: D.C. Miller, 1933. "The Ether-Drift and the Determination of the Absolute Motion of the Earth," Rev. Modern Phys., Vol. 5, p. 234 (July); photo courtesy of Case Western Reserve University Archives.

all four epochs was not present when the data were plotted against civil time. Miller took this as strong evidence for his conclusion that the orbital velocity is only a small fraction of the Earth's cosmical velocity through the absolute ether. (Civil time is based on the apparent position of the Sun in the sky, and thus reflects the Earth's orbital motion. Sidereal time is a measure of the Earth's rotation against the background of relatively fixed, distant stars; the Earth's orbit of the Sun is not involved.)

The phase correlation is also strong, almost irrefutable, evidence of the existence of a real effect, as opposed to a spurious or accidental cause. Miller also showed how the orbital component was responsible for the flattening of the curves in February and April, and the accentuated minimum six months later—again a coincidence of theory and observation which is difficult to ascribe to accident.

The Debunkers

In 1955, R.S. Shankland of the Case Institute of Technology in Cleveland, who had been a research associate of Miller in the 1932-1933 reanalysis, reported on a new study of Miller's work by a four-man team which he led. His conclusion was that

> the small periodic fringe displacements found by Miller are due in part to statistical fluctuations in the readings of the fringe positions in a very difficult experiment. The remaining systematic effects are ascribed to local temperature conditions [Shankland et al., 1955, p. 167].

Shankland re-examined Miller's 1923 laboratory tests on the effect of temperature variations on the instrument, in which Miller intentionally exposed different parts of the apparatus to the output of electric heaters. Shankland believed that the laboratory records showed "small but certain temperature effects," in contrast to Miller's conclusion. By a sophisticated analysis, he attempts to prove that it is possible for temperature variations to produce regular periodic effects. Examining the careful temperature records from Mount Wilson, Shankland then concludes that temperature variations in the exposed shed on Mount Wilson were the cause of the periodic fringe displacements, which Miller and his assistants observed.

By itself, the Shankland study might not be too significant, but it is supported by two other important elements. One is the great credibility afforded the Theory of Relativity, which requires as a premise the non-existence of the effects detected by Miller. The second, stronger supporting element is the fact that the results of a number of other interferometry experiments, carried out by careful and competent investigators contemporary with Miller, produced almost null results. These were, in summary:

- An experiment by R.J. Kennedy, using a very sensitive interferometer sealed in helium, on Mount Wilson in 1926.
- An interferometer enclosed in a vacuum casing, sent up by balloon to an altitude of 2,500 meters, and later taken to the summit of Mount Rigi, by A. Piccard and E. Stahel of Brussels in 1927.
- An interferometer having an effective light path of 25.9 m, mounted in the constant temperature vault of the Mount Wilson Observatory, by Michelson himself, with assistance of F.G. Pease and F. Pearson in 1929.
- An interferometer of 21m light path mounted on a quartz base (to avoid effects of magnetostriction), in a vacuum housing with photographic registration, by Georg Joos at Jena in 1930.

(The light path of Miller's apparatus was 32m.)

To account for the almost zero displacements found in these varied attempts, Miller noted that in all these experiments, the interferometer was enclosed either in metal casings, or basement rooms of laboratories, or both. "If the question of an entrained ether is involved in the investigation, it would seem that such massive and opaque shielding is not justifiable" (Miller 1933, p. 240). He also noted that none of the other experimenters conducted observations over a sufficiently extended time period to be able to detect epochal variations.

In 1959, Maurice Allais commented on the Shankland paper:

However, this criticism does not account for the extraordinary consistency of Miller's results with the motion of the earth about the sun (see Figs. 23 and 28 of his paper, pp. 232, 237). Similarly, it does not account for the remarkable adjustments with phases which agree with sidereal time, as shown on p. 235 of his work. It also leaves out the agreement between Miller's and Esclangon's results. . . [Allais 1959].

Science and Uncertainty

As difficult as it is to prove with absolute certainty (without more experimentation) that Miller's results are real, and not spurious, it is worth considering that the opposite case, an *absolutely null* result, as required by Einstein's theory, is far more difficult to establish with certainty. It is, first of all, in the nature of things that *nothing* is very difficult to prove, and for such reasons, we do not require a criminal defendant to prove his innocence, but rather put the burden on the other side to establish guilt.[12]

The uncertainty in connection with Miller's observations does not at all diminish their importance; quite the opposite. The experimental detection of very small deviations from an expected result is the very heart of science, and the foundation of its progress. It is always attended by uncertainty.

Kepler's determination of the very slight deviation of the Earth's orbit from a perfect circle is a case in point.[13] A statistical analysis of Tycho Brahe's data, combined with consideration of the effects on his metallic instruments of the horribly cold winter nights on the island of Hven, in Denmark, can provide plausible grounds for ignoring the tiny angular deviations on which the whole of Kepler's astronomy rest. The difference between the major and minor axis of the ellipse, which, as every school child is taught, constitutes the Earth's orbit around the Sun, is about one part in one thousand. It is not visible to the naked eye in a scale drawing, nor would it be in a time-lapse photograph taken from a spacecraft hovering above the disk of the solar system. A test by reproducibility was not a possibility. In short, the experimental grounds for Kepler's astronomy were not valid at the time he developed it, by the standards many scientific authorities would wish to apply today! The same applies to many of the most important discoveries in the history of chemistry, the proof of which rested on extremely fine measurements, at the edge of uncertainty, with a precision balance. One could start with Antoine Lavoisier's early work in determining the minute impurities present in water, for a case study.

Scientific discovery has never been the surefire certainty that textbooks and popular commentaries so often portray. Like all creative exercise of the mind, it is filled with uncertainty, ambiguity, subjectivity. It is always an uphill battle, too often amidst great adversity. Matters here are not decided by majority vote, popular opinion, or consensus. The timid, the faint-hearted, the seeker of praise, of public approval, or recognition within his lifetime had best stay away. If this disqualifies the vast majority of our current crop of, even highly decorated academic specialists, so be it.

The Contribution of Maurice Allais

The beauty and genius of M. Allais's work in physics is that he recognizes the necessary existence of an anomaly in our understanding of the propagation of light, and at the same time seeks to discover its meaning by extending the investigation into the necessarily related realm of gravitation. In this issue, we are, regretfully, limited to a presentation of his unique analysis of the Dayton Miller experiments. In future, we hope to be able to present the rest.

A brief overview of Allais's scientific work is found in the box accompanying his article, p. 26. To put it in a nutshell: Allais found that anomalies in the motion of the Foucault pendulum, and in a pendulum of an additional degree of rotational freedom (paraconical), exhibited a periodic character inexplicable by accepted gravitational theory. He discovered an identical periodicity in the anomalies found in reciprocal optical sightings made by two theodolites, aligned on north-south axis, and thus he established a lawful connection between the separate domains of mechanics and optics. This led to the proposal for experimental verification of the hypothesis that simultaneous observations of the paraconical pendulum, the reciprocal theodolite sightings, and the Michelson interferometer would lead to a coincidence of effects. M. Allais, age 86, has not yet enjoyed the opportunity to see his prediction tested.

Related Investigations

Dayton Miller provides a summary, in his 1933 report, of some of the related investigations, which he regarded as showing evidence of a cosmical motion similar to that he detected. They might, alternatively, be interpreted from Allais's standpoint as evidence of an *optical anisotropy* of space.

At the same time that Miller was conducting his experiments, the director of the Paris Observatory, E. Esclangon, made extensive studies of periodic deformations in the Earth's crust (Earth tides). These suggest a motion of the solar system in the plane cutting through the sidereal time meridian of 4 and 16 hours. Esclangon also studied anomalies in the reflection of light which, he concluded, was evidence of an "optical dissymmetry of space" around an axis lying in the plane of the meridian of 8 hours and 20 hours. Allais also references Esclangon's work.

Observation of the intensity of cosmic rays at the time of Miller's work showed a definite maximum in the sidereal meridian of 5 hours and 17 hours. Studies of galactic motions, and anomalies in astronomical observations are also cited. Finally, the work of Karl Jansky at Bell Telephone Laboratories in 1933 showed a hissing sound in shortwave radio reception, coming from a cosmic direction in the sidereal meridian of 18 hours.

A systematic review of more modern work is not available to us. The recent observations of astronomers Nodland and Ralston are worth noting.[14] By studying the rotation of plane of polarization of radiowaves from distant cosmic sources, an anisotropy is adduced. The axis of anisotropy lies in the direction between constellation Aquila and Sextans at right ascension 21 and 7 hours ±2 and declination 0° ±20°. This might be considered as perpendicular to the apex of cosmic motion determined by Miller.

Laurence Hecht, an associate editor of 21st Century, *is in the fifth year of a 33-year prison sentence imposed by the Commonwealth of Virginia. He was sentenced by jury trial in January 1991 in the aptly named venue of Salem, Virginia, as*

part of a nationwide witch-hunt against leading political associates of Lyndon H. LaRouche, Jr. All appeals have been denied. A worldwide campaign is under way for the exoneration of LaRouche and the release of Hecht and four other LaRouche prisoners, all serving long sentences arising from a politically motivated frame-up. For more information and to find out what you can do to help, contact the Schiller Institute, P.O. Box 20244, Washington, D.C. 20041, Tel. (703) 771-8390.

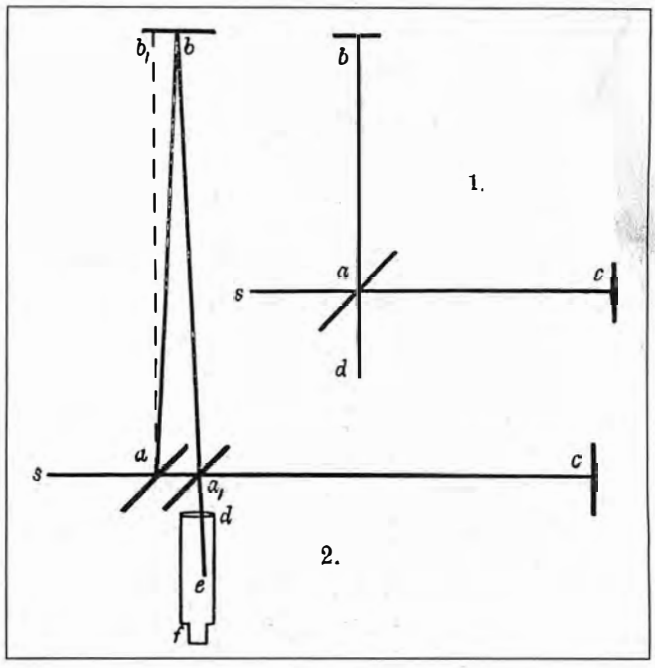
Notes

1. A. Fresnel, "Memoir on the Diffraction of Light," in Henry Crew, ed., *The Wave Theory of Light* (New York: American Book Co., 1900) p. 116.

   The Huygens-Leibniz conception of propagation as a self-reproducing phenomenon is considerably more sophisticated than many later defenders of the wave theory recognized. Modern discussion of the issue tends to focus on two other problems: the existence, or non-existence of a transmitting medium, and the question of wave versus particle. Whichever alternative is chosen, the problem of what occurs in between transmission and reception is usually subjected to an overly close shave with Occam's razor. The assumption of a linearly continuous action is introduced, ignoring the fact that the whole power of modern optics rests on Fresnel's recognition of the efficient power of a non-linear, self-reproducing mode of propagation known as Huygens's Principle.
2. Laurence Hecht, "The Atomic Science Textbooks Don't Teach: The Significance of the 1845 Gauss-Weber Correspondence," *21st Century Science and Technology,* Fall 1996, pp. 21.
3. Bernhard Riemann, "Philosophical Fragments," and excerpts from "On the Hypotheses Which Lie at the Foundations of Geometry," in *21st Century,* Winter 1995-1996, p. 50.
4. Present approved history of physics is premised on an oft-repeated historical fraud concerning Maxwell's alleged contribution to the interpretation of Weber and Kohlrausch's 1854 determination of the *Weber constant* (what is today, mistakenly, referred to as the ratio of the electromagnetic to the electrostatic unit of action). In a letter to his brother in 1853, Riemann, who would assist at the classic experiment the next year, had already predicted the identity of the velocity of light with the velocity of propagation of electrodynamic action. Weber, preceded in publication by Gustav Kirchoff, demonstrated by 1857 the theoretical propagation of an electric wave in a conducting wire at the velocity of light. The solution of the problem of a unified conception of gravity, electricity, and magnetism, on which Riemann and associates labored, was not advanced, but set back, by the acceptance of Maxwell's mechanistic reductionism.
5. E.T. Whittaker, *A History of the Theories of the Ether and Electricity.*
6. Michelson's experiment was the second serious American challenge to British scientific authority in the period. The first was the 1879 work of Edwin Herbert Hall and Henry Augustus Rowland in discovering the transverse electrical force known as the Hall effect. Hall's report of the discovery in "On a New Action of the Magnet on Electric Currents," (*Am. J. Math.,* Vol. 2, p. 287, 1879), describes his and Rowland's doubt over the truth of Maxwell's assertion that a magnet acts "not on the electric current [in a wire], but on the conductor which carries it." Their experiment proved Maxwell in error, and established the existence of a force on an electric current, acting perpendicular to the direction of its flow, when the current is moving in a plane perpendicular to the line connecting the north and south poles of a magnet.
7. To find the difference in the two paths *aba* and *aca,* Michelson shows in his 1887 paper:

   Let V = velocity of light
   v = velocity of the earth in its orbit.
   D = distance *ab* or *ac,* fig. 1.
   T = time light occupies to pass from *a* to *c.*
   T′ = time light occupies to return from *c* to *a′* , (Fig. 2).

   Then $T = \frac{D}{V-v}$, $T' = \frac{D}{V+v}$. The whole time of going and coming is $T+T' = 2D\frac{V}{V^2-v^2}$, and the distance traveled in this time is $2D\frac{V}{V^2-v^2} = 2D\left(1+\frac{v^2}{V^2}\right)$, neglecting terms of the fourth order. The length of the other path is evidently $2D\sqrt{1+\frac{v^2}{V^2}}$ or to the same degree of accuracy, $2D\left(1+\frac{v^2}{2V^2}\right)$. The difference is therefore $D\frac{v^2}{V^2}$. If now the whole apparatus be turned through 90°, the difference will be in the opposite direction, hence the displacement of the interference fringes should be $2D\frac{v^2}{V^2}$ Considering only the velocity of the earth in its orbit, this would be $2D \times 10^{-8}$. If, as was the case in the first experiment, $D = 2 \times 10^6$ waves of yellow light, the displacement to be expected would be 0.04 of the distance between the interference fringes [Michelson 1887, p. 336].



8. C. Seegers, 1864. "De motu perturbationibusque planetarum secundum legem electrodynamicam Weberianam solem ambientium" (Göttingen).

   F.F. Tisserand, 1872. "Sur le mouvement des planètes autour du Soleil d'aprês la loi electrodynamique de Weber." (Paris: *Compt rend.,* Sept. 30).
9. Hecht, *op. cit.*
10. For an English translation of the relevant correspondence, see *21st Century Science & Technology,* Fall 1996, pp. 41-43.
11. C.F. Gauss, 1832. *Intensitas vis magneticae terrestris ad mensuram absolutam revocata.* Unpublished English translation.
12. The difficulty of experimentally verifying a null result has an important precedent in the history of modern physics. When Wilhelm Weber set out to establish the validity of Ampère's angular electrodynamic force, he noted as a weakness of Ampère's case, that his experimental evidence rested on null results, the *non-appearance* of movement in certain configurations of current-carrying wires. Weber noted that it were possible that effects, such as friction, might be masking very small forces which Ampère had not considered. With the help of Carl Friedrich Gauss, Weber was able to design an experiment which measured the electrodynamic interaction with such precision that the Ampère angular force could be established through positive evidence.

    See Wilhelm Weber, 1846. "Elektrodynamische Maasbestimmungen: über ein allgemeines Grundgesetz der elektrischen Wirkung" in *Wilhelm Webers Werke* (Berlin: Julius Springer, 1893) Vol. 3, pp. 25-214. Unpublished English translation by Susan P. Johnson.
13. Pedagogical series by Jonathan Tennenbaum, "How Gauss Determined the Orbit of Ceres," in *The New Federalist* newspaper, beginning in December 1997.
14. See David Cherry and Charles B. Stevens, "Does Light Travel Faster in the Earth-Sextans Direction?" and interviews with Nodland and Ralston in *21st Century,* Summer 1997, p. 72.

References

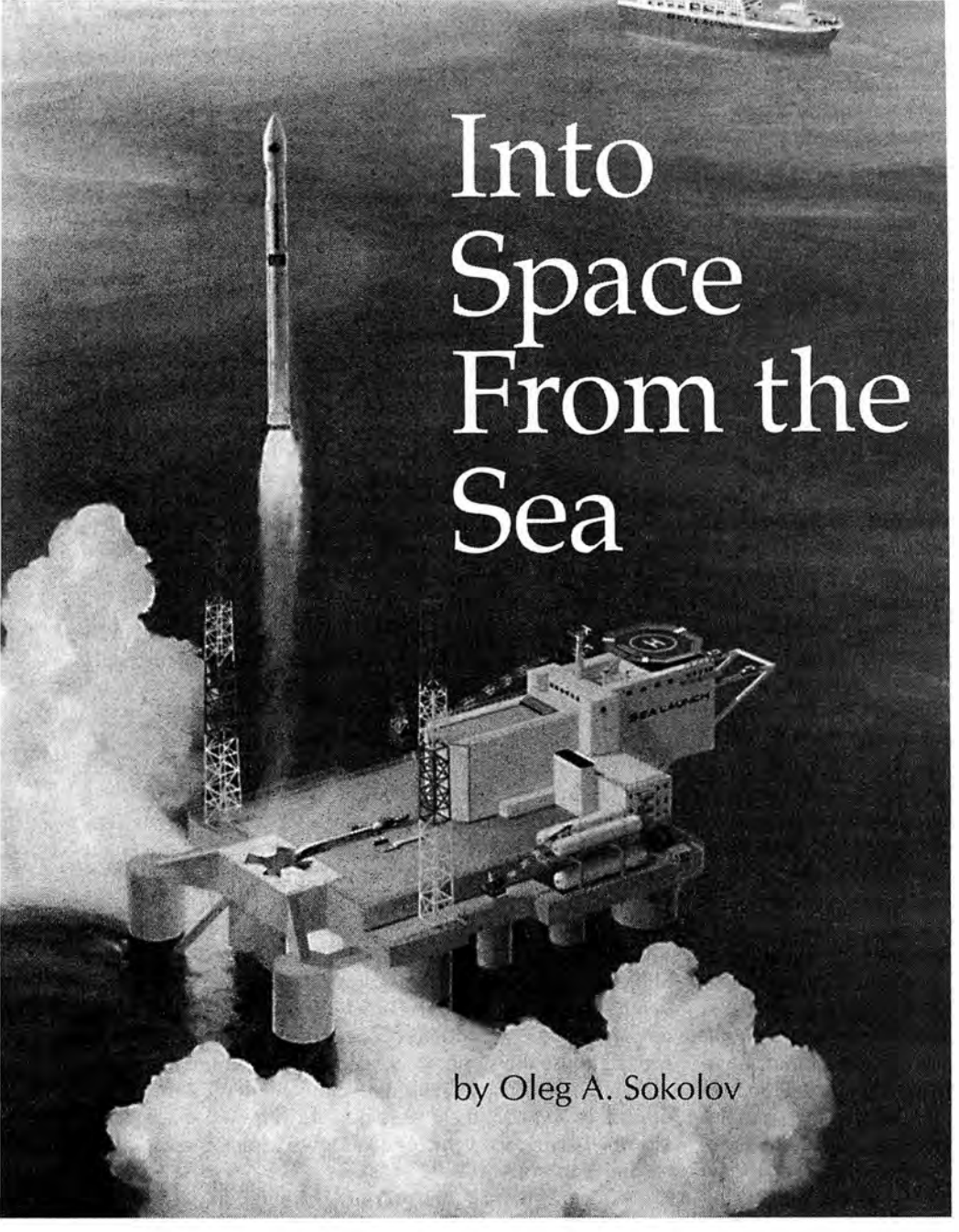
M. Allais 1959. "Should the Laws of Gravitation Be Reconsidered (Part II)" *Aero/Space Engineering,* Vol. 18, No. 10, Oct., pp. 51-55.

A.A. Michelson, 1881. "The Relative Motion of the Earth and the Luminiferous Ether," *Am. J. Sci.,* Vol. 3, No. 22, p. 120.

A.A. Michelson and E.W. Morley, 1887. "On the Relative Motion of the Earth and the Luminiferous Ether," *Am. J. Sci.,* Vol. 3, No. 34, p. 333 .

D.C. Miller, 1933. "The Ether-Drift and the Determination of the Absolute Motion of the Earth," *Rev. Modern Phys.,* Vol. 5, p. 203 (July).

R.S. Shankland, S.W. McCuskey, F.C. Leone, G. Kuerti 1955. "New Analysis of the Interferometer Observations of Dayton C. Miller," *Rev. Modern Phys.,* Vol. 27, p. 167.



Sea Launch

Artist's drawing of the launch of a Zenit rocket from the Sea Launch platform. In the background is the rocket Assembly and Command Ship.

Since the dawn of the space age, nations have lofted satellites into space from launch sites on land. Soon, for the first time, satellites will also be reaching space from the sea.

The way to space began in 1957, from the Earth's surface—a surface in the true sense of the word, from the hard soil of land. Later, it was proposed that space launchers be lifted into the air by airplanes before their launch into space, and it seemed logical that rocket launchers should be started in the sky, closer to space.

However, when a recent project was proposed, to put to sea a launch site for a large rocket intended for geostationary satellite injections, this project was met with astonishment, and raised questions not only from the general public, but also from some specialists. The proposal in question is the international Sea Launch project, which is now in the process of final implementation. Sea Launch will use the Ukrainian-built Zenit three-stage launch vehicle; a floating, self-propelled launch platform converted from a former oil-drilling platform; and a special command ship for launch control (see illustration). Its first commercial launches are scheduled for October 1998.

Sea Launch is not the only proposal for using the sea as a base for space launchers. Two years ago, the Russian/American "Surf" project was near to realization, but was halted for political reasons. The San Marco floating platform, from which the Italians launched their suborbital Scout rockets many years ago, is still in the sea near the coast of Kenya, and the Russian builders of submarine-launched ballistic missiles (SLBMs) continue to propose conversion of their missiles into space launchers, and have launched one such missile along a sub-orbital trajectory, with a scientific payload.

Why Launch from Sea?

In order to understand the prospects for realizing the "into space from the sea" concept, it is necessary to examine its advantages in comparison with the ground- and air-basing of space launchers. Launches of ballistic missiles and, later, space launches, have been traditionally considered dangerous work, not only for the personnel involved in their preparation and operation, but also for the regions situated near the launch sites. Two recent disasters in China, where a number of peasants were killed when Long March launchers failed, unfortunately confirmed this danger.

There is danger near a launch site in the initial part of the trajectory, and also with the descent of the spent missile or launcher stages, after its burning is completed. For example, during the recent (March 4, 1997) first launch from the new Russian Svobodny cosmodrome in the Far East, one of the Start launch vehicle's stages landed near the Yakut settlement. Only the fact that no building (to say nothing about people or animals), was in this spot, has apparently prevented the Yakuts from receiving their first space revenue in the form of compen-

sation from the Russian Military Space Forces. The Yakuts have brought a lawsuit.

For safety reasons, builders of missile test ranges and launch sites, or cosmodromes, always chose deserts or seas as the regions over which rockets should fly. Deserts have the advantage that after any failure, hardware can be easily found and examined, in order to determine the reason for the failure. However, the problems of equipment deliveries, infrastructure, astronaut rescue, and so on, are more difficult to solve in desert regions than in the sea. So, from the point of view of operational safety, a cosmodrome optimally should be surrounded by a sea, which extends sufficiently in the direction of flight to provide for safety from jettisoned rocket stages.

The United States, having placed its first cosmodrome at Cape Canaveral, is luckier than the former Soviet Union, which had no suitable launch location surrounded by a sea. The United States had further advantage when injections of geostationary payloads were begun, because Cape Canaveral was closer to the equator than the Soviet Baikonur Cosmodrome. A significant addition of injected payload mass is possible if the space launch has low inclinations from near-equatorial latitudes.

Some countries, however, have no territory or colonies near the equator. Why couldn't such an unhappy country, which has powerful geostationary launchers, but no near-equatorial cosmodromes, use the cosmodromes of other countries under cooperative arrangements, partnerships, or simply by leasing of facilities? This would seem to be a better solution than the development and manufacturing of complicated special ships for sea launches, or even airplanes, to be used as mobile air-launch sites.

There are two important factors influencing this solution in the present political-economical environment: First, is competition, and an unwillingness on the part of the countries that have rocket technologies, to spread such technologies. It is difficult to imagine the construction of a launch site for any competing geostationary launcher, side by side with the European Ariane launch sites at Kourou, French Guyana, for example, with the permission of the French authorities. Even a proposal for the construction of a launch site at Cape Canaveral, for the Russian Proton launch vehicle, which is now being marketed in a business partnership with Lockheed Martin, was wrecked in a sea of prohibitions and coordination agreements.

Similarly, a proposal to use the Brazilian Al Cantara launch range for commercial purposes met with the accusation that rocket technologies were being transferred for military purposes. The underlying opposition apparently, was the unwillingness of certain space interests (including the U.S. Department of State) to foster the creation of a new, competing launch facility. In addition, the Al Cantara site does not yet have infrastructure sufficient for commercial launches.

There are similar concerns about the new cosmodromes being created at Cape York near Darwin in Australia, and in Papua New Guinea. Many hundreds of millions of dollars, if not billions, will be required to upgrade these sites to cosmodromes operating at a level that can attract international customers.

The second factor militating against the use of third-country launch facilities, is that the leading technological countries have already accumulated vast experience in the development, manufacturing, and operation of mobile platforms for launches of long-range ballistic and cruise missiles. Some of these sea carriers seem suitable for use as mobile cosmodromes because, as is well known, a majority of space-launch vehicles were derived from ballistic missiles, and some of the recent ballistic missiles, including even Submarine Launched Ballistic Missiles (SLBMs), recently became comparable to space-launch vehicles of the lightweight class, in mass and size.

There have been numerous projects to convert ballistic missiles to launch vehicles, mostly in Russia and Ukraine. After the Soviet Union collapsed, these countries had an abundance of excess armaments, and a great lack of money to support their economies.

One solution proposed was the conversion of ballistic missiles into commercial space launchers. It is clear that there are sufficient grounds to justify the development of sea-based space launchers. It is also clear that, between Russia and the Ukraine, Russian engineers are better qualified, by reason of their experience, and technical capabilities, to create these launchers, because their Ukrainian rocket/space colleagues never developed SLBMs.

Rocket Launches from the Air

Before examining the Russian capabilities to provide space launches from the sea—and before answering the question of why the Ukrainians are taking part in such launch preparation—it is necessary to examine whether air-based space launchers could compete with sea-based launchers, and if not, why not.

As is well known, the former Soviet Union had land-based intercontinental ballistic missiles (ICBMs), in addition to SLBMs. After the end of the Cold War, some projects to convert the ICBMs to air-based launchers were developed; for example, the Shtil MA and the "Space Clipper." There was also a project to use the strategic supersonic TU-160 bomber for an air launch of cruise-missile-derived technologies, the Burlak project. In addition, there were non-conversion projects of air-launched aerospace vehicles, like the old Spiral project, or, its modern version, MAKS.

However, the post-Soviet countries, including Russia and Ukraine, had no money to develop new projects like the MAKS, and all of the projects for converting air-based launchers had one mutual shortcoming: These former ballistic missiles could only be converted into launch vehicles of a lightweight class. Although they had been designed to carry heavy military payloads, these missiles were required only to reach sub-orbital flight, in order to hit a target on Earth. They had no capacity to inject payloads into geostationary orbit (GEO), which is the orbit required for communications and other commercial satellites. In order to be able to compete with ground-based launch sites, it was necessary to use a significantly larger, and more powerful, air carrier that could lift a heavy geostationary launcher into orbit.

Most lightweight payloads, however, such as Earth remote-sensing satellites, need to be injected into low-Earth orbits (LEOs), which include near-polar and high-inclination orbits. Therefore, for such low-Earth orbits, the proximity of the launch site to the equator, which is possible with a launch from an airplane, does not provide any significant advantage.

Figure 1
DESIGN FOR THE AIR-LAUNCHED ZENIT
Although the Ukrainians proposed that their Mria plane would be able to air-launch the Zenit rocket, there were doubts that this could be done successfully.

Source: Courtesy of Oleg Sokolov

Ukraine has a large, powerful carrier, the largest in the world, the Mria cargo plane, which is being developed and built in Kiev by the Antonov company. (It should be noted that Ukraine was, and is, more interested in "cosmodrome-less" space launches, because it has no cosmodromes at all, although its missile/space industry has significant capacities and experience, and could be a source of national income.) The Mria would be able to lift the fueled, Ukraine-built Zenit launcher. The addition of the Russian Block-D upper stage, gives the Zenit a geostationary injection capacity.

Such a concept had been developed (Figure 1), but its realization was in doubt, because a horizontal launch of the near-500-ton Zenit rocket from the "back" of a giant airplane, would create non-calculated side overloads and other conditions, which were not foreseen in the design of the existing Zenit.

The number of modifications required for air-launching the Zenit would be so great, that it would have been simpler to create the all new MAKS project, using the same airplane and a new, reusable aerospace vehicle. But, unfortunately, neither Ukraine nor Russia had the money to realize this new project. They could only consider using existing (developed and tested) hardware. Because of this, the Ukrainians were forced to involve their Zenit in the unknown (for them) field of sea-launch technologies, with which their Russian colleagues were familiar because of their experience with military technology.

Launching Missiles from the Sea

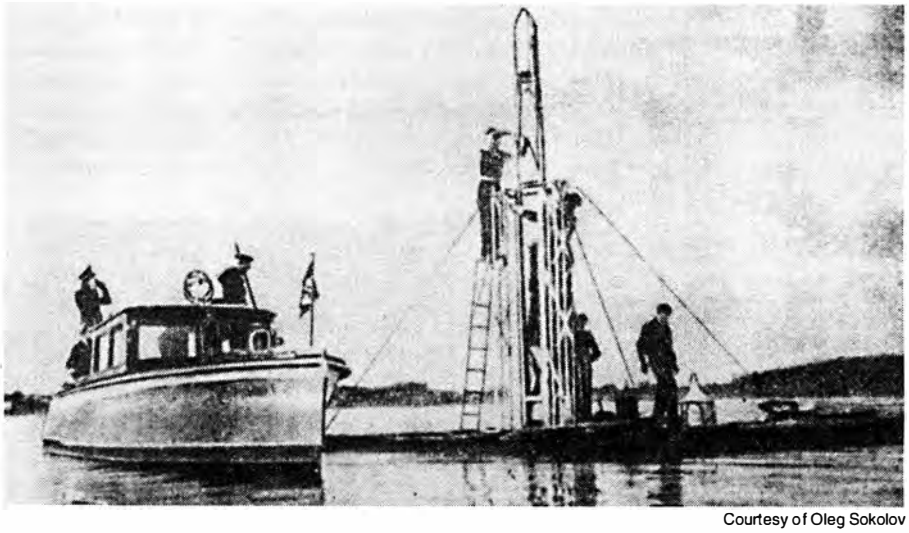
The history of rocket launches from water begins with the German rocket pioneers of the 1920s and 1930s, who launched their experimental rockets in 1933 from a raft, floating, for safety reasons, in the Shwilov Lake, near Berlin (see photo).

Modern ballistic missile history and the evolution of space launchers began with the wartime German V-2, and the history of sea-launched ballistic missiles also had its origin in the development of the sea version of the V-2. The reasons for the development of this version were understandable. Although the V-2 was an impregnable weapon (anti-aircraft defense could not intercept ballistic missiles at that time), the Germans had no possibility of using it against remote targets because its range is very limited—at most, 200 miles.

However, the Germans had a means which could assist them in stealing up on remote targets—the submarine. Germany very successfully used its submarines, or U-boats, during both World Wars, and its submarine technologies were then the most advanced in the world. Of course, the idea of a synthesis of these two most advanced weapons came into the minds of the German engineers.

For a submarine-based V-2, the missile would be housed in a separate pressurized container to be towed by the submarine in a submerged position with ballast cisterns. Before a launch, this container would be transferred to a vertical position by a partial filling and drainage of the ballast cisterns. Then the missile would be fueled from the submarine, through flexible pipelines passing to the container, together with a tow rope. The container with the fueled missile would be raised to the surface of the water so that its top lid was above the surface. The lid would be opened, and a missile would be launched by a command transmitted from the submarine through a cable.

Some experiments were performed in the Baltic Sea at the end of World War II, but the Germans did not solve their main problem: the production or storage of liquid oxygen for the V-2, on board a submarine. Because of this, the sea-launch technology was not adopted by the Allies, including the Russians, after the war. But it was not forgotten.



Courtesy of Oleg Sokolov
The first test launch of a rocket from the sea was carried out in 1933 by the amateur German Rocket Society, seen here.

The time of real SLBM development came in the 1950s, but different methods were used in the Soviet Union and United States. Neither country adopted technology similar to the German V-2, although the Soviet technology was closer to it, perhaps because the Russian engineers began to develop a SLBM somewhat earlier than their American colleagues. Let us see what experience and technologies were at the disposal of Russian engineers in this field, after the multi-year development of SLBMs for the Soviet Union.

In the early 1950s, the R-11 tactical ballistic missile was developed in the Design Bureau of Sergei P. Korolev, who is well known as the father of the first ICBM, the first space launcher, the first artificial satellite, the first manned spacecraft, and so on. At that time, however, Korolev was only the author of the Russian R-1 (which was a copy of the V-2), and its improved R-2 version. The R-11 missile was the Russian replacement for these German/Russian designs.

Anyone who would like to see the R-11 in action, should take a look at a film about the 1991 Gulf War: The Scud missiles were direct descendants of the R-11, with only a few changes, thanks to the reliability and relatively simple design of this missile. With one chambered rocket engine burning nitric acid and kerosene, this missile covered approximately the same range as the V-2, but had only half the mass. The R-11 was designed for mobile basing on a tracked transporter; consequently, it was suitable for other kinds of mobile basing, including in the sea.

The development of the R-11 sea version (R-11 MF) was performed under the personal management of Korolev, who even took part in test launches from a submarine. Why was a submarine selected as a sea carrier for a missile? For the same reason that it had been selected by the Germans: The Soviet Navy never had the capacity to come near enemy coasts with surface ships in wartime, because, like the German Navy of World War II, it had no aircraft carriers which could defend these ships.

The R-11 MF was housed vertically inside a missile tube that passed through the hull and house of a submarine. These mass-produced submarines had two or three missile tubes. Initially, missiles could be launched only when the submarine was on the surface. A missile was loaded into the submarine in an unfueled condition. Later, in a harbor, the rocket was fueled. Before a launch, the missile was pulled out of the tube and fastened by a special device, in order to keep it in position during pitching or rolling. During the launch of a missile, this device was opened automatically. Because of its shape in the opened position, the device received the nickname, "horns and hoofs."

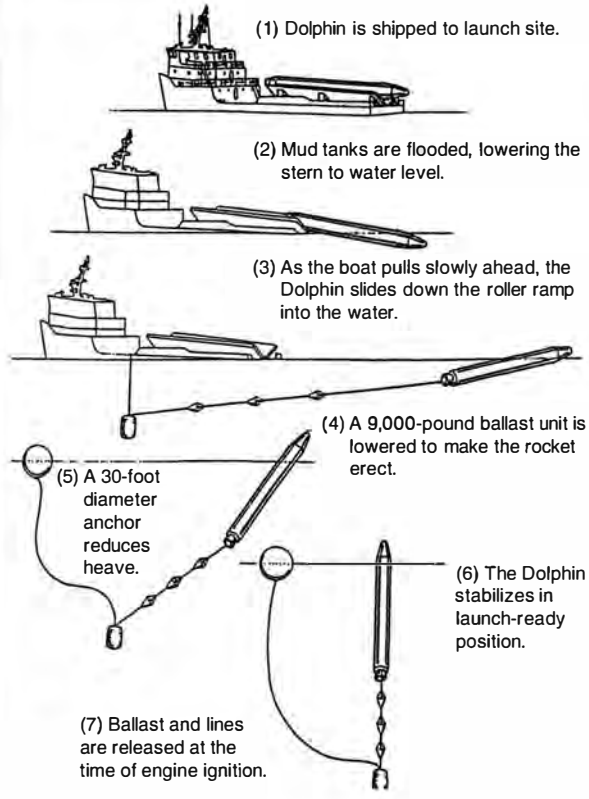
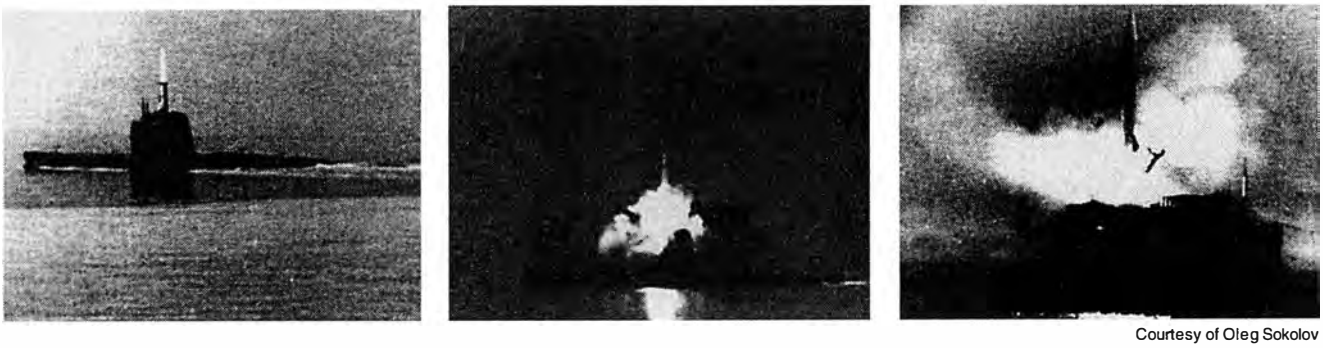


Figure 2
SCHEMATIC OF THE PROPOSED DOLPHIN LAUNCH
The Dolphin rocket was to be launched from a free-floating stabilized position in Hydra, a 1960s American sea-launch project that was never carried out.

Source: Courtesy of Oleg Sokolov

The first launch of an R-11MF, from aboard a B-67 diesel submarine, took place on Sept. 16, 1955. This was the first launch in the world of a ballistic missile from the sea (see photo). Some time later, the R-11FM version with an underwater launch was developed.



Courtesy of Oleg Sokolov

The underwater version of the Soviet ballistic missile, the R-11, is readied and launched from a Soviet submarine.

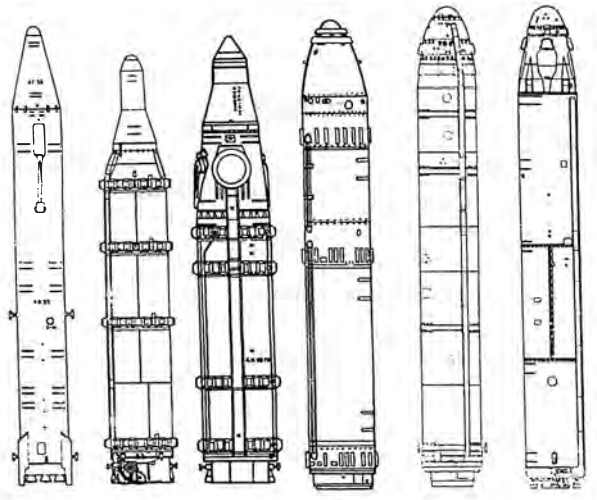


Figure 3
THE FAMILY OF SOVIET SUBMARINE-LAUNCHED BALLISTIC MISSILES
From left: the R-21 (SS-N-5), the RSM-25 (SS-N-6), the SS-NX-13, the RSM-45 (SS-N-17), the RSM-50 (SS-N-18), and the RSM-54 (SS-N-23).

Source: Courtesy of Oleg Sokolov

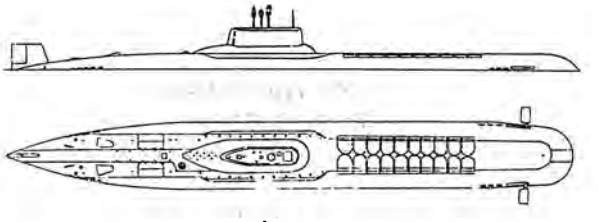


Figure 4
TYPHOON NUCLEAR SUBMARINE
The Typhoon submarine carries 20 RSM-52 missiles. The largest SLBM in the world, weighing about 90 tons, was designed for the giant Typhoon-class submarines.

Source: Courtesy of Oleg Sokolov

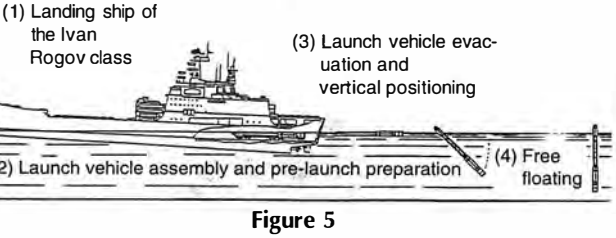


Figure 5
THE SEA-BASED SURF LAUNCH SYSTEM
Like the U.S.-designed Hydra Project, the Russian Surf concept fires the rocket directly from the water. Although this is more difficult than firing from a ship, it avoids the terms of the Strategic Arms Reduction Treaty.

Source: Courtesy of Oleg Sokolov

At approximately the same time in the United States, development began of the Polaris SLBM. This became the first real battle SLBM, but was less like future sea space launchers than the R-11FM. From 1960 to 1975, the Americans also developed the German concept of sea launch in their HYDRA program. Indeed, it is sufficient to look at Figure 2, to see the likeness. It is a towed container, which was transferred to a vertical position by ballast cisterns before the launch of a sounding rocket (instead of a ballistic missile). The launch itself was commanded by a cable from a tow ship (instead of a submarine). The main difference was the use of a solid-propellant rocket, which avoided an in-water fueling or preliminary fueling of liquid propellant.

All Russian SLBMs after the R-11MF were designed in the Design Bureau for Machine-building, situated in the town of Miass, in the Urals. This Design Bureau was headed by a young assistant of Korolev, Viktor P. Makeev. (When Korolev proposed making Makeev the chief of a newly established subsidiary in Miass, Makeev declined the appointment, saying that he would depart only to become the chief designer of an independent design bureau. This requirement was met, and Korolev made no mistake, because Makeev played a brilliant role in his new post.

Under Makeev's management, a range of Soviet SLBMs was developed. Mostly two-staged, they had many interesting features. For example, the missile designated the SS-N-13 in the West, was designed especially for hitting aircraft carriers, and had a radar homing warhead. However all the SLBMs had a general mutual feature—they used liquid propellants, in contrast with the solid-fueled SLBMs of the United States. Illustrations of some Soviet SLBMs are shown in Figure 3.

The design of the first Soviet solid-propellant SLBM, the RSM-52 (SS-N-20 by the Western designation), was finished just after Makeev's death in 1985, by his successor, Igor I. Velichko. This SLBM, the largest in the world (launch mass was about 90 tons), became a weapon of the giant Typhoon class submarines, which had a displacement of about 24,000 tons (Figure 4).

Velichko became widely known, not as a designer of this SLBM and the RSM-54 (SS-N-23), or the more advanced liquid propellant SLBM that followed it, but because he was the first to propose using his SLBM missiles as space launchers.

Attempts to Convert Missiles to Launchers

At the end of the Cold War, the Soviet Union rapidly approached its collapse. Most of the military industry's design bureau managers searched for commercial applications for their products, in order to remain afloat in the rough waves of the approaching market economy. Velichko and his colleagues from the former Design Bureau for Machine-building, renamed the Makeev State Rocket Center (SRC), proposed a range of suborbital sounding rockets and lightweight launch vehicles, using all of the types of SLBMs used by the Soviet (later the Russian) Navy.

One of these converted launchers, the Volna, was actually launched from a nuclear submarine with a scientific payload, a part of which was a German installation for experiments with materials under microgravity conditions (see photo). But this was a flight along only a sub-orbital trajectory, and the payload capacity was quite small.

Courtesy of Oleg Sokolov

Igor I. Velichko, who completed the design of the first solid-fueled sea missile.

The main shortcoming of Makeev SRC's projects was the use of nuclear submarines as platforms for space launches. Indeed, the limited volumes of missile tubes provided no capacity for increasing the payload accommodation zones; further, the routine conditions on board a submarine, did not meet the needs of pre-launch preparation of the payload. The advantages of using submarines as mobile launch platforms, very doubtful for lightweight launchers, was eaten up by the high cost of the submarine's operation.

So, the Makeev designers developed projects of surface-based and even air-based launch vehicles, based on their SLBMs. One of them, the Rif launcher, is shown in the photo.

However, surface and air versions of converted SLBMs had strong competition from converted ICBMs (such as the Start and Rockot), which were just being tested in flight as space launchers, and had ready launch sites. Further, the use of large cargo airplanes had the same shortcomings that submarines had. Moreover, some skeptics asked, maybe it would be more profitable to earn money by using such cargo airplanes for their original purpose, and then to use the money gained from this to buy a launch of the Start, Rockot, or Cosmos launch vehicle.

So, designers of SLBMs were forced to return to their element—the sea. During this return, Velichko and his colleagues used their full store of advanced technologies, created during the development of the most recent SLBMs. These were a solid-propellant propulsion system, and the so-called containered launch of an SLBM. While the first technology is well known, the second one requires some explanation.

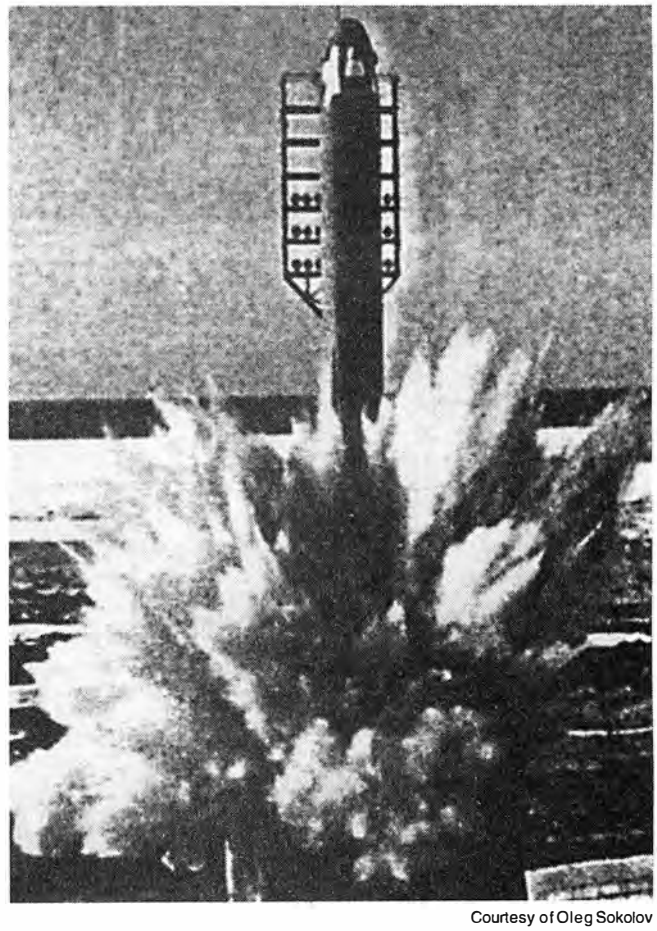
The containered launch technology installs the SLBM in a sealed, pressurized container. During a launch, the container with the SLBM is pushed off from a submarine's missile tube, and the missile is started when the top end of the container is opened on to the sea surface. The structure of a missile (or launcher) could be less sturdy, because it is inside the container and does not have to bear hydraulic loads.

One application of these technologies was the Priboy, or Surf project. The Surf project consisted of using a former landing ship of the Ivan Rogov class, which had a submerged dock chamber and large holds, intended for the transportation of battle vehicles. The Surf launch vehicles, up to three in one ship, could be accommodated in these holds. The launch vehicle was fully sealed, and could float autonomously at sea, in a vertical position. From this position, it could launch upon a command transmitted by a radio or by wires. The overall view of the Surf launch vehicle is shown in Figure 5.

Dropping the launch vehicle into the water is performed through a docking chamber. The sealed body of the launcher, including the rear plug in the first stage's nozzle, was containerized. It was not necessary to make a separate container because the water surface pressure was equal to the atmospheric pressure. So, as can be seen in the figure, the Surf design repeated the concept of the HYDRA (DOLPHIN) project and, therefore, also of the German V-2 sea version.

Why should the launcher be fired from the water, rather than from a ship? For one, it provides safety and, at first, this launcher was the only proven one. But its positioning and aiming would be much simpler during launch from a ship, rather than as a floating sealed tube with ballast cisterns. The answer concerns nontechnical issues: The requirements of the Strategic Arms Reduction Treaty, or START, forbids launches of SLBMs from surface ships, and the Surf launcher, having the first stage of an SLBM, was considered by START to be equal to an SLBM.

The Surf project had many advantages over its predecessors. It did not require the expensive operation of a nuclear submarine; it used manufactured (and paid for!) hardware—the stages of SLBMs and a landing ship; and it provided mobility and, therefore, could launch from near the equator. Because its sufficiently powerful launcher had a capacity for injections of some payloads into geostationary transfer orbits, being near the equator would be a benefit. In fact, the Surf project was recognized to be so attractive, that the American Sea Launch Investors company was established in order to provide investments for the project's realization.



Courtesy of Oleg Sokolov

The Volna rocket, converted from an SLBM, was successfully launched from a nuclear submarine in 1995.

However, while the Makeev SRC's managers and engineers were waiting for money from the United States, they received instead political protest. The U.S. State Department accused Russia of the "creation of a sea-launched intercontinental ballistic missile based at a free-floating platform," which was prohibited by the START Treaty. Thus, the activity of Sea Launch Investors was halted, and future prospects of the Surf project were discussed in diplomatic circles—without success. The Makeev engineers have recently redesigned the Surf launcher into its surface-based cousin, the Berkut (Golden Eagle) launcher project. The prospects of this project, however, are very questionable because of strong competition from existing lightweight launchers that are being converted from ICBMs.

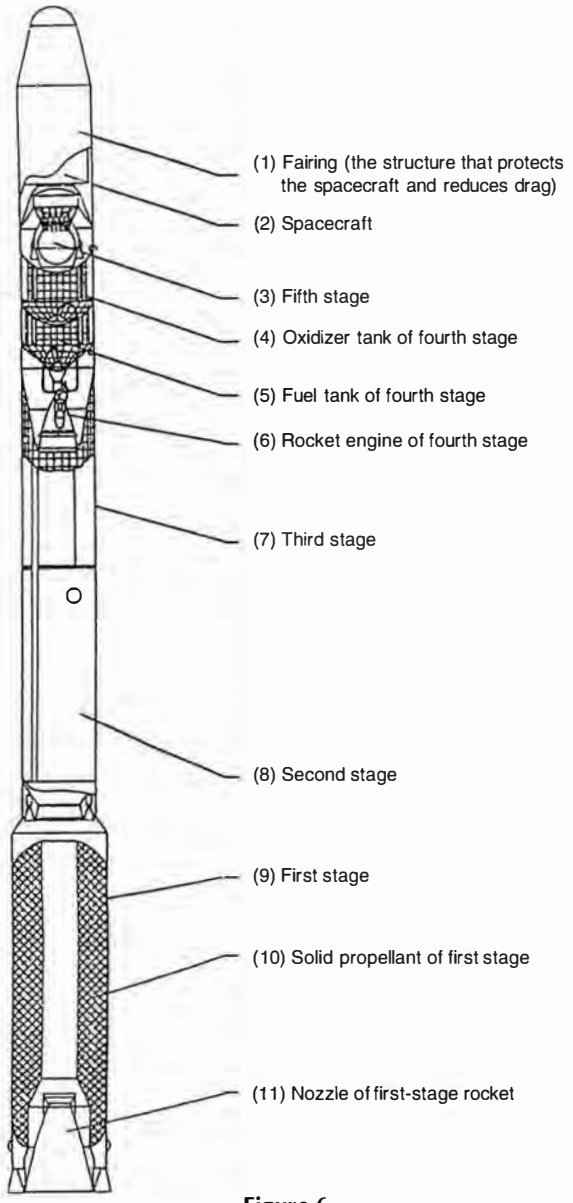


Figure 6
SCHEMATIC OF THE SURF LAUNCHER

Source: Courtesy of Oleg Sokolov

(So, one can say that a political surf has cast ashore a semi-dead golden eagle, for all that.)

The last attempt of the Makeev SRC to put its new launcher to sea, was its participation in the Riksha project. Developed jointly with the Energomash NPO, known in the United States as a supplier of rocket engines for the new version of the Atlas launch vehicle, this new lightweight launcher will use liquid oxygen/liquid methane as the propellant for its two stages. When a scaled mock-up of the Riksha was shown at the Paris Air Show in Le Bourget, France, in 1995, it was announced that this launcher would have a ground launch site, as well as a railway platform or surface ship, preferably a former refrigerator trawler, because it has the refrigeration equipment necessary for cryogenic propellant storage.

The Riksha is not a converted launcher and, consequently, limitations of START do not apply. However, for the same reason, the opportunity for using existing, formerly military, hardware is lost, and the project will be more expensive. In any case, this project will be realized in its land-based version, if it is to be realized at all.

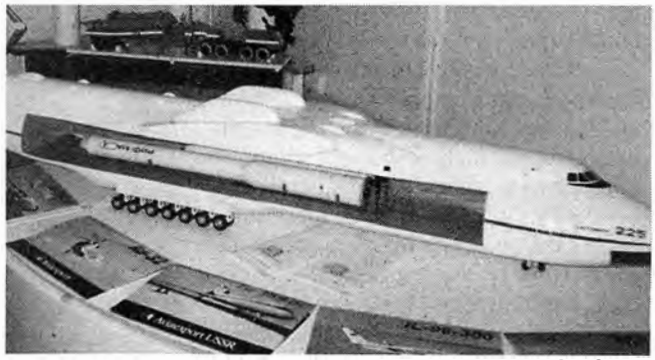
The Prospects for the Sea Launch Project

The gradual transition of the Makeev SRC's projects to land-basing exemplifies the loss of hope for the sea-basing concept, for space launchers in this Russian company. However, while the "sailors" are disappointed, the falling banner has been suddenly taken up by "land rats."

These "rats" are the size of an elephant, even in comparison with the Makeev SRC, which was not a small company. They are the Russian Energia SRC (Space/Rocket Corporation), the Ukrainian Yuzhnoye NPO, and the American Boeing Commercial Space Company, and, more recently, the Norwegian Kvaerner. (It is interesting that the present Energia SRC is the former Korolev outfit that had begun sea launches many years ago. A circle has been closed.)

The first negotiations began in 1994, and at times the businesses were on the verge of breaking off relations. However, in 1996, the Russian/Ukrainian partners began to manufacture hardware, while Kraevner began to reconstruct a former offshore oil-drilling platform in Norway, (see photo).

Although the concept of the Sea Launch project may be understood, some questions may remain to be answered for laymen, and even for specialists. The first question is, undoubtedly, why the Zenit launch vehicle was chosen as the basis of



Oleg Sokolov

A cutaway model of the air-launched version of the Rif launcher, which was designed also to use the RSM-52 missile.

Figure 7
ZARIA SPACECRAFT DESIGN
Artist's conception of the Zaria manned reusable spacecraft, designed in Russia. Launched by the Zenit rocket, the Zaria would use small rocket thrusters for a gentle, controlled landing, as pictured here.

Source: Courtesy of Oleg Sokolov

this project. Indeed, it is a Ukrainian launcher and, because of political clashes between Russia and Ukraine, the Russian Space Agency (RKA) recently declined to use the Zenit for Russian participation in the International Space Station (ISS) project.

Further, the Zenit in its present two-staged version, Zenit-2 (the number denotes its stages), has no geostationary injection capacity, although the Zenit-3 version was developed in order to give it this capacity.

And last, the Zenit does not yet have as high a proven reliability as that of the Russian Proton. The destruction of one of the two Zenit launch pads at the Baikonur Cosmodrome remains as a reminder of the Zenit explosion in 1990 (see photo).

Despite these problems, the selection of the Zenit for the Sea Launch project was well grounded. It is the most advanced launcher in the formerly Soviet states, and may even be the most advanced operational launcher in the world. Developed in the 1980s as one of the main designs of the new Soviet space launch vehicle fleet, the Zenit used a version of the Energia super-heavy launch vehicle's strap-on booster. Because it was considered as a booster for the Soviet manned space shuttle, Buran, the Zenit's reliability standards were set for manned spaceflight. Moreover, the basic Zenit itself was intended for injections of the reusable Zaria manned spacecraft (Figure 7).

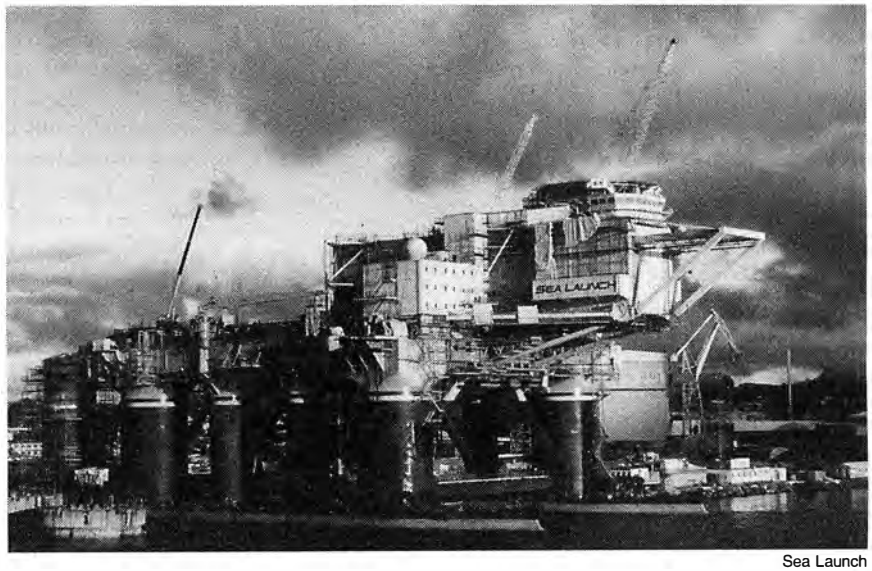
Regarding the failures of the Zenit to date, there are two causes: First, the designers were in a hurry, wishing to put a new launcher into operation as soon as possible; second, there were unavoidable disturbances of order and discipline during the events accompanying the *Perestroyka* (Reconstruction) in the former Soviet Union.

The main technical innovation of the Zenit was its launch site. Because the Zenit was designed during preparation for a "Star Wars" program, the prime developer of its ground infrastructure, the Design Bureau for Transport Machine-building in Moscow (the Russian acronym is KBTM), was given the task by the launcher developer, Yuzhnoye Design Bureau, of developing a completely unmanned launch site. Work on this concept was begun during the development of the Tsyklon launcher.

There is a legend that Mikhail Yangel, former chief designer of the Yuzhnoye Design Bureau, had vowed after an explosion of his R-16 ICBM at Baikonur in October 1960, which killed about 90 men, that he would aspire to have no man near the launch site during preparation or launch. Apparently, however, there were also more important, "practical," military reasons for a quick and safe launch preparation.

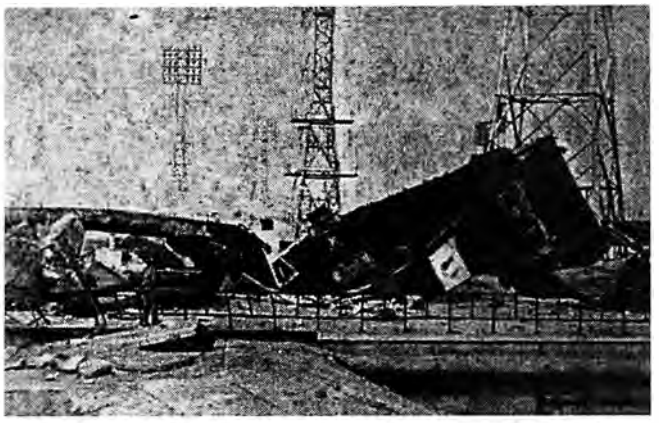
In any case, the KBTM created such an automated launch site. Its performance is striking; there are no men at the launch site, and only a few men in a sheltered control room. The launcher is prepared over a period of 2.1 hours, beginning with the delivery of an unfueled launch vehicle. A second launch can follow the first after 5 hours, and up to five such consecutive launches can be carried out, with only a brief time for repair! This feature of Zenit was never used for war, fortunately, but it will be very useful when the Zenit is prepared and launched from a sea platform. The KBTM is one of the Russian participants in the Sea Launch project.

The necessary increase in payload capacity of the Zenit is relatively simply achieved by the addition of a third (upper) stage. After examining a range of upper stages, including the most advanced oxygen/hydrogen ones, the designers at Yuzhnoye decided in favor of the existing Block-DM upper



Sea Launch

Sea Launch's self-propelled launch platform, shown here under construction in 1996. It is 430 feet long, and displaces 31,000 tons. It is being converted from an offshore oil rig, in Stavanger, Norway.



Courtesy of Oleg Sokolov

Photo of one of the two Zenit launch pads at the Baikonur Cosmodrome, which was destroyed during the explosion of a launcher.

stage, which was used, and continues to be used, in the four-staged version of the Russian Proton heavy launcher (see photo).

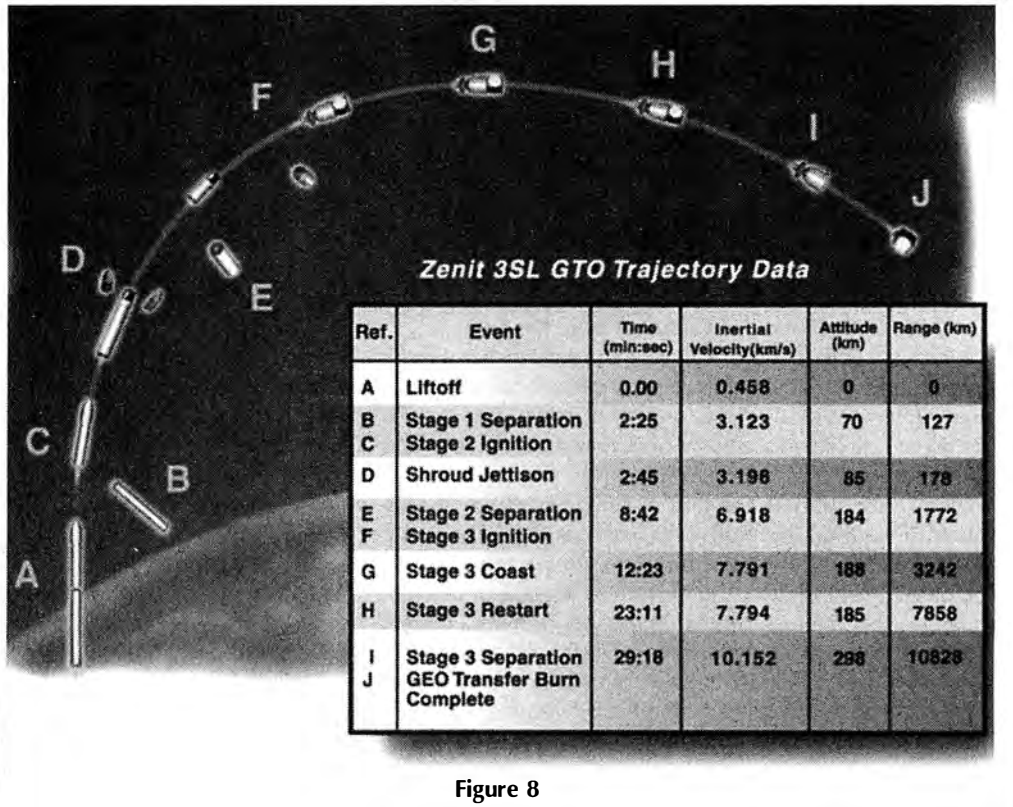
This upper stage was developed by Energia RSC and is manufactured by the Krasmash Machine-building Plant in Krasnoyarsk, Siberia. The installation of the guidance and control equipment, and final testing, are provided by Energia itself. In the Sea Launch project, Energia is responsible for the adaptation of the Block-DM to the Zenit-3, and for calculations on its dynamics and other performance characteristics. Preliminary calculations indicate good prospects for using the Sea Launch's Zenit-3 as a geostationary launcher (Figure 8).

Using Energia's Block-DM upper stage for the Sea Launch Zenit partially answers the question: What is the role of Russian companies, especially Energia, in the Sea Launch activity?—but only partially. This is only the above-water part of the iceberg.

The Zenit was not really designed as a Ukrainian product, but a Soviet one. Russian design bureaus developed not only the on-the-ground infrastructure, including the launch site, but also the rocket engines, the control/guidance system, and many other systems and subsystems. Not without reason, do Russian engineers today humorously describe the Zenit as, "a Russian launcher, which has Ukrainian tanks, is assembled in Ukraine, and is launched from the Kazakh territory by Russian troops." It is only a joke, of course, because the general design of the Zenit was created by the Yuzhnoye Design Bureau in Dnepropetrovsk, Ukraine. But the production of this launcher requires wide cooperation, mostly with Russian companies.

Which Russian organization will be the manager, supervisor, and coordinator for this cooperation? Not the Russian Space Agency (RKA), which declined to use the Zenit for the Russian space program. Even the Zenit's launch site at the Plesetsk cosmodrome, which was near completion, is being reconstructed to be used instead for Russia's advanced Angara heavy launch vehicle.

Coordinating the project on the Russian side is Energia RSC, the oldest and one of the most powerful Russian space companies, which is now a joint stock company, not officially subordinated to the RKA. However 51 percent of Energia's shares belong to the RKA! Most probably, this is a far-sighted policy of the RKA's higher management: In this way, through Energia, the RKA not only receives control over the prospective commercial project, but also supports (at the expense of



Zenit 3SL GTO Trajectory Data

Ref.	Event	Time (min:sec)	Inertial Velocity(km/s)	Attitude (km)	Range (km)
A	Liftoff	0.00	0.458	0	0
B C	Stage 1 Separation Stage 2 Ignition	2:25	3.123	70	127
D	Shroud Jettison	2:45	3.198	85	178
E F	Stage 2 Separation Stage 3 Ignition	8:42	6.918	184	1772
G	Stage 3 Coast	12:23	7.791	188	3242
H	Stage 3 Restart	23:11	7.794	185	7858
I J	Stage 3 Separation GEO Transfer Burn Complete	29:18	10.152	298	10828

Figure 8
SEA LAUNCH CAPACITIES

The Sea-Launched Zenit rocket, with an added third stage, will be able to deliver 15,000 kg of payload to low-Earth orbit, and 2,800 kg to geostationary orbit. Shown here are its trajectory data.

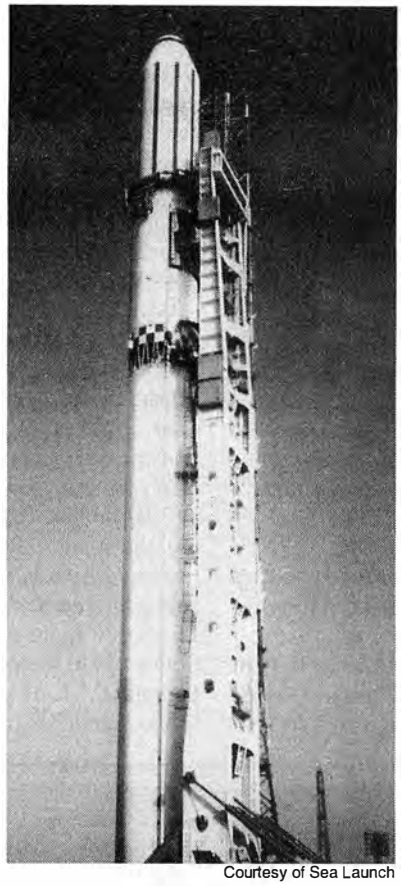
Source: Courtesy of Sea Launch

American investments) production of the advanced Zenits, which the RKA would need as a back-up in case of an Angara project failure.

Using the sea-based Sea Launch capability would free the Russian Space Agency from the need to use the Baikonur Cosmodrome in Kazakhstan, for geostationary, interplanetary, and near-equatorial launches. Even manned projects, like the resurrection of the Zaria, would be possible, because the Zenit was certified for manned spacecraft.

Finally, with Sea Launch, one can note that the second and most advanced of the Confederation of Independent States launchers (after the Proton), is coming into the international space launch market in its most profitable sector—geostationary injections. From an international point of view, this will mean an intensification of competition and, consequently, opportunities for price decreases and the opportunity of additional access to space for interested customers.

This would seem to be enough to have the Sea Launch with seven feet of water under the keel, waiting for the first launches. However a last item remains undiscussed: Will the Sea Launch project have successors, or will it be like the Italian San Marco platform, which, after the first successful launches, was left unused for many years?



Courtesy of Sea Launch

The Zenit rocket, here being readied for a launch at the Baikonur Cosmodrome, will be the workhorse of the Sea Launch project.

What Is the Future of Launches from the Sea?

As discussed above, there are two main reasons for the development and manufacturing of such complicated and expensive equipment as a floating launch platform, and the use of command and logistics ships. These reasons are safety, and avoiding the need to use foreign territories near the equator. However, as mentioned, the task of providing safety is also solved at the coastal cosmodromes, such as Cape Canaveral and Kourou. Hence, the question comes down to the political-economic problems of the long-term leasing of areas at existing or newly built near-equatorial cosmodromes, and real guarantees that large-scale investments in the construction of a launch site, and its infrastructure at this leased site, would not be lost for any political or economical reasons.

Because of the political uncertainty, a necessary condition for ground-based launch sites should be lower prices for the construction of both the launch site and the infrastructure, as well as for shipping of the necessary hardware, in comparison with using floating launch platforms and supporting ships. As can be seen from the projects of commercial cosmodromes at Cape York, Port Darwin, and even Al Cantara, the last condition could be relatively simply met. However, the political-economic guarantee of long-term stability of foreign launch sites is a more serious problem, especially for such countries as Brazil or Papua New Guinea.

Even such stable countries as the United States, France, and Australia are not free of this problem. Indeed, considering the difficult economic situation in Russia today, for example, each one of these countries that owns near-equatorial cosmodromes should require rent in advance, and this would be more expensive for Russia than using a sea-floating platform, even a newly built one, at Russia's own expense.

At the same time, Russia (or Ukraine, or both together) could find that their property at the leased territory could be used against them as a tool for political or economic manipulation (in order to repay debts, for example), especially if the economic situation in these countries deteriorates further. Competition could also play a negative role.

Also, one should not forget about the technological aspects of this problem. Standards and common equipment being used in the infrastructure of existing near-equatorial cosmodromes are not compatible with those of Russian/Ukrainian technologies, while for the construction of floating platforms, the Russian specialists can use their own equipment.

Second—and this is very important—everyone who is interested in the new, advanced Russian Angara heavy launch vehicle, developed by the Khrunichev State Research and Production Space Center, as ordered by the RKA, should pay attention to the fact that the Angara could use the Zenit launch pad.

Hence, the floating platform could be used to launch the Angara, which would have twice as much payload mass capability as the Zenit, with approximately the same lift-off mass. True, the Angara, in contrast to the Zenit, will use liquid hydrogen in its second stage, but the necessary additional equipment could be installed in a floating platform without serious difficulties. If the Angara were put to sea, after the Sea Launch's Zenit, in the next decade, it would not have any competitors among expendable launchers anywhere in the world, and the floating cosmodrome would have a long life.

Only when the political and economic problems are solved at the level of intergovernmental agreements between national companies, will floating cosmodromes return to hard land, where space launches are not exposed to the dangers of the sea. Apparently, however, this time will not come very soon.

Oleg Sokolov is chief of the department for international programs at the Krunichev State Research and Production Space Center in Moscow, and a laboratory chief at the Moscow Aviation Institute. Since the 1960s, he has worked on the spaceplane program, the Soviet manned lunar program, and cruise missile and other military programs.

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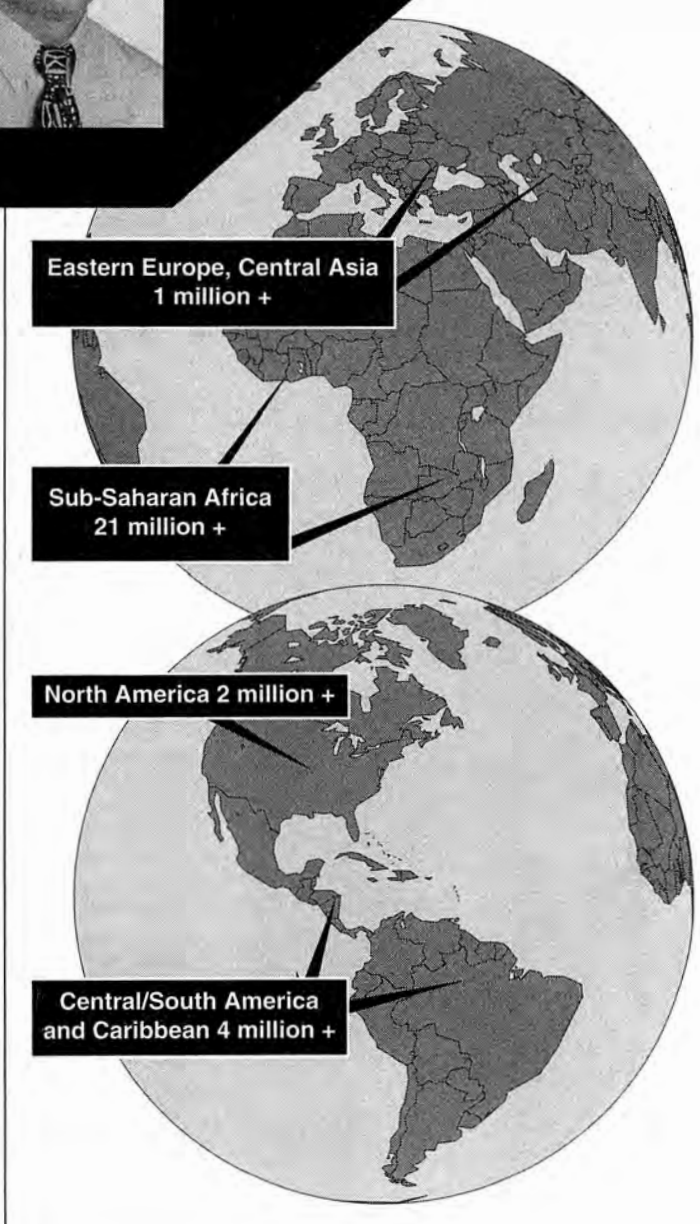
AIDS and the

Science Versus The HIV Phenomenon

by Gary R. Robertson



EDITOR'S NOTE

This article, by Australia-based journalist Gary Robertson, is a response to Dr. Wolfgang Lillge's criticism of Prof. Peter Duesberg's approach to the AIDS pandemic ("Statistical Tricks and 'The Big Lie about AIDS,'" which appeared in 21st Century, *Summer 1995, p. 45, and a follow-up comment by Lillge, "We Need a Commitment to Eradicate AIDS," which appeared in* 21st Century, *Fall 1995, p. 7.*

Duesberg is professor of molecular and cell biology at the University of California at Berkeley, and this article was written with his collaboration. Lillge's response appears on alternate pages.

21st Century exposes propaganda and fraud in science—a function that necessitates analytical rigor and a high degree of impartiality. Dr. Wolfgang Lillge, however, exhibits a profound lack of discernment in his appraisal of the dissension over the cause of AIDS. Indeed, "Statistical Tricks and 'The Big Lie about AIDS' " is a highly selective and biased commentary on a paper that had previously been refuted[1] in the scientific literature. Moreover, the article is hostile and contains unwarranted allegations.

We therefore welcome this opportunity to voice corrections to Dr. Lillge's article, and to delineate the reasons for the growing dissent from the consensual HIV hypothesis.

'Correlation' between AIDS and HIV?

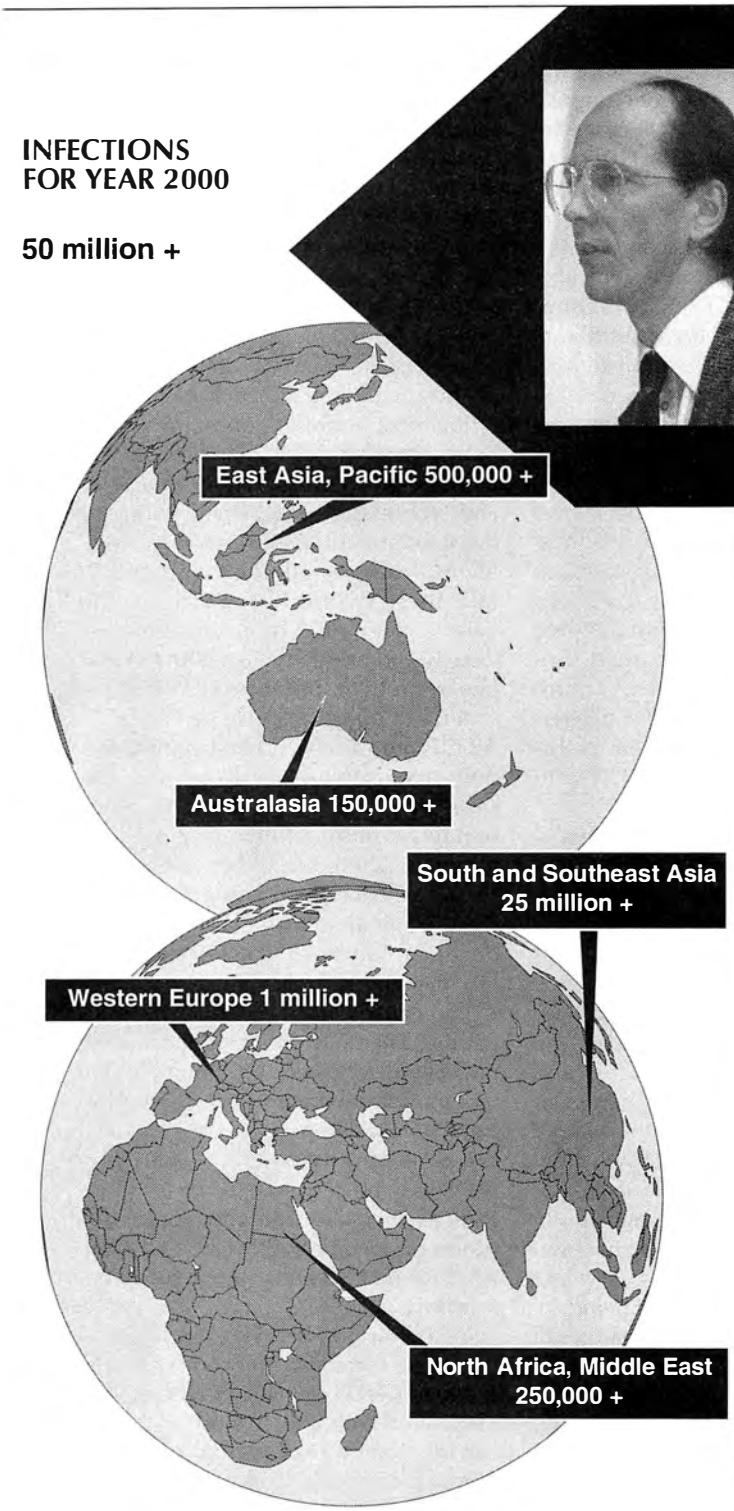
Lillge believes that "an unambiguous relationship exists between infection with HIV and the appearance of 'AIDS'." However, this belief is unfounded because of the following:

(1) AIDS is biased toward a correlation with HIV because AIDS is defined as diseases occurring in the presence of HIV antibodies. Thus, the "unambiguous" correlation between AIDS and HIV is an artifact of the definition itself. Moreover, this "correlation" is between AIDS and HIV antibodies—not HIV (see Point 2).

Duesberg Controversy

AIDS, Duesberg, And Fundamental Skepticism

by Wolfgang Lillge, M.D.



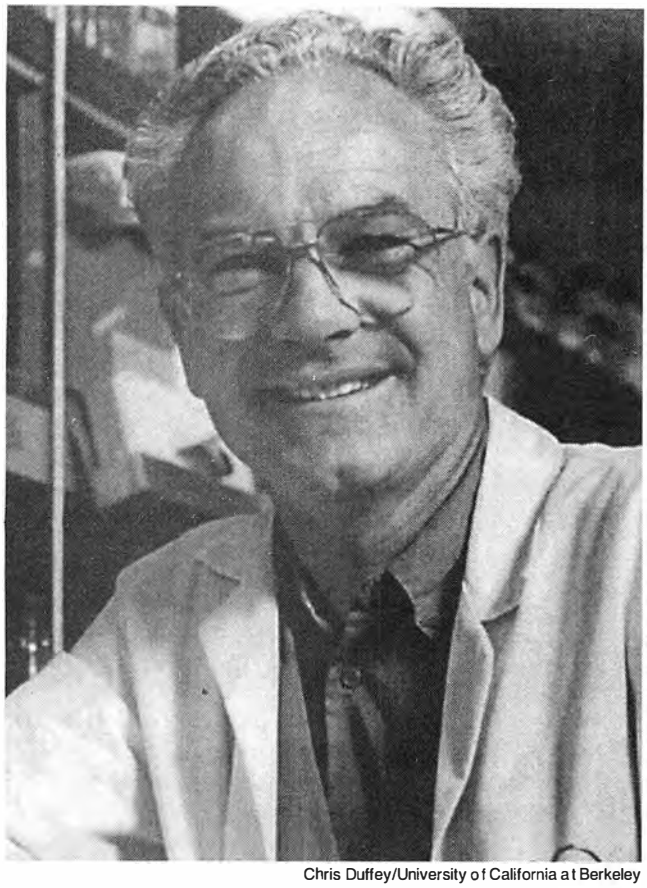
Wolfgang Lillge, M.D., is the editor of the German-language Fusion *magazine, and a member of the scientific advisory board of* 21st Century. *Lillge has followed the AIDS issue since 1980.*

The only reason that it may be useful to pick up Prof. Peter Duesberg's arguments again, as they are presented here by journalist Gary Robertson, is to direct a warning to those who feel attracted by such modern skepticism, that they not lose sight of the reality of the AIDS problem. AIDS is a pandemic with a potential to depopulate the world.

In the scientific community, Duesberg's views have been considered a lost cause for a long time. Someone who consistently presents the same fixed arguments over a period of at least 10 years, may be able to impress a crowd of unshakable disciples, but he can not lead a scientific debate—especially so when we are dealing with such a vital issue as AIDS.

It is not true that Duesberg is rejected only by the so-called "AIDS establishment," which decides on research grants and determines the latest "official" opinion on AIDS research. He has increasingly angered especially those virologists and medical AIDS researchers who do not agree either with the rushed dogmatic statements of the "AIDS establishment" (Gallo & Co., the condom dogma, and so on) but who are committed to uncovering the real workings of the HIV virus with *scientific hypothesis* and especially to develop effective therapies for this disease—an aspect which, in Duesberg's case, always falls by the wayside.

Robertson and Duesberg are masters of twisting words. This is characteristic of those who cling to a fundamental skepticism and forget that thereby objective reality is lost in an absolute relativism of permanent doubt. In the end phase of ancient Rome, this type of skepticism was very widespread and represented then, as in all times of cultural degeneration, a typical state of mind: a completely impotent



Chris Duffey/University of California at Berkeley

Prof. Peter Duesberg: "AIDS fails the criteria of infectious disease."

(2) Most AIDS tests do not measure HIV, they measure only HIV antibodies. Consequently, it is not known how many cases of AIDS have been HIV-antibody-positive, but virus-negative. Therefore a proportion of AIDS cases may have HIV antibodies, but no HIV—a phenomenon indicative of a successful immune response.

(3) The diagnosis of AIDS is largely based on presumption:

(a) Only about 75 percent of U.S. AIDS patients have been tested for HIV antibodies; the remainder are presumptively diagnosed on the basis of their disease symptoms;[2]

(b) In Africa, HIV is presumed to be the cause of nearly all AIDS cases as estimations of the number of HIV-positive Africans are extrapolations from antibody tests of small populations.[3]

(4) AIDS testing is grossly inaccurate. Both Elisa and Western Blot tests have a high false-positive rate due to cross-reactions with other microbes[2,4] and chronic parasitic infections.[5] Indeed, in Africa, where concurrent microbial infections are prevalent, HIV tests have been shown to register more than 70 percent false-positive results.[5] Thus, it is possible that a considerable number of apparently HIV-antibody-positive AIDS cases are actually HIV-antibody-negative.

(5) The Centers for Disease Control and Prevention's (CDC) guidelines on the definition of AIDS stipulate how to diagnose AIDS when patients test HIV-antibody-negative.[2]

(6) It is not known how many HIV-negative AIDS cases exist as the CDC does not record HIV-free AIDS cases.[2] Despite this, almost 5,000 AIDS sufferers have been documented as HIV-antibody-negative (Table 1).

Because of these factors, the extent of correlation between HIV and AIDS is largely unknown. Hence there is no basis for Lillge's assertion that the "relationship" between the two is unambiguous. Likewise, Professor Eigen's calculation supposedly showing a "100 percent" correspondence between "the annual incidence of AIDS cases" and "the annual incidence of HIV-seropositive persons 6 to 8 years ago" is without merit, because it is not known how many cases of HIV-free AIDS exist, nor how many cases of HIV-seropositivity diagnosed annually are really antibody- or virus-negative.

Correlation Doesn't Prove Etiology

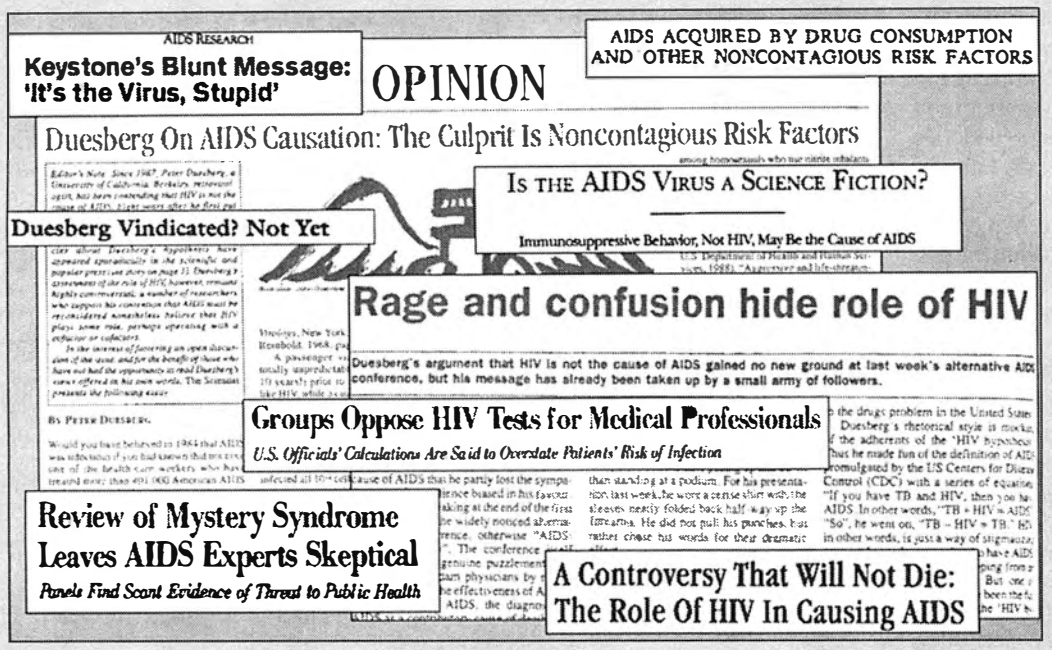
Because a "great deal of unclarity still prevails about the actual workings of HIV infection," the only tangible evidence for the HIV hypothesis is epidemiological correlation[6] (although, as we have just shown, this "correlation" is ambiguous at best). However, correlations—unambiguous or otherwise—represent inconclusive support for a hypothesis, because they cannot distinguish between a causal and a non-causal correlate of a disease. For example, there is an "unambiguous relationship" between yellow teeth and lung cancer, yet this does not prove that one causes the other. Further, there is a perfect correlation between death and eating tomatoes as everybody who eats a tomato eventually dies. However this does not prove that tomatoes kill.

Because correlations or "unambiguous relationships" are inadequate for determining the cause of a disease, the standard etiologic criteria of infectious disease consist of more rigorous parameters, such as Koch's postulates and various genetic and molecular requirements (Table 2).

Thus, regarding the etiology of AIDS, "[t]he most important question to clarify" is not whether an unambiguous epidemiological correlation between HIV and AIDS exists, but whether HIV passes the standard criteria for establishing infectious-disease etiologies. Since HIV fails these criteria[7,8] the virus would have to cause AIDS by mechanisms previously and presently unknown to virology. Moreover, because AIDS fails the criteria of infectious disease (Table 3), AIDS is most likely caused by non-infectious agents (which explains why, despite apocalyptic predictions, AIDS remains confined to the original risk-groups[7]). Therefore, other hypotheses should be considered[9] and relevant epidemiological studies should be conducted to test existing evidence for the HIV hypothesis.

The causes of HIV-free AIDS (idiopathic CD4+ T-lymphocytopenia) have not been determined. Yet if non-HIV immunosuppressive agents can cause AIDS in HIV-negative people, they can also cause AIDS in HIV-positive people. Thus, AIDS may be caused in some or all instances by the immunosuppressive agents or conditions that cause HIV-free AIDS, and HIV could merely be a confounding variable.

In contrast to HIV, drug use is unambiguously correlated with American and European AIDS.[7,10] Nearly all cases are associated with one or more of the following: long-term, habitual consumption of recreational drugs; long-term exposure to protein contaminants in blood-clotting factors or blood transfusions; or short-term exposure to DNA



Although the scientific establishment has rejected Duesberg's claim that HIV is not the cause of AIDS, the establishment has come to the same conclusion on what to do about it: No public health measures are necessary to stop its spread.

attitude toward reality, full of indifference and cynicism derived from its inherent relativism.

When one doubts that the very disease symptoms of AIDS, as complex as they may be, are *the consequence of an infection* and that HIV at least plays *a prominent role* (disregarding here possible co-factors in the individual expression of the disease, or other, not yet identified viruses), then one is bound to manically look for ever new "factors" of etiology and for an ever larger—and thus impractical—definition of AIDS.

For that reason we will not attempt to refute all the individual points made by Robertson and Duesberg in their paper. That would be a fruitless enterprise, because the inner logic of their argumentation would generate, miraculously, ever new "factors" which would cast "doubt" on certain factual statements—the typical characteristic of an addicted skeptic.

However, one thing should be stressed right from the beginning: Whoever, after all the latest findings, still maintains that there is no clear correlation between HIV and AIDS, can no longer claim that he is serious. Although the exact pathogenic mechanism (etiology) also may be known only partially in the cases of many other infectious diseases, nevertheless, no one will doubt that these are *infectious diseases*. And, especially in the case of AIDS, there was very little doubt, more or less from the beginning, that we were dealing with an infectious disease, and even a worldwide pandemic.[1]

Conceptualizing the AIDS Process

As in the time of Robert Koch, the German scientist who isolated the first pathogens at the end of the last century, we are faced with the task of uncovering the pathogenic mechanisms of AIDS, which threatens to depopulate whole regions of the world, in particular, in black Africa.

Given the tremendously complex processes associated with HIV, the first human "lentivirus" discovered at the beginning of 1983, scientists were moving into new territory, and completely new hypotheses had to be put forward to at least begin to uncover the most important mechanisms by which HIV destroys the human immune system. In this initial phase, it was not only admissible but absolutely mandatory to be "open to all sides," in order to steal a march on the new disease, Acquired Immune Deficiency Syndrome, or AIDS.

Questions had to be answered, such as: Why did the disease break out first among homosexual men in the United States? Why did the disease spread so quickly among intravenous drug users who shared their needles? Why, in Africa, were women affected as much as men from the beginning? Were there common characteristics which defined AIDS as a disease in its own right?

Later, when it was observed that individuals outside of the so-called "high-risk groups" also became ill with AIDS—patients who had received HIV-positive blood transfusions; hemophiliacs treated with HIV-infected clotting factors; hospital personnel who came into contact with HIV-contaminated blood; persons outside of "risk groups" who became infected through sexual intercourse—the suspicion increased that HIV played a central role in the disease process of AIDS. All the other assumed transmission pathways, including the "lifestyle" of homosexuals, drugs, and so forth were excluded, one after the other.[2] The key was that the infectious character of AIDS became undeniable. AIDS was established as a pandemic spreading in different parts of the world, in different ways and at different speeds.

To conclude that there was no pathogen meant to become lost in a multitude of singular causes, such that only an individual predisposition (incapable of disproof), or "lifestyle," played roles, but the regularly isolated virus was seen only as a "harmless companion."

Approaches to New Treatments

In recent years, physicians and pharmacologists have learned to combine the available anti-viral substances, including some completely new ones, to prolong the life expectancy of AIDS sufferers significantly. Even though no one should claim that AIDS patients or the HIV-infected can be cured, nevertheless, in many cases, the disease symptoms have completely disappeared with such therapies. The simple empirical fact that HIV-positive patients live longer when their virus counts decrease or even disappear, in response to therapy, is probably the most striking indication that there is a direct relationship between HIV and

chain-determining chemotherapies, like AZT.[10] Given the importance Lillge places on unambiguous relationships in determining etiology, we wonder why he gives the HIV hypothesis precedence over the drug-AIDS hypothesis. Further, in Africa, HIV antibodies have been detected in only about 50 percent of all AIDS cases,[2,7] whereas malnutrition—the world's leading cause of immunodeficiency[11]—is almost 100 percent correlated with AIDS.[7]

It is noteworthy that Eigen, in his *Naturwissenschaften* article, cautions that although epidemiological studies show a correlation between HIV and AIDS, the cause of AIDS "remains unsettled."[12]

In short, an "unambiguous relationship" is not sufficient to prove etiology. Indeed, the use of epidemiological correlation as the only criterion of etiology has resulted in some of the most spectacular misdiagnoses in virology.[13]

Table 1
HIV-FREE AIDS CASES DOCUMENTED IN THE SCIENTIFIC LITERATURE

Risk Group	U.S./Canada	Europe	Africa
Homosexuals	722	37	—
Intravenous (IV) drug users	251	335	—
Infants of IV drug users	55	11	—
Hemophiliacs	256	78	—
Unclassified/Unreported	352	14	2,555
Totals	1,636	475	2,555
Sum total	4,666		

Sources: Peter H. Duesberg, 1993. "The HIV Gap in National AIDS Statistics," *Bio/Technology* Vol. 11, pp. 955-956; Bryan J. Ellison et al., 1996. "HIV as a Surrogate Marker for Drug Use: A Re-analysis of the San Francisco Men's Health Study," in Peter H. Duesberg (ed.), 1996, *AIDS: Virus- or Drug-Induced?* (Dordrecht: Kluwer Academic), pp. 97-104.

Table 2
STANDARD CRITERIA FOR ESTABLISHING THE CAUSE OF AN INFECTIOUS DISEASE[1]

(1) The agent is present in every case of the disease and in quantities sufficient to cause pathological effects.

(2) The agent is absent in other diseases, or present in quantities insufficient to cause pathological effects.

(3) After it is isolated and grown in culture, the agent can induce the disease anew.

(4) The disease caused by the agent can be prevented through naturally acquired immunity or vaccination.

(5) The disease can be cured by drugs which target the agent.

(6) The disease can be prevented by preventing infection with the agent.

Note
1. HIV fails to meet any one of these criteria.

Sources: Peter H. Duesberg, 1992. "AIDS Acquired by Drug Consumption and Other Noncontagious Risk Factors," *Pharmacolgy and Therapeutics* Vol. 55, pp. 201-277; and Peter Duesberg and John Yiamouyiannis, 1995. *AIDS: The Good News Is That HIV Doesn't Cause It* (Delaware: Health Action Press), p. 11.

Establishing Etiology Is Important

Lillge's charge that Duesberg lacks a commitment to combat AIDS ("We Need a Commitment to Eradicate AIDS," *21st Century,* Fall 1995, p. 7) is preposterous. Since 1987, Duesberg has spent countless hours collating and publicizing crucial evidence against the HIV hypothesis. He has just as consistently enunciated why AIDS is not an infectious disease[14] (Table 3) and campaigned against the unjustifiable use[7] of highly toxic,[7,10,15] anti-HIV drugs—such as AZT. Realizing the dire ramifications of a faulty hypothesis, Duesberg has offered to conduct epidemiological tests which would demonstrate "whether HIV or non-HIV factors cause AIDS."[16] He also applied for a research grant with the National Institute on Drug Abuse to test his hypothesis that chronic recreational- and medical-drug use are the main causes of AIDS.[17,18]

In spite of intimidation, lost research funding, noncitation in the scientific literature, the rejection of his papers for publication, and social isolation from the scientific community, Duesberg has not deviated from his commitment to provide the Public Health Service with a factual basis from which it may devise and implement effective public health strategies to combat AIDS.

Pathogenetic Mechanisms

Lillge is correct to point out that the lack of knowledge of how HIV supposedly causes AIDS does not exonerate the virus, because an understanding of the pathogenetic mechanism of a microbe is not a criterion for establishing etiology. However, Duesberg does not reject the HIV hypothesis because the pathogenetic mechanism of HIV in AIDS is not understood; he bases his rejection on the failure of HIV to meet the standard criteria for establishing etiologies. Thus, Duesberg does not "throw the baby out with the bathwater." Rather, by pointing out the failure of HIV to meet these criteria, he shows that there is no baby—only murky bathwater.

Lillge's bias toward the HIV hypothesis is exemplified by his statement: "If we were to learn more precisely how HIV disables the body's immune response, this sort of speculation [about AIDS etiology] would quickly disappear." It seems that Lillge regards testing the hypothesis as unnecessary because he "knows" that one day researchers will end the causation argument by discovering HIV's pathogenetic mechanism.

The failure so far to find this hypothetical mechanism does not deter Lillge, as he deems the lack of success to be a result of "deficiencies of current methods of scientific research" and of an "ideological-reductionist blindness" of the scientific establishment. It is this biased attitude that is responsible for Lillge's lack of commitment towards urging policy-

AIDS.[3] Simply said: When HIV "disappears" from the blood, the symptoms of AIDS also disappear.

The currently used therapy, combining various anti-viral substances (to avoid the development of resistance to a single drug), has the effect of massively suppressing virus reproduction, which means that patients will survive. It is now regularly observed that, if the virus can no longer reproduce, no one will die from AIDS any more.

So, AIDS research, accused of disorientation and lack of planning—not without reason—has finally developed substances that are effective against viral disease. Logic has to be severely twisted to claim, as Duesberg does, that just such a drug as AZT, and surely also the more recent drugs (ddI, ddC, d4T, 3TC, F-dda, and so on) are the causes of AIDS, when it has been shown that it is the reduction of the HIV load which offers the greatest likelihood of reducing the symptoms of the disease.

That the new AIDS therapies are very expensive, so that the vast majority of AIDS patients, especially in the developing sector, will never be able to afford them, is an entirely different issue. The recent progress in AIDS research will benefit only a relatively small group of AIDS patients in North America and Western Europe, until a cheap vaccine or other preventative can be found.

Even the use of AZT alone, the first anti-AIDS drug, with severe side-effects in some cases, shows that, as a monotherapy, resistance quickly develops. But its use was justified because of its clear (although weak) anti-HIV effect. To outlaw AZT, as Duesberg demands, because it is supposed to be the cause of AIDS on account of its immune suppressive effect, is irresponsible and inhuman.

Scientific studies have established that especially children born to HIV-positive mothers treated with AZT, develop a much lower incidence of AIDS than they would if their mothers had not been so treated.[4] With new testing equipment, it is now possible to determine the viral load in the blood, which is a very reliable indicator of the future development of the disease. High viral load is associated with a bad prognosis, while a low viral load is associated with a good prognosis. Every HIV-infected person and AIDS patient, who is currently under a combination therapy, knows this. A more definite correlation between HIV and AIDS *in practice* is hardly imaginable!

The Case of the Hemophiliacs

Duesberg is extremely evasive concerning hemophiliacs who have been infected by HIV-contaminated blood products, and with good reason. This aspect is not mentioned in the Robertson/Duesberg paper published here; in other places, Duesberg usually refers to "contaminations" of factor VIII products with foreign proteins from blood donors.[5] The more of such anti-clotting blood products a hemophiliac has received, the more "immunosuppressive" contaminations he has received which may cause AIDS. And HIV, again, is here only a "harmless companion" which is only useful as an index for the number of blood transfusions received.

In this case, Duesberg's search for an HIV-independent factor for AIDS becomes absurd indeed. It is somewhat unclear what he really understands by these "contaminations," but it has been shown, in at least two large studies, using simple statistical methods, that the cause of infection, subsequent disease, and death of many hemophiliacs was associated with HIV, and not with contamination of clotting factors.[6]

Here, some recollections from the first years of AIDS are helpful. In 1982, reports suddenly began to accumulate in the United States and Europe of patients who had received blood transfusions, and shortly thereafter also hemophiliacs, becoming ill with AIDS. All of a sudden, a part of the population was hit by AIDS which did not manifest any of those practices dominant in the original risk groups of homosexuals and intravenous drug users.

All of these persons had only one thing in common: They had received blood transfusions or had been treated with clotting factors, sometimes years before. In almost every case reviewed at that time, it was possible to trace a blood product to an HIV-positive donor in the risk groups. All large statistical analyses also established, without doubt, that HIV infection was not the consequence of the practices of the risk groups (including drug use) but was always associated with presence of HIV antibodies in the donor.[7]

In 1985, actually very late, systematic HIV antibody testing of all blood donors and the safe processing of blood products was started. The effects of this procedure were shown in a British study between 1977 and 1992, which included 6,278 hemophiliacs. From 1979 to 1986, 1,227 of them were infected by therapy with blood products. Among the 2,448 severe hemophiliacs of that group, the death rate between 1977 and 1984 was stable at 8 per 1,000. Between 1985 and 1992, the death rate among *HIV-negative persons* with severe hemophilia remained unchanged, while the death rate among seropositive persons zoomed, and reached 81 per 1,000 in 1991 to 1992. Among the remaining 3,830 hemophiliacs with moderate or slight hemophilia, the same picture emerged: The death rate was 4 per 1,000 between 1977 and 1984, and increased to 85 per 1,000 in 1991-92 among seropositive individuals.[8]

"Whoever, after all the latest findings, still maintains that there is no clear correlation between HIV and AIDS, can no longer claim that he is serious."

In Duesberg's theory, practically no AIDS deaths occur because of infected blood transfusions, because, apparently, he has not yet found a "factor" which could be cited as a cause. AIDS deaths among hospital personnel are said to be casual, the cause of which may still be found in yet undiscovered drug consumption. As a cause of AIDS in women, whose husbands are HIV-infected hemophiliacs, Duesberg refers to the "normal aging process" or misclassification.[9]

Koch's Postulates

Robertson/Duesberg claim in their paper that Koch's postulates are not fulfilled by HIV. At the end of the last century, Robert Koch set forth the following conditions for establishing a microbe as the cause of an infectious disease: (1) The microorganism must be found in all cases of the disease. (2) It must be isolated from the host and grown in pure culture. (3) It must reproduce the original disease when introduced into a susceptible host. (4) It must be found in the experimental host so infected.

Table 3
CLASSICAL CRITERIA OF INFECTIOUS DISEASE[1]

(1) The pathogen is abundant and very active in target tissues during the course of the disease.

(2) The disease manifests within days or weeks after infection.[2]

(3) The disease spreads exponentially in an unimmunized population within weeks or months, and subsequently diminishes as immunity builds up (Farr's law).

(4) The disease is equally distributed between the sexes.

(5) The disease mostly affects those with weak or immature immune systems, such as those under 20 and over 60 years of age.

Notes
1. AIDS does not fulfill even one criterion of infectious disease.
2. "Slow viruses" or lentiviruses have never been isolated, and thus remain hypothetical entities.

Source: Peter H. Duesberg, 1996. "How Much Longer Can We Afford the AIDS Virus Monopoly?" in Peter H. Duesberg (ed.), *AIDS: Virus- or Drug-Induced?* (Dordrecht: Kluwer Academic), pp. 241-270.

makers and scientists to campaign for a provable cause of AIDS.

Lillge's casual and risky approach to settling the etiological debate (to wait and see if a pathogenetic mechanism can be found) belies the inherent seriousness of the current situation. If HIV is not the cause of AIDS, the search for a presumed pathogenetic mechanism is a waste of time and money, and current medical treatments and public health strategies directed at combatting AIDS are based on a false premise.

In view of this, and the fact that tests have been devised that may either confirm or falsify the HIV hypothesis,[16,19,20] why recommend that we wait to see if the etiological argument can be settled by the discovery of a pathogenetic mechanism of HIV?

Public Health Strategies

Lillge calls for the worldwide implementation of effective public health measures aimed exclusively at controlling the spread of HIV. We wonder why public health systems should commit solely to preventative "measures" based on an incoherent hypothesis that is supported only by circumstantial evidence and anecdotes.[7] To make such a restricted commitment is not only unjustifiable, but irresponsible.

We believe that AIDS researchers should commit to establishing a proven cause of AIDS so as to provide the Public Health Service with a tenable basis from which it may devise and implement effective public health strategies. At present, 15 years after the first official cases of AIDS were diagnosed, the Public Health Service cannot demonstrate that its efforts have saved even a single life. Moreover, all public health measures developed on the basis of the HIV hypothesis have failed to stop the spread of AIDS.

Until the cause of AIDS is identified, public health measures for combatting the syndrome are hit-or-miss affairs. Indeed, if AIDS is caused by factors other than HIV, such as chronic intravenous drug use, then current public health measures, like supplying sterile needles to intravenous drug users, could be exacerbating the epidemic. Viewing HIV as synonymous with AIDS, as Lillge does, is to ignore non-HIV immunosuppressive factors, such as those which cause HIV-free AIDS. We believe that such tunnel vision represents "a public danger."

Testing the HIV Hypothesis

The HIV hypothesis became international dogma before it was subjected to the usual scientific scrutiny and debate afforded by refereed publication.[21,22] In other words, the U.S. government's endorsement of the premise that HIV causes AIDS was based solely on the allegations of Gallo and his collaborators.[23] Thus, despite the fact that only 26 out of 72 AIDS patients studied by Gallo were infected with HIV,[24] this less-than-convincing "correlation" was touted as "overwhelming evidence" and the HIV hypothesis was subsequently carved in stone at a press conference.

Although most AIDS researchers agree that the strongest evidence that HIV causes AIDS is merely epidemiological,[6] they state that testing the hypothesis is unnecessary. This is because they have an unrelenting faith in the HIV hypothesis—a faith that often can only be justified with circular reasoning. For example, the editor of *Nature,* John Maddox, writes that "the evidence [that HIV causes AIDS] necessarily seems circumstantial" because "[t]he mechanism of the pathogenesis of the disease has not yet been uncovered."[25] For most researchers though, circumstantial evidence is sufficient for the HIV hypothesis because they believe in 'guilt by association'—at least where HIV is concerned.[6]

Some researchers are even satisfied with anecdotal evidence. For instance, commenting on a rare case in which a laboratory worker developed AIDS after accidental infection with HIV, Anthony Fauci, head of the National Institute of Allergy and Infectious Diseases, declared, "As far as I'm concerned, the . . . [anecdotal evidence]. . . . prove[s] causation. I don't need any more than that."[17]

However, since the burden of proof rests with proponents of an unproven hypothesis, the AIDS establishment is ethically obligated to perform tests, such as those that have already been proposed,[16,19,20] to establish whether or not HIV is the cause of AIDS.

Simian Immunodeficiency Virus

Lillge states that the development of "AIDS-like symptoms" in monkeys inoculated with simian immunodeficiency virus (SIV) is evidence for the HIV hypothesis. However, we fail to see the connection.

The hypothetical characteristics of HIV pathogenesis include a long latent period, the depletion of T-cells, the development of AIDS only in the presence of antiviral antibodies, and the development of certain diseases such as Kaposi's sarcoma and dementia. None of these parameters is applicable to the pathogenesis of SIV. Moreover, even if the parameters of SIV infection were completely analogous to the parameters of HIV infection, it would prove only that, under analogous conditions, other retroviruses may cause diseases in animals.[7]

We acknowledge that a putative etiological agent, such as HIV, meets Koch's third postulate if it reproduces a disease when introduced into a susceptible host. However, SIV is not HIV, and simian acquired immunodeficiency syndrome

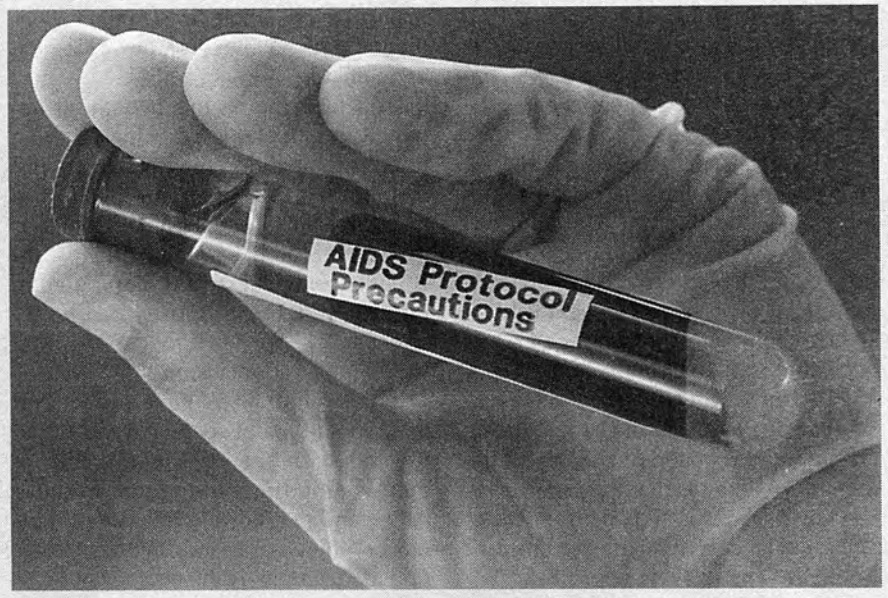
But a 1995 paper, "The Relationship Between the Human Immunodeficiency Virus and the Acquired Immunodeficiency Syndrome,"[10] issued by the U.S. National Institute of Allergy and Infectious Diseases (National Institutes of Health) shows that Duesberg is also wrong on this account.

By means of PCR (polymerase chain reaction), according to the paper, the presence of cell-associated as well as cell-free HIV (as RNA or proviral DNA) can be established in practically all patients with AIDS and in persons with earlier stages of HIV infection. Improvements in co-culture techniques have also made it possible to isolate HIV in practically all AIDS patients and almost all seropositive persons.[11]

The paper includes a report on three laboratory workers, with no other risk factors, who developed AIDS or severe immunosuppression after accidental exposure to a concentrated, molecularly cloned HIV strain (HIVIIIB) in the laboratory. In all three cases, it was shown that the Koch postulates were fulfilled. Two of the laboratory workers were infected in 1985, and one in 1991. All three have shown marked CD4+ T cell depletion, and two had CD4+ T cell counts dropping below 200/mm^3 of blood. In all three cases, HIVIIIB was isolated from the infected individuals, and shown to be the original infecting strain of the virus. Furthermore, two of the infected persons had not been treated for a long time with AZT, which Duesberg claims to be the cause of AIDS, and none of them had any other "risk factors."[12]

Apart from this clear evidence, the insistence on the strict fulfillment of Koch's postulates sounds very much like fundamentalism. First, Robert Koch had set them forth only for bacterial infections (viruses, which until recently could not be cultured, or only with great difficulty, were not known in his time), and, second, they are not always completely fulfilled for other infectious diseases. At the end of his research career, Koch deviated from his own rules, for example, in uncovering the causes of cholera.[13]

In connection with Koch's postulates, Robertson/Duesberg claim that HIV does not lead to AIDS in chimpanzees, and therefore, Koch's third postulate is not fulfilled. Thus, HIV could not be the cause of AIDS. This is an especially vicious argument, because it is only true that HIV-1 does not lead to AIDS in chimpanzees. It is not true for the other basic strain, HIV-2, that is prevalent in West Africa and differs from HIV-1 only slightly, but is very similar to the simian immune deficiency virus SIV. HIV-2 causes a strong disease process in Asian monkeys extremely similar to AIDS in humans, with all typical characteristics.[14]



NIAID

Contrary to experience with hemophiliacs and others, who developed AIDS after receiving blood transfusions from HIV-positive donors, in Duesberg's theory, practically no AIDS deaths occur because of infected blood transfusions.

Cause or Marker?

Because Duesberg rejects HIV as cause of AIDS, he is forced to develop a theory that inserts at every point a new factor for every proven aspect of the disease development. Since AIDS hits such diverse groups as male homosexuals, drug addicts, hemophiliacs, and transfusion recipients, and also has a completely different manifestation in Europe and North America than in Africa, Duesberg is compelled to give a different cause for every single manifestation of the disease—an extraordinarily unnatural procedure.

According to Duesberg, AIDS is caused in Africa by malnutrition and tuberculosis, or else it appears only by misclassification; in male homosexuals in the United States, it is caused by consumption of nitrites; in female intravenous drug users and their babies, it is caused by consumption of other drugs; in many other HIV positives, who take no drugs, it is caused by taking AZT; in hemophiliacs, it is caused by contaminations of the clotting factors, and so on.[15]

It is pointless to review the validity of these arguments case by case: If one of the factors were to drop out, the skeptics would easily find a new one, so that the whole game would start again. In general, malnutrition, tuberculosis, drugs, and so forth will, of course, weaken the immune system, and HIV will have greater opportunity, but the mechanism of immunological weakening is different in each case, and the sum of them does not define AIDS. Duesberg's theory is a hunt for a "bad infinity." A typical sign of it is that his theory is always far behind current developments and is unable to predict.

If HIV is only a marker for a multitude of practices or "lifestyles," which explain the failure of the immune system better than infection by HIV, then it should be possible to predict by means of these factors the future development of AIDS in individuals still healthy today, in a more precise way than is possible by means of their HIV status. That is not the case. Rather, it has been shown in large studies that HIV-positive persons will develop AIDS with regularity—independent of those factors presented by the HIV skeptics as the causes.

Finally, to admit, in biology or medicine, that *most* of the molecular mecha-

does not resemble AIDS. Koch's third postulate remains unfulfilled because in the 13 years since chimpanzees were injected with HIV no chimpanzee has developed AIDS.[7]

Statistical Tricks and 'Big Lies'

Lillge charges Duesberg with manipulating data, stating that, "Calculations and statistics cannot be arbitrarily thrown together to suit the researcher's purpose." However, Lillge might well tar Eigen with the same brush, since Eigen's calculations are biased towards correlation: the number of HIV-seropositive persons *N(t)* "can be constant or fluctuating and still be correlated overall" with the cumulative total of AIDS cases *n(t)*. Any assertion that the discrepancies in Duesberg's and Eigen's calculations constitute trickery is hypercritical conjecture.

If Lillge is truly concerned about the manipulation of data, he might wish to examine the tactics that AIDS researchers use to salvage the HIV hypothesis. For example, knowing that HIV fails Koch's postulates—the standard etiologic criteria of infectious disease (Table 2, points 1-3)—they either reject the postulates[7,26] or alter them to fit the HIV hypothesis.[27] The dismissal of Koch's postulates is defended by the circular logic that the failure of HIV to meet the postulates invalidates the postulates, rather than the hypothesis.[7]

Furthermore, each time their speculative model of HIV pathogenesis is shown to be at variance with orthodox virology, AIDS researchers modify it to accommodate the HIV hypothesis. Also, when it became evident that HIV could not be the cause of AIDS, they saved a role for the virus by hypothesizing that it required a cofactor to cause AIDS. However, although various candidates have been proposed as cofactors, not one has been supported by tenable evidence.

Since "it is the details that matter" and since Lillge considers "an unambiguous relationship" to be the "most important" criterion for establishing etiology, we are curious to know how he rationalizes the unambiguous relationship between AIDS and drugs.[7,10] Lillge states that "Serious research exists by means of hypothesis and experiments." We submit, as an addition, that accurate interpretations of research experiments exist by means of logical and unbiased reasoning and observation. In the case of HIV and AIDS, mainstream interpretations of the experimental data have been far from logical and unbiased.

If evidence points to a hypothesis being invalid, the honest and logical thing to do is to abandon the hypothesis and formulate a new one that does fit the facts. Surely the ascription of miraculous properties to HIV so that it fits established virological facts is manipulating data to suit the purposes of the researchers.

Conclusion

In this rebuttal, we have shown that the correlation between HIV and AIDS, the basis for the HIV hypothesis, is merely an artifact of the definition of AIDS, and that correlation, unambiguous or otherwise, is an insufficient criterion for determining the etiology of a disease. We have also shown that the data contradicting the HIV hypothesis are significant and that AIDS fails the criteria of infectious disease.

Because of the foregoing, we and many other investigators[28] question the HIV hypothesis and propose that "a thorough reappraisal of the existing evidence for and against the hypothesis be conducted by a suitable independent group" and that "critical epidemiological studies be devised and undertaken."[29]

Acknowledgment

I thank Professor Peter Duesberg for editing the draft and for his suggestions. This response is almost entirely based on his published works.

Notes

1. Peter H. Duesberg, 1990. "Responding to 'The AIDS Debate' " *Naturwissenschaften*, Vol. 77, pp. 97-102.
2. ——, "The HIV Gap in National AIDS Statistics," *Bio/Technology*, Vol. 11, pp. 955-956.
3. Phillip E. Johnson, 1994. "HIV and AIDS: The Present State of the Controversy," *Reappraising AIDS*, Dec., pp. 1-4.
4. Eleni Papadopoulos-Eleopulos, et al., 1993. "Is a Positive Western Blot Proof of HIV Infection?" *Bio/Technology*, Vol. 11, pp. 696-707.
5. Charles L. Geshekter, 1995. "Rethinking AIDS in Africa," *Reappraising AIDS*, Feb., pp. 1-4.
6. Robin A. Weiss and Harold W. Jaffe, 1990. "Duesberg, HIV and AIDS," *Nature*, Vol. 345, pp. 659-660; William Booth, 1988. "A Rebel Without a Cause of AIDS," *Science*, Vol. 239, pp. 1485-1488; William Blattner, et al., 1988. "HIV Causes AIDS," *Science*, Vol. 241, p 515.
7. Peter H. Duesberg, 1992. "AIDS Acquired by Drug Consumption and Other Noncontagious Risk Factors," *Pharmacology and Therapeutics*, Vol. 55, pp. 201-277.
8. Robert S. Root-Bernstein, 1993. *Rethinking AIDS: The Tragic Cost of Premature Consensus* (New York: The Free Press), pp. 94-98.
9. For example, the drug-AIDS hypothesis, which resolves all paradoxes of the HIV hypothesis, is epidemiologically and experimentally testable. In fact, the drug-AIDS hypothesis was the first AIDS hypothesis proposed by the CDC (though they called it the "lifestyle" hypothesis). For a detailed explanation of the drug-AIDS hypothesis, see refs. 7, 10, and 20.
10. Peter H. Duesberg, 1996. "How Much Longer Can We Afford the AIDS Virus Monopoly?" in Peter H. Duesberg (ed.), *AIDS: Virus- or Drug-Induced?* (Dordrecht: Kluwer Academic), pp. 241-270.
11. M. Seligmann, et al., 1984. "AIDS—An Immunologic Reevaluation," *New England Journal of Medicine*, Vol. 311, pp. 1286-1292.
12. Manfred Eigen, 1989. "The AIDS Debate," *Naturwissenschaften*, Vol. 76, pp. 341-350.
13. Peter H. Duesberg, 1989. "Human Immunodeficiency Virus and Acquired Immunodeficiency Syndrome: Correlation But Not Causation," *Proceedings of the National Academy of Sciences, USA*, Vol. 86, pp. 755-764.
14. See for example: Peter H. Duesberg, 1991, "AIDS Epidemiology: Inconsistencies With Human Immunodeficiency Virus and With Infectious Disease," *Proceedings of the National Academy of Sciences, USA*, Vol. 88, pp. 1575-1579; and Peter H. Duesberg, 1994. "Infectious AIDS—Stretching the Germ Theory Beyond its Limits," *International Archives of Allergy and Immunology*, Vol. 103, pp. 131-142.
15. John Lauritsen, 1990. *Poison by Prescription: The AZT Story* (New York: Asklepios), *passim.*
16. Peter H. Duesberg, 1995. " 'The Duesberg Phenomenon': Duesberg and Other Voices," *Science*, Vol. 267, p. 313.
17. Jon Cohen, 1994. "The Duesberg Phenomenon," *Science*, Vol. 266, pp. 1642-1649.
18. Serge Lang, 1996. "To Fund or Not to Fund, That is the Question: Proposed Experiments on the Drug-AIDS Hypothesis," in Peter H. Duesberg (ed.), *AIDS: Virus- or Drug-Induced?* (Dordrecht: Kluwer Academic), pp. 297-307.
19. Group for the Scientific Reappraisal of the HIV/AIDS Hypothesis, 1995. "AIDS Proposal," *Science*, Vol. 267, pp. 945-946.
20. Peter H. Duesberg, 1996. *Inventing the AIDS Virus* (Washington, DC: Regnery), *passim.*
21. Robert S. Root-Bernstein, *op cit.* p. 24.
22. The usual procedure for testing a hypothesis is to submit written evidence supporting the hypothesis for publication in a scientific journal. Once submitted, the hypothesis undergoes peer review for evaluation, and, if plausible, is published in the journal. The hypothesis can then be scrutinized by other scientists who may attempt to verify or falsify the findings via relevant studies.
23. When Gallo's papers were eventually published, they revealed a less-than-convincing correlation between HIV and AIDS. They showed that HIV was isolated from only 36 percent of AIDS patients, 80 per cent of patients with AIDS-related complex, and 20 percent of clinically healthy high-risk patients (see ref. 24).
24. Robert C. Gallo, et al., 1984. "Frequent Detection and Isolation of Cytopathic Retroviruses (HTLV-III) from Patients with AIDS and at Risk for AIDS," *Science*, Vol. 224, pp. 500-503.
25. John Maddox, 1993. "New-Style Abuse of Press Freedom," *Nature*, Vol. 366, pp. 493-494.
26. Root-Bernstein, *op cit.* pp. 94,99.
27. Root-Bernstein, *op cit.* p. 102.
28. More than 600 scientists, doctors, journalists and concerned citizens are members of the Group for the Scientific Reappraisal of the HIV/AIDS Hypothesis.
29. Mission statement/proposal of the Group for the Scientific Reappraisal of the HIV/AIDS Hypothesis.

G. Diez/WHO

"Most outrageous is that [Duesberg] attacks my demand for effective public health measures to contain the AIDS pandemic." Here, AIDS education for massage parlor "sex workers" in Thailand, the establishment's substitute for public health.

nisms of a disease (or life process) are unknown, is not the exception, but the rule. Duesberg should not boast that he is able to find the cause by skillfully correlating those factors which seem to be most plausible to him. What we know today about cancer, the aging process, the brain, and many other key questions—despite substantial scientific effort—is fragmentary at best. The general problem here is the dominant *empiricist* approach, which ultimately views life processes only as the sum of non-living phenomena. However, the problems are so complex, that it is scarcely possible to approach them by combining statistical correlations.

Public Health Measures

It is most outrageous, but at the same time most revealing of Duesberg's state of mind, that he attacks my demand for effective public health measures to contain the AIDS pandemic. Although this was only treated in passing in my previous article, Robertson/Duesberg attack especially the idea of such "not only unjustifiable, but irresponsible" measures. Apparently, we have hit a particularly sensitive point with Duesberg.

Consider what it means to reject public health measures (or—the same thing in effect—to take such measures only when the cause of AIDS has been completely resolved from Duesberg's standpoint), and this in the case of AIDS, a deadly, worldwide pandemic. It means to give away voluntarily the only instrument at the disposal of governments for protecting their populations from suffering and death.

Clearly, these measures have to be adapted to the relevant disease, but to deny that public health measures are a central aspect also in the case of AIDS, will be denied only by someone who has other motives than protecting the well-being of the population. Even without knowledge of the infectious agent and in the absence of a cure, public health measures, as provided for by law, have proven to be effective. In the case of AIDS, however, an infectious agent is known, and useful treatment is now available. It would be inhuman not to implement all proven public health measures, including testing for HIV antibodies, as early as possible in cases of suspicion.

Notes

1. See also Jon Cohen, 1994, "The Epidemic in Thailand," *Science*, Vol. 266, Dec. 9. In Thailand, a comprehensive HIV antibody test program was begun in 1985 and was documented by Bruce Weniger of the U.S. Centers for Disease Control. At the end of 1987, 200,000 blood tests from all known risk groups were available—with less than 100 HIV-positive cases. In the following period, the virus began to spread rapidly. At the end of 1988, among intravenous drug users alone, there were 1,000 HIV positives. From other calculations and tests it was estimated that at the end of 1993, more than 700,000 Thais had been infected with HIV. The key is that the steep increase in HIV infection was followed by a corresponding increase in AIDS cases. At the end of 1993, more than 8,000 cumulative AIDS cases were reported in Thailand. "The Thai data are quite compelling that HIV preceded AIDS, and that the increase in HIV infection is now being seen in AIDS cases," Weniger said.
2. M.T. Schechter et al., 1993. "HIV-1 and the aetiology of AIDS," *Lancet*, Vol. 341, pp. 658-9, and also M.T. Schechter et al., 1993, "Aetiology of AIDS," *Lancet*, Vol. 341, No. 8854, pp. 1222-3.
3. J.H. Darbyshire, 1996. "Delta: a randomised double-blind controlled trial comparing combinations of zidovudine plus didanosine or zalcitabine with zidovudine alone in HIV-infected individuals," *Lancet*, Vol. 348, No. 9023, Aug. 3.
4. E.M. Connor et al., 1994. "Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment," *New England Journal of Medicine*, Vol. 331, pp. 1173-1180. In the AIDS Clinical Trial Group Protocol 076 (ACTG 076), it was shown that administering zidovudine (AZT) to HIV-infected women during pregnancy (100 mg per os, 5 times per day) and after going into labor (2 mg/kg body weight IV during the first hour, then 1 mg/kg/h until birth) as well as to the newborns (2 mg/kg per os every 6 hours for 6 weeks) could reduce perinatal HIV transmission by two thirds. See also Ellen J. Landsberger, 1996, "Critical Issues in Treating HIV During Pregnancy," in *Medscape Women's Health*, Vol. 1, No. 6.
5. P. Duesberg, 1994. "AIDS acquired by drug consumption and other noncontagious risk factors," *Pharmacol. Ther.*, Vol. 103, No. 2, pp. 118-27.
6. To cite but one of many works: M.M. Lederman et al., 1995. "Human immunodeficiency virus (HIV) type 1 infection status and in vitro susceptibility to HIV infection among high-risk HIV-1-seronegative hemophiliacs," *J. Infect. Dis.*, Vol. 172, No. 1, pp. 228-31.
7. A detailed statement of the case is in S.B. Harris, 1995, "The AIDS heresies: a case study of skepticism taken too far," *Skeptic*, Vol. 3, No. 2, pp. 42-79.
8. S.C. Darby et al., 1995. "Mortality before and after HIV infection in UK population of haemophiliacs," *Nature*, Vol. 377, pp. 79-82.
9. P. Duesberg, *op. cit.*
10. "The Relationship between the Human Immunodeficiency Virus and the Acquired Immunodeficiency Syndrome," The National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland, Sept. 1995.
11. S. Hammer et al., 1993. "Use of virologic assays for detection of human immunodeficiency virus in clinical trials: Recommendations of the AIDS Clinical Trials Group Virology Committee," *J. Clin. Microbiol.*, Vol. 31, No. 10, pp. 2557-64.
12. W. Blattner et al., 1993. "HIV/AIDS in laboratory workers infected with HTLV-IIIB," IX. Internat. Conf. on AIDS (Abstract PO-B01-0876), June 6-11, 1993. Also M. Reitz et al., 1994. "Viral variability and serum antibody response in a laboratory worker infected with HIV type 1 (HTLV type IIIB)," *AIDS Res. Hum. Retroviruses* Vol. 10, No. 9, pp. 1143-55. See also J. Cohen, 1994, "Fulfilling Koch's postulate," *Science*, Vol. 266, No. 5191, p. 1647.
13. Harris, *op. cit.*
14. International Conference on AIDS, June 16-21, 1991; 7(1):27 (Abstract M.A.22). Internat. Conf. on AIDS, Aug. 7-12, 1994; 10(1):60 (Abstract 193A). Symp. Nonhum. Primate Models AIDS, Nov. 6-9 1991; 9:74 (Abstract no. 53).

Some Additional Remarks on the Duesberg Controversy

by Dr. Jonathan Tennenbaum

Jonathan Tennenbaum heads the Fusion Energy Foundation in Europe and is a member of the scientific advisory board of 21st Century.

1 As Wolfgang Lillge has correctly stated (p.65), the strength of Dr. Duesberg's argumentation, and that of his followers, lies exclusively on the *negative* side. They observe, and partially correctly so, that current scientific opinion concerning AIDS and HIV has not been proven in many key points. However, not much is won by that. Because, strictly speaking, Duesberg, too, has proven nothing, not the least his *own* theory on the cause of these fatal diseases which fall under the clinical definition of AIDS.

Where is his detailed account of the biological processes, which produce the symptoms associated with AIDS? Where are his experiments and other crucial evidence? Vague references to "abnormal" lifestyles, special problems of hemophiliacs and other so-called risk groups, effects of drugs, and so on, may impress the inexperienced layman by superficial plausibility; valid proofs have not been presented by Duesberg. Rather, his arguments remind one of the bitter resistance to Louis Pasteur, when he had to push through the concept of communicable pathogens against the then popular dogma of "spontaneous" creation of diseases.

2 It is no scandal at all, when scientific opinion and clinical practice, in the fight against AIDS, are based only on *hypotheses,* which at most have a limited, but not an *absolute* claim for truth. Whoever demands that medicine only be practiced on the basis of truths proven with "mathematical certainty" and beyond any conceivable doubt, would thereby cause a complete paralysis of medical practice, and would be culpable for the death of millions of patients by negligence.

The question is, how to react to an un-

Dr. Peter Duesberg: Disinformation Agent?

by Ernest Schapiro, M.D.

Ernest Schapiro works with the Schiller Institute in Washington, D.C.

Dr. Leonard Horowitz is the first scientist to conclusively demonstrate that the AIDS virus was not natural, but rather that it began in a laboratory, quite possibly at the National Cancer Institute. Horowitz, a dentist with an master's degree in public health, lays out the evidence in his 1996 book, *Emerging Viruses—AIDS & Ebola: Nature, Accident, or Intentional?*[1]

In this book, Horowitz shows that a team of scientists was employed with government funding, specifically to develop new infectious agents for which the immune system would have no defense. The funding for the project included a portion of the 1970 Department of Defense budget. One of the team members was Dr. Robert Gallo, who shares credit for the "discovery" of the AIDS virus with fellow retrovirologist Luc Montagnier of the Pasteur Institute in Paris.

Horowitz also makes the case that Duesberg was involved in this, working on a Special Virus Cancer project under the National Cancer Institute.

The Population Motivation

The infectious agents project was initiated, Horowitz says, by Henry Kissinger, then head of the National Security Council during the Nixon administration. The underlying policy, he says, concealed under the cover of biological warfare, was one of population control. Horowitz documents the Malthusian fanaticism of Kissinger, George Bush, and their collaborators, and shows how, beginning under Nixon, Malthusianism became U.S. policy.[2]

Horowitz states that Gallo conducted experiments, reported in 1972, in which he combined the outer shell of a monkey retrovirus with the viruses that cause leukemia in chickens and cats, and then grew the new hybrid viruses in human white blood cells, thereby breaching the natural species barrier which ordinarily renders one species immune to the retroviruses which are found in other vertebrates. This type of experiment had been strongly opposed, starting in the 1960s, by some immunologists, such as Nobel Prize winner Sir McFarlane Burnett, as likely to lead to catastrophe.

Duesberg's Involvement

Gallo's work was part of the massive, government-supported research on cancer-causing and immune-system-destroying viruses. Much of this work was done as part of the semi-secret Special Virus Cancer Program, under the auspices of the National Cancer Institute. Dr. Peter Duesberg was director of a Special Virus Cancer Program project, whose purpose was to determine the mechanisms by which certain types of retroviruses, including the C types, produced cancer in a variety of animals. As such, Duesberg was listed in 1971 as a consultant to the Special Virus Cancer Program.

As Horowitz puts it: "The fact is that Duesberg, like Gallo, Montagnier, Francis, Hilleman, and a few others—had been part of a core group of investiga-

paralleled threat to mankind on the basis of necessarily incomplete knowledge.

3 Duesberg makes it easy for himself, because he chooses as a rhetorical target of his criticism, an extremely dogmatic position that is not at all typical of serious AIDS research. It is doubtless the case, that a number of cofactors, perhaps even other viruses (including so far undiscovered ones), play a more or less important, or possibly even decisive, role in the development of AIDS. In fact, it is true for any communicable disease, that the specific state of health of the individual and many other cofactors are highly determinant for the course of the infection.

4 Without doubt, it is important to critically review the question, to what extent the HIV virus constitutes the *sole* biological agent responsible for the spread of the AIDS syndrome, and to what extent HIV is the crucial factor in all, or only for a part, of the cases diagnosed as AIDS. From our point of view, not everything has been resolved in this field. But when Prof. Duesberg directs the main thrust of his attacks exclusively against the role of HIV, he avoids the *really decisive* question; namely that question which is key for the practical fight against AIDS: Are we dealing with a pandemic spread of a communicable disease—at least in a large part of, if not in almost all, AIDS cases?

5 It really becomes dangerous if the disorientation caused by Prof. Duesberg over the issue of HIV as *sole* cause of AIDS—which is an important, but secondary question—diverts attention from *the fact, that a deadly pandemic is in progress.* Even if the existence of HIV antibodies were at best a "marker" for the probability of future AIDS (which we do not believe), that would already be of inestimable value for fighting AIDS, for lack of more precise knowledge about the causes of AIDS.

6 Until the late 19th century, there were physicians and even researchers who—similar to Prof. Duesberg in the case of AIDS—denied vehemently the communicability of, for example, cholera. They stressed that cholera was the result of bad environmental influences, poisons of different kinds, bad lifestyle, and so forth. Some of them even went so far as to drink contaminated water, in order to disprove the thesis of communicability of cholera.

The natural phenomenon "cholera," as well as the natural phenomena "tuberculosis," "influenza," and several others, are in reality much more complicated than they tend to be presented in the textbooks of medicine and biology. But the entire experience of man's life-and-death battle against disease demonstrates, that blocking the potential pathways for chains of infection leads to an effective containment of these and other diseases.

It would be irresponsible, and even negligent, to ignore this experience, given our current—admittedly incomplete—knowledge about AIDS.

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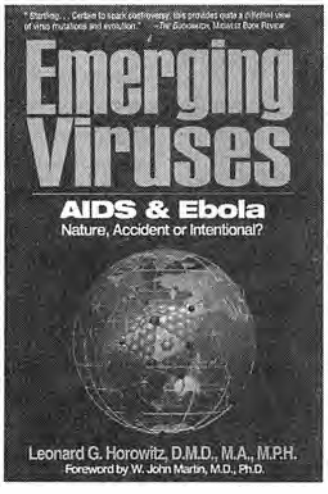
tors funded by the NCI [National Cancer Institute] to study 'special' viruses and their links to cancer."

When AIDS first appeared, Dr. Donald Francis, one of the top virologists at the Centers for Disease Control, and former head of the Hepatitis Branch, noted the occurrence of opportunistic infections in AIDS patients as reminiscent of a similar pathology in feline leukemia, a disease on which he had done research. This example should make clear why research which purported to deal with viruses that caused cancers of the cells of the immune system, was also potentially research in the production of immune deficiency.



It is scarcely surprising that the chief suspects, as Horowitz points out, have been uniformly unwilling even to consider the evidence that the virus was man-made. Duesberg, Gallo, and Max Essex, for example, but also the public spokesmen for the biological research establishment, have put forward a series of preposterous, ad hoc "explanations," starting in 1981, with the idea that homosexuals—at that time the only known victims of AIDS—were getting sick because of their use of chemical inhalants. Then we had the green monkey theory that the disease was transmitted in Africa from monkeys to humans.

Everything to date indicates that the epidemic began separately in the United States and Africa, the two areas where this type of research was being conducted by the same people and institutions involved in large scale vaccine trials. No animal has been found in nature harboring the AIDS virus, or the Ebola virus. And there has never been any evidence demonstrating the existence of the AIDS virus prior to 1976.

It is interesting, however, that there were laboratories in Africa which were conducting virus cancer research at the same time as the National Cancer Institute project. Litton Bionetics, a division of Litton Industries, the military technology giant, was the principal supplier of monkeys for use in research around the world. Litton managed the vast NCI Cancer Research Facility in Frederick, Maryland (which had formerly been the Fort Dietrick biological warfare facility); Litton also, Horowitz believes, ran the laboratories in Uganda in a parallel operation.

Duesberg is undoubtedly just as aware of these matters as Gallo and the rest of the scientists in the Special Virus Cancer Program. In his case, it is like the boy who gets caught with his fingers in the cookie jar and says, "What cookie jar?"

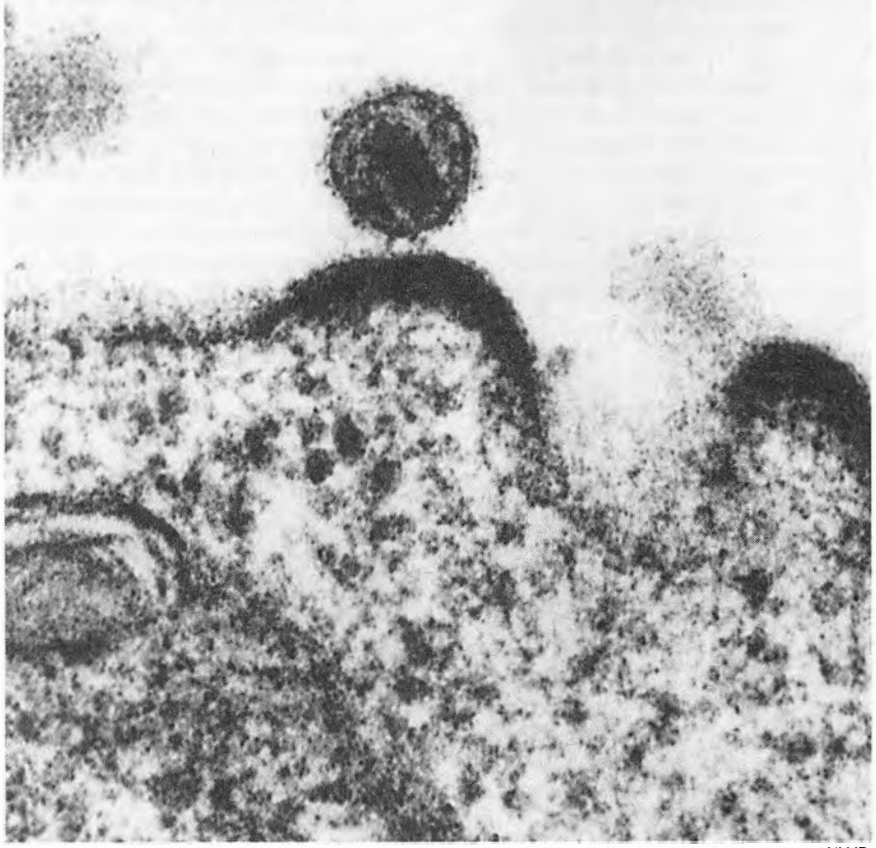
Notes

1. Leonard G. Horowitz, 1996. *Emerging Viruses—AIDS & Ebola: Nature, Accident, or Intentional?* (Rockport, Mass.: Tetrahedron Inc.).

   Among Horowitz's previous books is *Deadly Innocence*, in which he showed that a dentist, David Acer, had deliberately infected his patients with the AIDS virus.
2. It was in the 1974-1976 period that the classified document National Security Study Memorandum 200 was put forward, targetting 13 Third World countries for population reduction. NSSM 200 in essence implemented the depopulation plan put forward at the 1974 United Nations World Population Conference, held in Bucharest. See "The Near-Term Danger of World Population Implosion," by Paul Gallagher, *21st Century*, Winter 1997-1998, p. 12.

The Challenge of Developing An AIDS Vaccine

by Colin Lowry



NIAID

HIV budding from the membrane of a T-cell.

The rapid spread of the AIDS epidemic throughout the world in the past year underscores the need for an effective vaccine against the HIV virus. In 1997, the World Health Organization estimated there were 5.8 million new cases of HIV infection, 30.6 million people infected, and 2.3 million deaths due to AIDS worldwide.

Research toward developing a vaccine against HIV has given scientists new insights into how the immune system responds to this virus, while presenting formidable obstacles scientists will have to overcome if they are to succeed in creating an effective vaccine. At present, the increased specialization of biology has led to the isolation of much of the research, preventing scientists from other fields from effectively contributing to AIDS research. A crash research program, implemented with policies similar to those of the Apollo Program, would be an important step toward overcoming many of these obstacles.

Vaccination is one of the great breakthroughs of modern medicine, starting with vaccines against smallpox, diphtheria, and then polio, which led to the control or elimination of these diseases. However, modern medicine confronts an unyielding enemy in HIV, a retrovirus that turns the immune system against itself. Science cannot fully explain how the HIV virus causes massive immune defects when it infects only a small percentage of immune cells. Also, the HIV virus's ability to mutate frequently, may undermine the effectiveness of a vaccine.

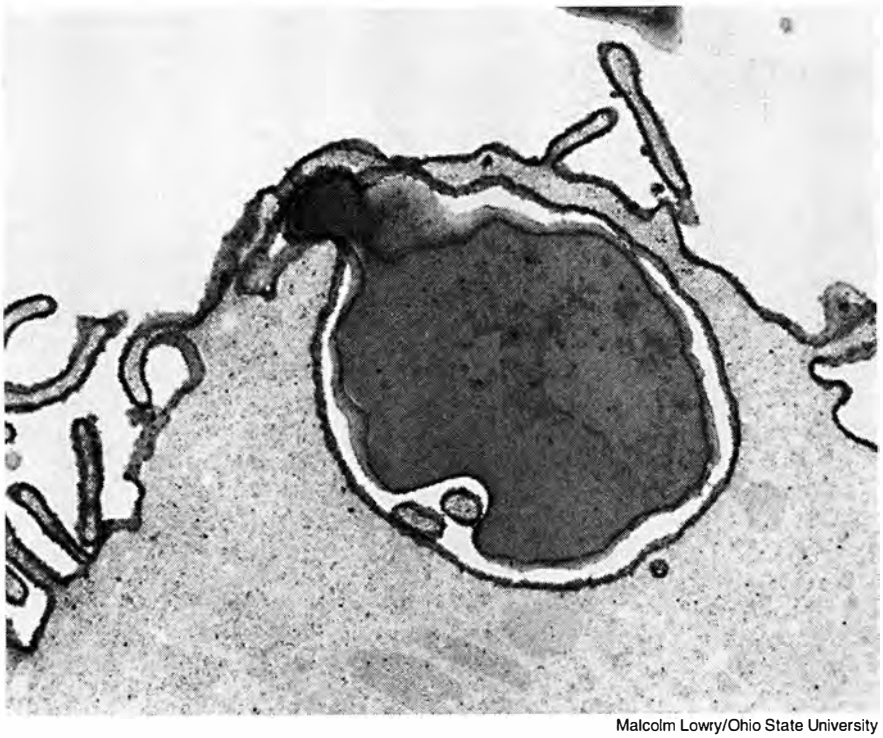
A vaccine generally works by educating the immune system in advance about a specific infectious agent, stimulating a response that creates a reserve of immune cells designed to attack the infectious agent. When these reserve cells encounter the active infectious agent, they mobilize the immune system to defend the body from infection. In order to understand how the HIV virus destroys the immune system, and the difficulties in developing an effective vaccine, a closer look at the immune response is necessary.

The Immune Response

The immune system responds to a pathogen in two ways: The first is humoral immunity, which involves the production of antibodies. The second is called cellular immunity, and involves the killing of infected cells, which is key in clearing viral infections.

Humoral immunity is a primary defense against viruses, bacteria, or other pathogens that are in circulation in the blood or lymph. Antibodies are produced by B-cells, and bind specifically to the pathogen, neutralizing it, and tagging it for destruction by other immune cells. The B-cell can bind soluble proteins, or engulf invaders, chopping up these foreign proteins, which are processed and then presented on the membrane surface of the B-cell on a specific receptor. Surface receptors are produced inside the cell, and protein fragments that are being processed there are bound by the receptor, which is then shipped to the membrane surface for presentation.

In order to become active, and start producing a specific antibody, the B-cell needs the help of another immune cell, known as the CD4 T-cell (or helper T-cell). The B-cell presents a protein fragment (antigen) from the pathogen on its membrane receptor known as MHC II, which is found only on immune cells. The CD4 T-cell can bind to MHC II receptors, and it will bind to the antigen presented by the B-cell, if the variable region of its T-cell receptor has the spe-



Malcolm Lowry/Ohio State University

Electron micrograph of a monocyte engulfing an antibody-coated target.

cific binding affinity for that antigen. Once the T-cell and B-cell have bound together, the clustering of other receptors on the membrane produces signals that activate the B-cell to produce antibodies, as well as to proliferate. The activated T-cell will also secrete molecules known as cytokines, which cause the proliferation of this T-cell, and the production of a line of memory T-cells specific for this antigen.

To complete the process of humoral immunity, the antibody-secreting B-cells indirectly recruit the help of other immune cells, including macrophages, monocytes, and neutrophils, that engulf and chemically destroy targets bound by the antibody.

Cellular immunity is responsible for destroying cells that are infected with viruses or have become damaged or cancerous. The CD8 T-cell, often called a cytotoxic lymphocyte, identifies infected cells by the presence of foreign proteins on the membrane surface. The CD8 T-cell binds to the MHC I receptor, reading the antigen held by the receptor, which is found on the surface of almost all cell types. As an example, a virus-infected cell will produce viral proteins internally, and fragments of these proteins will be presented on the MHC I receptor. A CD8 T-cell with the correct specificity, can bind to MHC I presenting a viral antigen. Once bound to the MHC I receptor, the clustering of coreceptors may activate the CD8 T-cell, which will then kill the infected cell, by lysing (bursting) it with chemicals. The activated CD-8 T-cell will then proliferate, and memory cells specific to the antigen will also be produced. CD-8 T-cells are restricted to killing cell targets that express the MHC I receptor, and are not involved in attacking free viruses or bacteria in the circulatory system.

HIV's Devious Attack

By studying the progression of patients from initial infection with HIV, to total immune suppression characteristic of full-blown AIDS, scientists have learned what damage HIV does to the immune system, but how this damage occurs is not completely understood.

The HIV virus uses many of the immune system's defense mechanisms to its own advantage, infecting responding T-cells, and relentlessly suppressing and defeating the immune system as a whole. HIV is a retrovirus, which uses RNA as its genetic material, but transcribes this into DNA using a special enzyme. A retrovirus can integrate its DNA into the genome of the host cell, and remain dormant, or it can force the cell to replicate the virus until the cell is killed, and the new viruses are released.

One of the ways HIV destroys the immune system is by infecting CD4 T-cells, disabling their function, and eventually killing them. HIV can bind to the CD4 receptor on the membrane surface of the T-cell, and, with the help of another coreceptor, gain entrance into the cytoplasm of the cell intact. This is very unusual, in that the virus escapes any enzymatic cleavage or processing by the host cell, by entering through these receptors. Once inside, the virus may replicate, killing the cell, or may integrate into the genome and lie dormant.

The destruction of CD4 T-cells, is reflected by the low T-cell counts in the bloodstream of AIDS patients. The CD4 T-cell acts mostly as a mediator for activation of immune responses. Communication within the immune system is necessary for mobilizing a response. HIV disrupts this communication, altering the normal production of signalling molecules, called cytokines, which would be produced in response to infection. By destroying CD4 T-cells, HIV also damages the function of B-cells, which require the help of CD4 T-cells to produce antibodies.

HIV also directly destroys another important immune cell, known as the dendritic cell. Dendritic cells reside in the mucous membranes, in lymph nodes, and in epithelial tissue generally. These cells act as surveillance against viruses or bacteria, by taking in foreign antigens, and presenting them to T-cells. Dendritic cells normally take in pathogens, digest them with proteolytic enzymes, and display the protein fragments on their surface within the MHC II receptor. A CD4 T-cell with the correct specificity can then bind to the MHC II receptor of the dendritic cell, becoming activated to proliferate. In this way, dendritic cells activate a T-cell response to pathogens encountered within mucous membranes, often before the pathogen gets into the bloodstream.

The HIV virus uses the ability of the dendritic cell to pass antigens to T-cells, as a direct route to infect the CD4 T-cell population. HIV can also bind to and enter the dendritic cell intact. When an infected dendritic cell contacts a CD4 T-cell, it often passes intact HIV to it, infecting the T-cell. In AIDS patients, the number of dendritic cells remaining in

the mucous membranes decreases rapidly, as the disease progresses.

Cytotoxic T-lymphocytes, predominantly CD8 T-cells, responding to HIV proteins on the surface of infected cells, are activated to destroy infected CD4 T-cells, dendritic cells, and others, also contributing to the decline in immune function. However, cells infected with HIV that are in latency, with no viral proteins being expressed on their cell surface receptors, will not be detected and killed by CD8 T-cells, leaving a reservoir of the virus. Once the HIV virus has infected enough immune cells to suppress immune function, the amount of virus present in the blood increases, accompanied by the loss of CD8 T-cell response to HIV antigens, overwhelming the system in the final phase of AIDS.

Vaccine Problems Specific to HIV

The HIV virus presents some special problems for scientists who are designing an effective vaccine. The virus mutates frequently, disguising itself, so variants may escape detection by the immune system. The coat proteins of the virus are not highly antigenic; they are not recognized well by B-cells, meaning that they do not elicit a strong antibody response. Also, most of the antibodies to HIV coat proteins isolated from AIDS patients, do not neutralize the virus, or are antibodies to viral debris or immature coat proteins, that are not found on the actual infectious virus.

An effective vaccine would have to stimulate an antibody response, and a strong cytotoxic T-lymphocyte (CTL) response. Vaccination with HIV coat proteins may be able to generate an antibody response, but not a CTL response, because CTLs recognize foreign proteins made within cells that are presented on the cell surface. By the time antibodies in the blood can bind to HIV, it is usually too late, because the virus has infected the CD4 T-cell population, through the dendritic cell pathway.

Many vaccines against viruses have been based on live, non-pathogenic, weak versions of the infectious virus. Application of a live, weakened HIV virus vaccine in human beings would be very dangerous, for several reasons. No one knows what the long term effects of retroviruses are in human beings, and the fact that retroviruses can integrate into the host DNA, means they may create mutations which, in the long term, would lead to cancer. Also, there is the possibility of causing an active infection using a live HIV vaccine.

Experiments in monkeys using weakened versions of the simian SIV, which is related to HIV, have shown that viruses that were supposed to be non-pathogenic, when used as vaccines, caused full-blown AIDS symptoms in some of the monkeys. However, in monkeys that did not get sick, the live virus vaccines produced a strong immune response, which protected them from infection when the monkeys were challenged with the pathogenic SIV virus. Scientists are not sure how the weakened SIV caused disease, because several genes believed to be involved in pathogenicity had been deleted from it. When researchers analyzed the virus present in the sick monkeys, it was clear that the virus had undergone genetic changes. Because there are so many unknowns, and a high risk of causing infection, use of a live, attenuated HIV vaccine in human beings remains only a remote possibility.

The first vaccine designs, tested about 10 years ago in animals, involved injection of the coat proteins of HIV/SIV under the skin. These vaccines could elicit an antibody response in roughly 40 percent of the animals, but did not induce any cytotoxic lymphocyte response. When the animals that produced antibodies to the SIV coat proteins were challenged with infectious virus, only a very small percentage were protected from infection. The problems with this type of vaccine stem from the fact that it does not produce a CTL response, and it is unlikely that any of the antibodies produced will neutralize the infectious virus. Other problems with us-

Glossary

Antibody: A special protein, made with specific capacity to bind to a region of another protein. Produced by B-cells. Antibodies bind to foreign proteins on invaders, and target them for destruction by other immune cells, such as macrophages and monocytes, which engulf and chemically destroy the target.

B-cell: Responsible for production of antibodies. The B-cell binds to soluble proteins, or engulfs invaders whole, then presents these antigens on its surface within MHC II. Requires T-cell help for activation to proliferate, and secrete antibodies.

CD4 T-cell: Binds to antigens presented by the MHC II receptor. When active, helps B-cells by providing second activation signal for production of antibodies. Secretes cytokines which promote proliferation of T-cells.

CD8 T-cell: Acts as a cytotoxic cell, kills infected cells. Binds to antigens presented by the MHC I receptor. The CD8 reacts to proteins produced internally by other cells, that are held on the surface by MHC I.

Dendritic cell: A specialized immune cell, found within membranes and epithelial tissue. It engulfs pathogens, and presents antigens to T-cells on MHC II. It is easily infected by HIV.

Macrophage: A professional engulfing cell. Destroys foreign bacteria, viruses, etc. Can also present antigens on MHC II to T-cells.

M-cell: A mucosal membrane immune cell, found in the lining of the gut. It takes antigens from the gut, and passes them to immune cells in associated lymph nodes.

MHC I receptor: This cell surface receptor is known as the "self recognition" receptor. It presents protein antigens from proteins produced within the cell. It is found on almost all cell types. An HIV-infected cell will present viral protein antigens on this receptor.

MHC II receptor: This cell surface receptor is found only on immune system cells. It is used to present antigens from one immune cell to the next. CD4 T-cells recognize antigens held by this receptor. Immune cells interact by cell-to-cell contact.

Monocyte: A lymphocytic cell. It is also an engulfing cell. It can present antigens on MHC II to T-cells.

ing the whole HIV coat proteins as immune stimulators have only recently come to light.

Several scientists have pointed out that the degree of immune suppression in HIV-infected individuals before the development of AIDS is quite high. The percentage of infected immune cells, including CD4 T-cells, in these patients is too low to account for the immune defects observed. A study by K.J. Weinhold and D.P. Bolognesi et al., demonstrated that the purified HIV coat protein gp120 can suppress T-cell activation, and may set up the CD4 T-cell for cytolytic destruction by CD8 T-cells. The coat protein, gp120, is a glycoprotein, meaning it contains carbohydrate residues attached to its surface. The gp120 protein binds directly to the CD4 molecule on the surface of the T-cell. The binding of gp120 to CD4 may act to block the T-cell from receiving antigens presented to it within MHC II, which would result in a complete lack of T-cell activation. The binding of gp120 to the CD4 molecule of the T-cell, may also initiate programmed cell death (apoptosis), in the absence of another activating signal.

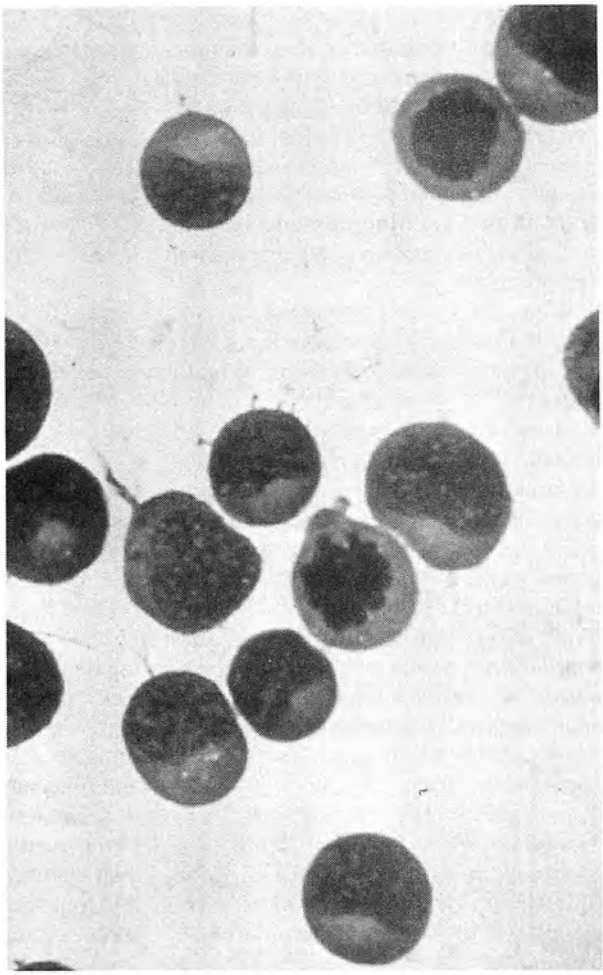
This is consistent with what was found in a study by J.J. Eron, in which individuals already infected with HIV, were given an immunization of recombinant gp120, which failed to slow the course of the disease. A trend that was perceptible but just under statistical significance, was that many of the immunized patients actually progressed to full-blown AIDS faster than the non-immunized group.

A DNA Vaccine Approach

The idea of using viral DNA as a vaccine offers several advantages over using viral proteins alone. The goal is to introduce a portion of viral DNA, such as a gene for the HIV coat protein, into cells using a vector such as a harmless virus, so that the DNA is translated into protein made inside the cell. Once the protein is produced inside the cell, portions of it will be displayed by MHC I surface receptors, which could activate a cytotoxic T-cell response. Also, the protein could be secreted by the cell, or cells already lysed (killed) by CTLs may release the viral protein, which would activate an antibody response.

Studies by E.L. Cooney and P.D. Greenberg compared the ability of a DNA-based vaccine and a protein vaccine, to induce an immune response against HIV in human beings. A vaccinia virus containing the HIV gene for the full length coat protein, gp160, was used as a DNA vaccine. Used alone, this vaccine elicited a low T-cell proliferative response in 8 of 11 patients. However, the response was not sustained, and 12 months after immunization, T-cells from these patients did not respond to HIV antigens. This vaccine also elicited a poor antibody response, with only 3 of 11 patients producing antibodies, none of which neutralized the virus. The antibody response was no longer measurable 12 months after immunization.

Results using gp160 protein alone gave even lower percentages of immune response. Only 1 of 4 patients produced antibody to HIV, and this response also disappeared within 12 months after vaccination. T-cell responses were even lower, and more fleeting than with the DNA vaccine alone. These unsuccessful results prompted the researchers to try a vaccine regimen combining the HIV gp160 DNA and gp160 protein.



Tom Folks/NIAID

Normal T-cells.

Combined vaccination with the vaccinia virus containing gp160 DNA, followed by injections of the gp160 protein, produced stronger and longer-lasting immune responses to HIV. Neutralizing antibodies to HIV were found in 7 of 13 patients. T-cell responses, primarily CD4 T-cell proliferative responses, were found in 12 of 13 patients. Cytolytic T-cells were detected in several patients, but the study, done in 1993, had difficulty determining if any of these were CD8 T-cells.

More recently, experiments conducted in 1996 by B. Fleury and Y. Riviere et al., at the Pasteur Institute in Paris, have shown that a combined vaccine regimen does induce a CD8 cytolytic T-cell response against HIV antigens. In these experiments, a canarypox virus containing HIV gp160, followed by two injections of recombinant gp160 protein, elicited CD8 T-cell responses in 7 of 18 immunized patients. In two of these seven subjects, the CD8 T-cell response was still present two years after immunization.

Peptides and Fusion Proteins

Vaccines containing the coat proteins of HIV suffer from their inability to activate a cytotoxic T-cell response, because the coat proteins are not internalized by cells. Several strategies are currently being worked on to use fusion proteins or peptides, that can get inside the cell, and be presented on the MHC I receptor, to elicit a CTL response. The immune system recognizes and reacts strongly to certain bacterial proteins, such as coat proteins from tuberculosis, or other common infectious bacteria. These bacterial proteins are often used

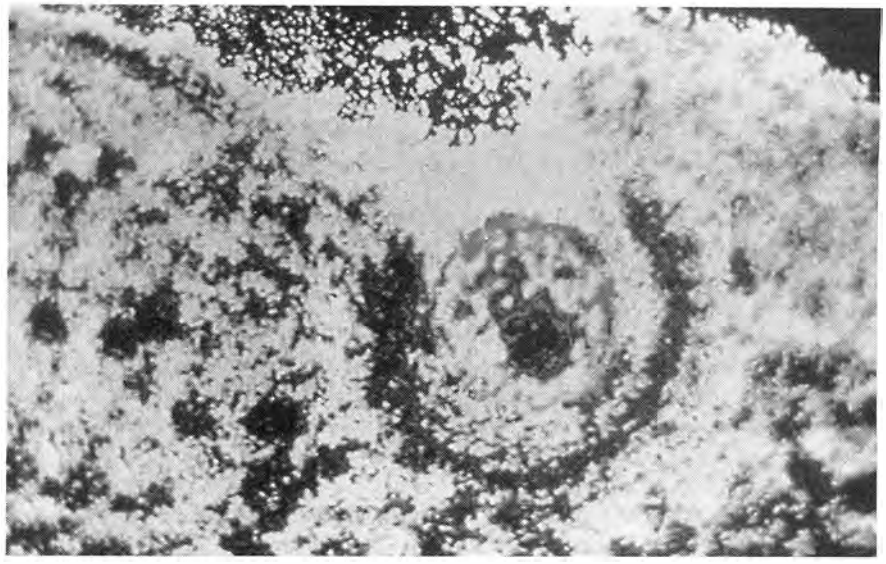
as an adjuvant, mixed with the vaccine antigens, designed to recruit an immune response that recognizes the vaccine antigens. Because the HIV proteins do not produce a strong immune response alone, fusing the HIV proteins to highly antigenic bacterial proteins would cause a mobilization of the immune system, and strong recognition of accompanying HIV proteins.

One of the more ingenious approaches uses the natural ability of proteins from the toxic anthrax bacteria, to cross cell membranes and enter the cytoplasm. Experiments by T.J. Goletz and J.A. Berzofsky, constructed genetic fusions of the HIV gp120 with the anthrax lethal factor, which had its catalytic domain deleted, making it non-toxic, and tested whether this fusion protein could be processed and presented on MHC I. The anthrax fusion protein acts as a "molecular syringe," delivering the gp120 protein inside the cell, which is then processed and presented on MHC I. This was shown to produce a strong CTL response in mice.

In experiments not related directly to HIV, heat shock fusion proteins have also been shown to be effective immune stimulators of antibody and CTL responses, and promising candidates for vaccines. Heat shock proteins are produced by cells under stress, and have the ability to chaperone other proteins across cell membranes. Heat shock proteins from mycobacterium act as their own adjuvant, stimulating a strong immune response, activating the immune system by triggering the production of cytokines, which enhance the proliferation of immune cells, such as T-cells.

Experiments by K. Suzue and R. Young, tested whether a tumor cell protein fused to mycobacterium heat shock protein could induce CTL response against the tumor cells. Mice were first immunized with the fusion protein, and then injected with tumor cells. These immunized mice produced strong CD8 CTL responses against the tumor cells, and 80 percent of the immunized mice survived, as compared to 100 percent fatality in the control mice, 21 days after injection of the tumor cells. The use of heat shock fusion proteins for HIV vaccines is very promising, and is currently under development.

A very different approach to vaccine design involving synthetic peptides is being developed by Jay Berzofsky and Jeffrey Ahlers. This approach requires knowing what parts of the HIV coat proteins actually bind to MHC receptors, and stimulate a strong response. The idea is to synthesize peptides that correspond to these HIV protein areas, which can then directly bind to MHC I and MHC II, and stimulate a neutralizing antibody response. By directly binding to MHC I, the peptide tricks the system, in that normally only internal protein fragments would be presented on this receptor, which is key to stimulating a CTL response.



NIAID

AIDS virus penetrating a cell, magnified many thousands of times.

Another variable in immune responses is that there are many different varieties of MHC receptor genes in the general population. The slight differences in variety influence what portion of an antigenic protein is strongly bound by the MHC receptors. Through careful study in mice and in infected humans, Ahlers and Berzofsky have identified regions of the coat proteins of HIV, that are recognized by multiple MHC types. By analyzing segments of these protein regions, they have identified specific sections, called determinants, that stimulate CTL response, neutralizing antibodies, and helper T-cells. These protein sections are usually 20 to 30 amino acids long, and can be synthesized in the form of peptides.

The vaccines based on this approach are composed of peptides that contain multiple determinants for several MHC binding types, consisting of protein regions common to several HIV subtypes. The peptides are mixed with an adjuvant, containing bacterial proteins known to elicit a strong immune response, which helps the peptides to be recognized by the immune system. Experiments with these vaccines in mice have been successful in stimulating neutralizing antibody and helper T-cell responses, as well as CTL responses to HIV coat proteins.

The stimulated T-cells from these mice were tested against various strains of HIV. These T-cells were found to react to two HIV strains common in Europe and North America, but not to two strains from Africa and Haiti, which differed enough from the peptide determinants used in the vaccine, to escape detection. This problem of recognition of several different HIV strains affects any vaccine design, but by adding peptides that represent determinants of more strains, this synthetic peptide approach may be able to overcome it.

HIV Variants Escape Detection

One of the most troublesome problems with HIV, is that small variations in its proteins occur rapidly as a result of mutation, which often allows these variants to escape detection by the immune system. This is one of the ways vaccines made against a specific subtype of HIV, can fail to protect against infection by a variant strain.

A case of a vaccine failure involving an unusual phenomenon known as T-cell antagonism, was documented in a study by S.J. Kent and M.J. McElrath. An

individual immunized with a vaccinia virus vector containing gp160 DNA, and boosted with recombinant gp160 protein, produced strong CD4 proliferative and CTL responses, as well as neutralizing antibodies to HIV. Researchers assumed that this level of immune response would provide protection against HIV infection. However, this individual later became infected with an HIV strain that differed slightly from the one used to make the vaccine.

T-cells that recognized a specific region of the HIV gp160 were removed from the immunized individual, before he became infected, and cultured. These cultured T-cells were compared to the T-cells present in the immunized individual after he became infected, for their ability to recognize and lyse target cells bearing the gp160 sequence used in the vaccine. Surprisingly, the T-cells taken after the individual became infected with the variant HIV, failed to recognize or lyse cells bearing the original gp160 sequence, to which they had previously responded. The strain of HIV that infected this individual had two mutations in the region of gp160 that was used to make the vaccine. This phenomenon of T-cell antagonism, where a variation in the region of the HIV protein bound by the MHC receptor, causes the T-cells to lose the ability to recognize the original strain, is not fully understood.

Other studies of T-cell antagonism have provided clues to its importance in the progression to AIDS. Experiments by D.A. Price and R.E. Phillips, have demonstrated that the immune system's CTL response in initial HIV infection, exerts a selective pressure on the virus, which promotes the survival of variants that can escape detection. These escape variants, were shown to have mutated the sites that were recognized by CTLs in proteins of the viral envelope. However, the escape variants did not become the dominant viral species. The variants' ability to antagonize T-cells, which causes the T-cell to fail to recognize the original, dominant form of the virus, does not require large numbers of variants. These escape variants provide protection for themselves, and the dominant species of virus, by disrupting T-cell function.

T-cell antagonism has been found to occur in hepatitis B infection, and the mechanism by which it inactivates T-cells has only been partly defined. Experiments using peptides, as substitutes for variant viruses, have shown that peptides with only 1 or 2 sequence changes, can bind to MHC I, but do not trigger activation of T-cells. Normally, immune cells require two signals for activation, as a safeguard to avoid over-responding to rare antigens or nonspecific binding of a receptor. A signal from an isolated receptor will be ignored, and no activation will occur. HIV isolates the components of the signalling network, cutting off activation, and turning the immune system against itself by interfering with this signalling. T-cells that have a variant peptide bound to MHC I, often go into programmed cell death in the absence of a second activation signal. This leads to inactivation of the T-cells, and by unexplained mechanisms, to the loss of recognition of the original protein to which they first responded.

THE FOUR MAIN WEAPONS OF HIV

(1) Infect the immune cells that respond to it. Gain entrance intact into CD4 T-cells and dendritic cells.
(2) Mutate coat proteins, use as disguise, and escape detection by immune system.
(3) Coat glycoproteins can bind and inactivate T-cells, disrupt T-cell communication.
(4) Use *nef* protein to rip down MHC I receptor from surface of infected cell. Allows HIV to hide and replicate undetected in the cell.

HIV has some other tricks to escape detection by the immune system. The virus can infect types of neuronal cells, which do not display MHC I receptors, allowing the virus to hide from immune responses. Latently infected neurons are tolerated by the immune system, which provides a reservoir of viruses which can be reactivated at a later time. This strategy is used by many viruses other than HIV, such as herpes.

Recently, HIV was shown to have a unique method of escaping detection once inside a cell. The HIV *nef* protein, critical to its pathogenicity, was shown to be capable of forcing the infected cell to eliminate the expression of MHC I receptors on its membrane surface. Without MHC I receptors, the cell cannot signal to immune cells that it is infected, as no viral proteins can be presented to CD8 T-cells. The virus can then replicate in the camouflaged cell undetected, until it is ready to kill the cell, and release more viruses. This effect requires some incubation time, and does not always occur.

An unexpected property of CD8 T-cells has been found through the study of their response to HIV-infected CD4 T-cells. Usually, CD8 T-cells lyse infected CD4 T-cells, but it has now been discovered that CD8 T-cells can secrete a soluble factor that inhibits viral replication in the infected CD4 T-cells in close proximity. This factor is believed to inhibit the transcribing of the viral genes, although it has not yet been identified.

Stimulating Mucosal Immunity

One of the main routes for the HIV virus to invade the body is through mucous membranes. A vaccine that can elicit mucosal immunity to HIV may provide effective protection against infection. Researchers are experimenting with salmonella bacteria as a vector for delivering HIV antigens specifically to the immune cells that reside in mucous membranes, and the gastro-intestinal tract. Within the gastro-intestinal tract membranes lie special clusters of immune cells, called Peyer's patches. These patches contain M-cells, which sample the antigens in the gut, and are associated with underlying lymph nodes, containing monocytes, T-cells, B-cells, and macrophages. M-cells act by presenting antigens to the cells in the associated lymph node. Salmonella is unusual in that it crosses the mucosal barrier, and targets M-cells. Salmonella is highly antigenic, and elicits strong mucosal immune responses. These characteristics make it a good vector for a mucosal vaccine to HIV.

Experiments by S. Wu, D. Pascual, and D. Hone, tested a salmonella vector expressing HIV gp120 in animals for its ability to stimulate mucosal immunity. Oral doses of this vaccine induced T-cell proliferative responses, and the secretion of IgA antibody, which is found in the

gut, and differs from the IgG antibodies found in the bloodstream. It was unclear whether any CD8 T-cells were stimulated by this vaccine, although they are present in the lymph nodes beneath M-cells, and are often stimulated by salmonella infection. The development of salmonella vectors as HIV vaccines is in an early stage, and has not been tested in humans, although animal experiments have shown it to be a promising approach.

Will a Vaccine Protect a Population?

Significant unanswered questions remain concerning the effectiveness of any of the HIV vaccines in protecting a large population from infection. There have been only small trials of vaccines in humans, from which it is very difficult to extrapolate results to a larger population. The first large-scale trial of an HIV vaccine, based on recombinant gp120 protein, is scheduled to begin in Thailand this year. Whether or not this vaccine will protect against infection from multiple strains of HIV, and how the genetic background of the population influences the vaccine's effectiveness, will only be partly known once the trial is over. Unfortunately, the gp120 vaccine being tested in Thailand, has shown poor results in small trials in the United States. The vaccine has been shown to be safe, and without side effects, and as such has been approved for further testing. However, some of the better vaccine designs, which have provided excellent results in small trials, should be accelerated to large-scale trials, especially in areas of the world where the HIV virus is spreading most rapidly.

Research on treating HIV-infected patients has led to treatments which do prolong their survival. However, the much touted "triple drug therapy" has been shown to leave reservoirs of the virus in the patient's infected T-cells. Even when this drug therapy eliminates the virus from the bloodstream, experiments have shown that resting CD4 T-cells from infected individuals, contain HIV, that when stimulated, actively replicates, as shown by T.W. Chun and Anthony Fauci.

Is the lack of more complete knowledge of the immune system, one of the largest obstacles to the effective treatment of AIDS, and the development of a vaccine against HIV? The problem with much of the research being done today, is that it rests on mechanistic, often linear, concepts of the immune system, and living systems in general. Key parts of the biological picture are missed by this mechanistic approach. The application of technologies usually reserved for physics, such as advanced spectroscopy, could provide scientists the means to explore the fundamental electromagnetic processes characteristic of living systems.

Proposals for a crash research program in biology using advanced biophysics, were made by this magazine's predecessor, *Fusion,* in 1985 and 1986, as part of a strategy to stop the spread of AIDS, and find a cure. Researchers have barely opened up investigations into the electromagnetic interactions between cells, which may provide insight into a new level of organization in the immune system. Perhaps if scientists can overcome these conceptual problems, the problems of creating an HIV vaccine will be solved.

References

J.D. Ahlers, J.A. Berzofsky, et al. 1996. "Candidate HIV Type 1 Multideterminant Cluster Peptide-P18MN Vaccine Constructs Elicit Type 1 Helper T-Cells, Cytotoxic T-Cells, and Neutralizing Antibody, All Using the Same Adjuvant Immunization," *Aids Research and Human Retroviruses*, Vol. 12, No. 4, pp. 259-72.

C.H. Chen, M.L. Greenberg, et al. 1993. "CD8+ T Lymphocyte-Mediated Inhibition of HIV-1 Long Terminal Repeat Transcription: A Novel Antiviral Mechanism," *AIDS Res. Hum. Retroviruses*, Vol. 11. pp. 1079-86.

T.W. Chun, A.S. Fauci, et al. 1997. "Presence of an Inducible HIV-1 Latent Reservoir During Highly Active Anti-retroviral Therapy," *Proc. Nat'l. Acad. Sci. USA*, Vol. 94, pp. 13193-97.

E.L. Cooney, P.D. Greenberg, et al. 1993. "Enhanced Immunity to HIV Envelope Elicited by a Combined Vaccine Regimen Consisting of Priming with a Vaccinia Recombinant Expressing HIV Envelope and Boosting with gp160 Protein," *Proc. Nat'l. Acad. Sci. USA*, Vol. 90, pp. 1882-86.

J.J. Eron, et al. 1996. "Randomised Trial of MN-rgp120 HIV-1 Vaccine in Symptomless HIV-1 Infection," *Lancet*, Vol. 348, Dec. 7.

B. Fleury, Y. Riviere, et al. 1996. "Memory Cytotoxic T Lymphocyte Responses in HIV-1 Negative Volunteers Immunized with a Recombinant Canarypox Expressing HIV gp160 and Boosted with a Recombinant gp160," *J. Infectious Disease*, Vol. 174, No. 4, pp. 734-38.

T.J. Goletz, J.A. Berzofsky, et al. 1997. "Targeting HIV Proteins to the Major Histocompatibility Complex Class I Processing Pathway with a Novel gp120-anthrax Toxin Fusion Protein," *Proc. Nat'l. Acad. Sci. USA.* Vol. 94, pp. 12059-64.

S.J. Kent, M.J. McElrath, et al. 1997. "Antagonism of Vaccine-Induced HIV-1 Specific CD4+ T-Cells by Primary HIV-1 Infection," J. of Immunology, Vol. 158, pp. 807-15.

W. Lillge. 1986. "Defeating AIDS: How Lasers Can Help," *Fusion*, May-June 1986, Vol. 8, No. 3, pp. 43-48.

D.A. Price, R.E. Phillips, et al. 1997. "Positive Selection of HIV-1 Cytotoxic T Lymphocyte Escape Variants During Primary Infection," *Proc. Nat'l. Acad. Sci. USA*, Vol. 94, pp. 1890-95.

K. Suzue, R.A. Young, et al. 1997. "Heat Shock Fusion Proteins as Vehicles for Antigen Delivery into the Major Histocompatibility Complex Class I Presentation Pathway," *Proc. Nat'l. Acad. Sci. USA*, Vol. 94. pp. 13146-51.

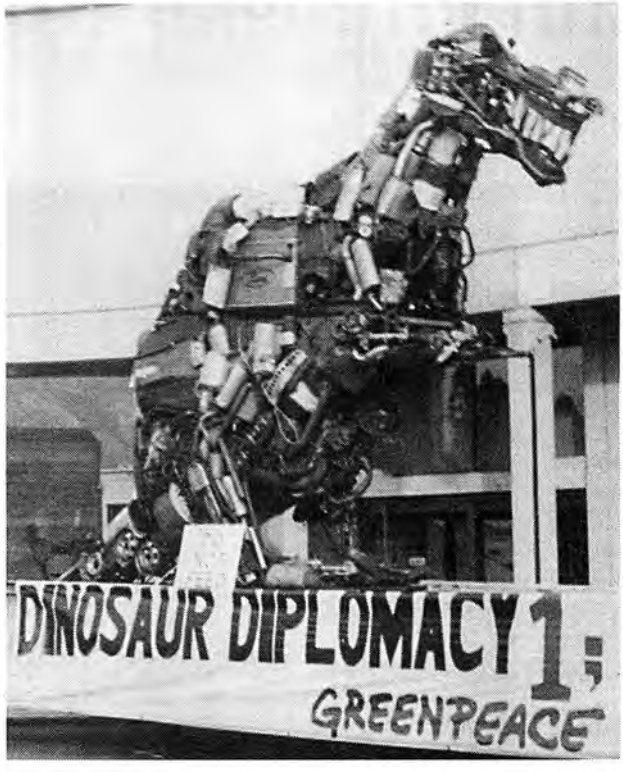
J. Tennenbaum. 1985. "The Coming Breakthroughs in Biophysics," *Fusion*, Sept.- Oct. 1985, Vol. 7, No. 5, pp. 20-27.

K.J. Weinhold, D.P. Bolognesi, et al. 1989. "HIV-1 gp120-Mediated Immune Suppression and Lymphocyte Destruction in the Absence of Viral Infection," *J. Immunology*, Vol. 142, May 1, pp. 3091-97.

S. Wu, D.W. Pascual, G.K. Lewis, and D.M. Hone. 1997. "Induction of Mucosal and Systemic Responses Against HIV-1 gp120 in Mice After Oral Immunization with a Single Dose of a Salmonella-HIV Vector," *AIDS Res. Hum. Retroviruses*, Vol. 14, Sept. 20, pp. 1187-94.

Kyoto Protocol Means U.S. Energy Austerity

by Marsha Freeman



Bey Wesley

Greenpeace's dinosaur at Kyoto is an appropriate symbol for the antediluvian low-tech, non-dense sources of energy that the global warming crowd is promoting.

As the U.S. Congress holds a series of hearings to weigh the Clinton Administration's commitments to meet the restrictions of the Kyoto Protocol, even the U.S. government's own energy analysis demonstrates that the proposed cuts in so-called greenhouse gas emissions will deal a body blow to the U.S. economy.

At a Feb. 4 hearing before the House Committee on Science, Jay Hikes, the director of the U.S. Department of Energy's Energy Information Administration, showed that in order to meet the Kyoto emissions caps, U.S. energy prices would have to increase. Even if all of the energy-efficient technologies into which the Administration is pouring money, come on line early in the next century, his testimony indicated that there will not be much energy efficiency to show for these technologies in the timeframe agreed to at Kyoto.

Numerous studies have tried to determine the "level of price mechanisms necessary to achieve stabilization or reduction of carbon emissions," Hikes stated in his testimony. These vary from $20 per ton of carbon to reach stabilization, to $320 per ton, to achieve the 7 percent reduction below 1990 levels agreed upon at Kyoto.

Although some of the emission cuts could be accomplished by making cars and refrigerators more energy-efficient, Hikes said, the Energy Information Agency "believes it will take a significant price signal" to achieve the cuts in emissions that the Administration agreed to at Kyoto. These increases in the cost of electricity and primary source energy will be passed on to consumers, Hikes added. "The more stringent the carbon emissions reduction target, the higher the GDP [Gross Domestic Product] loss."

'Climate Friendly' Austerity?

President Clinton presented his $6 billion Climate Change Initiative to the Congress Jan. 31, in an effort to set the nation on the path of cutting so-called greenhouse gas emissions to 7 percent below 1990 levels, as agreed to in the Kyoto Protocol. Over the next five years, $2.7 billion of that is to be spent on developing "technologies" that are supposed to be more energy "efficient" and "climate friendly."

Despite those who might fool themselves into thinking otherwise, the environmentalists who have brought us the global warming and ozone hoaxes, have no intention of supporting the development of new (or even old), technologies that increase the energy density and, therefore, *real* efficiency of the economy. Unfortunately, the Clinton Administration's environmental policies mirror those of the most rabid anti-science greenies.

Fully $100 million of the funds for the Climate Change Initiative are to subsidize the use of "renewable" energy sources, which have come to mean wind, geothermal, biomass, and small-scale hydroelectric power. All of the economic advantages of having created large-scale power plants that are integrated into a regional electric grid system will go out the window, as we turn back the clock to 19th century Holland, and to pre-industrial man, burning biomass, such as animal waste and trees.

The President has proposed tax credits of up to $4,000 for the purchase of "fuel efficient" automobiles, which will be able to go 80 miles per gallon of fuel. There are tax credits for placing solar collectors on the roof of a house. If this all sounds familiar, it is because it has been tried before.

Re-warmed Jimmy Carter

During the mid-1970s Administration of President Jimmy Carter, billions of dollars were spent on the same array of energy "technologies." They were promoted on the basis that in the near future, petroleum would rise to $100 per barrel, which would make burning manure "competitive." Of course, at today's price of about $14 a barrel of oil,

Continued on page 95

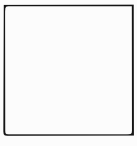
SPECIAL FOR YOUNG SCIENTISTS

Getting to the Square Root Of the Math Problem

by Elijah C. Boyd

A sure method for destroying the principal device used to effect "tracking" of children into various categories of stupidity in the United States, and elsewhere, is to engage in simple geometric constructions. Any of you can do these constructions, if you can write, or draw, and exercise your own powers of reason. It is these powers of reason that are denied, if not obliterated, in normal classroom practices.

First, draw a square.

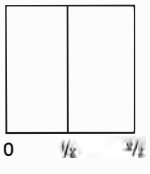


Now, next to it, draw a square root. No, not the symbol known as the *radical,* and the bar over it, the *vinculum,* but the thing which the symbol represents: the *square root itself.*

Hmm. What seems to be the problem? What do you mean, your brain seems to be frozen? How can that be? OK. Let's attack this from a different direction.

Multiplying Fractions

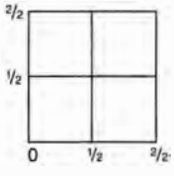
Let us, instead, do the simplest fraction multiplication problem in the world. Multiply 1/2 times 1/2, by using the square you have just constructed. Now, probably the first thing your mind asks, when confronted with the task of multiplying 1/2 by 1/2, is, one-half of *what?*



Barbara Boyd

The author (right) working on squares with a young scientist.

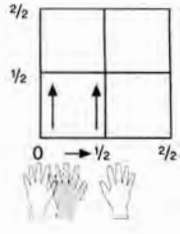
Aha! Let's try to use the square for this. We want to find 1/2 on this square, so we cut it in half.

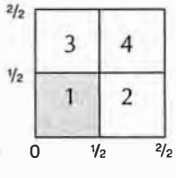


When we cut the square in half vertically, that takes care of one of our fractions, namely, the first 1/2.

Then we cut the same square in half horizontally, to account for the second fraction. Now, mark the bottom of the square, and the left-side of the square 0, 1/2, 2/2, as shown.

This is the *most important step,* so pay careful attention: Take your two index fingers, place them both at the corner labelled zero. Move *only* the right index-finger over to the line marked 1/2, and stop! Now, move *both* index-fingers up, to the line marked 1/2, and stop. Color in the little square that your fingers covered, inside the borders of 1/2 by 1/2. Now number the squares.

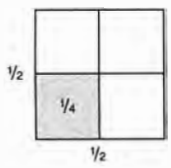




What Have We Accomplished?

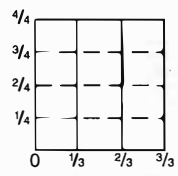
Well, we see that we started with a blank square. We divided the square in half, which gave us a square with two parts. Then we divided the square again in half, giving us a square with a total of four parts: four little squares. One of the

$1/2 \times 1/2 = 1/4$



little squares is colored in. So, we have multiplied $1/2 \times 1/2 = 1/4$.

Now, practice the above process by multiplying 2/3 times 3/4, geometrically. With this method, instead of memorizing, anyone can see what multiplying is about. And we now have the pattern to

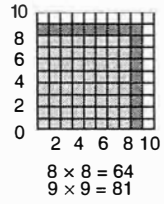


multiply *any fraction by any other fraction.* But, we have done something that also allows us to use our reason to enter philosophy and physics.

How's That Again?

Let's now tackle the idea of finding the square root of .81000. You can represent

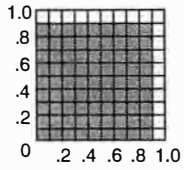
$\sqrt{.81}$



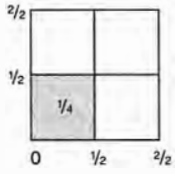
this by using the radical-and-vinculum symbol over .81000. (Yes, I know we are supposed to be answering the question of *what* is a square root, but be patient!) Now, first, what is 10 times 10? Everybody knows that it's 100. Well, let's draw that, a big square of 10 units by 10 units, which will have 100 units inside it—100 little squares.

Now, what is 8 times 8? Everybody knows that it's 64. And 9 times 9 is 81. You can see how this works in the big square, moving one index finger across the bottom (or top) of the big square, 9 squares, and the other finger starting from the same point and moving up (or down) 9 squares, and coloring in the square that this marks out.

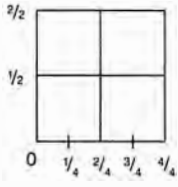
Now, we can use the same 10 × 10 grid for fractions of 1. By dividing all the



numbers on the bottom, 1, 2, 3, 4, . . . by 10, we'll have .1, .2, .3, .4, and so on. And if we do the same to the left side, counting off .1, .2, .3, .4. . . we can then find that .9 times .9 gives us .81. Voila! We have the square roots of .81 being equal to .9 times .9 (just as the square roots of 1/4 are equal to 1/2 times 1/2).



Further, we now see that square roots come in equal pairs, and are constructed as two sides of a square. And, we see that it is *impossible* to be able to construct a square, *without, at the same time, also constructing its square roots,* all four of them, taken two at a time, any way you like! But, there's also something more here.



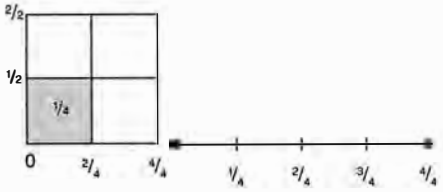
Look at the side of the square divided in half twice (1/2 times 1/2) above. Can we divide the side from 0 to 1/2 in half? Yes, this gives us the mark at 1/4. And we could go on to finish the process by dividing from 1/2 to 2/2, producing the mark for 3/4.

Now, the full weight of the conceptual difficulty arises. We had the colored-in square marked as 1/4, didn't we? But, now we have *another* marked place, 1/4. What gives? Is 1/4 equal to 1/4, or not?

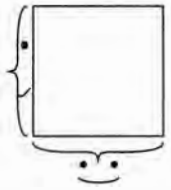
Pay Attention!

Pay careful attention here. This is where the tracking usually occurs. We have two different geometric entities: one is a square area, 1/4th of a square, and the other is a geometric line, 1/4 of a line. They both appear as parts of the same constructed square, and they are both numbered 1/4, but they are *different.* Once the *mind* grasps this distinction, the mystery vanishes and is replaced by the joy of mastering a mental process!

We can clear this up: Lines do not have square roots! But after constructing the square, we see that the *area* of the



square determines the line, which is also known as the square root. However, the line is merely a side of the square. If the distinction, between the area and the line, both labelled 1/4, is omitted from the investigation of numbers and mathematics, by the child—or by the parent, or teacher, for that matter, the math becomes mindless.



Let's look again at the first empty square. Do you see where the square roots are? They are looking back at you, smiling and laughing because you have caught them!

If you, or your child, is deprived of this, because the schools have omitted this geometry of squares from the course materials, what happens is that the student convinces herself or himself that "square roots," and all higher mathematics, is mysteriously difficult and therefore is something that only "smart people" can understand.

Does this sound familiar? Because of acts of omission, the student "brainwashes" himself, or herself, into lowered expectations. The next step, from this mathematics self-brainwashing, is "tracking" away from thinking.

THE LIFE OF CONTROVERSIAL PHYSICIST DAVID BOHM

Is There a Causality in Quantum Physics?

by Caroline Hartmann

Infinite Potential: The Life and Times of David Bohm
F. David Peat
Reading, Mass.: Addison-Wesley, 1997
Hardcover, 353 pages, $16.00

"In Berlin later that week Einstein had dined at the Grand Hotel with his old friend Fritz Kreisler, the violinist. They had been taking after-dinner drinks alone in Kreisler's rooms when Einstein recounted his discussion with Bohr. Kreisler listened carefully, then walked over to his violin case and took out his instrument, a two-hundred-year-old Stradivarius. Without any preliminary movement, he drew his bow back slowly over the E string and commenced to play the Adagio from Beethoven's Concerto in A-Minor. Kreisler played it without flourish and without excessive sweetness; the effect was a tone so pure that it wavered perfectly on the edge between the pure physics of sound waves and the magic of dreams. Einstein didn't remember its ending. But he remembered Kreisler's putting the instrument away and sitting down opposite him again.

"'Could such a thing exist in Bohr's universe,' Fritz had said softly, and placed his cognac to his lips. Both men felt that Bohr's challenge had been met and disposed of."[1]

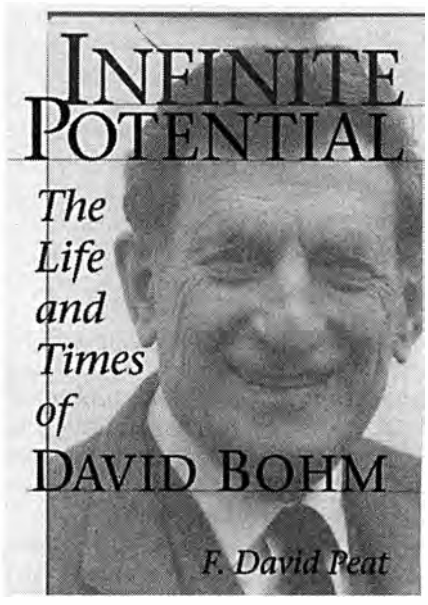
This book tells the extraordinary story of another 20th century physicist who disposed of Bohr's challenge: David Bohm. But to understand Bohm's contribution to physics, we must first set the stage:

Since the times of André-Marie Ampère, Carl Friedrich Gauss, and Wilhelm Weber, systematic research on natural phenomena like electricity or magnetism has virtually ceased to raise questions on what really happens at the level of the electron or atom. A wide gap—which opened before the turn of the century and continued to widen through both world wars—exists between those who experiment, to discover knowledge of the natural world (for example, Wilhelm Roentgen, Lise Meitner, Otto Hahn, and the Curies), and theoretical physicists like Max Planck, Albert Einstein, and Erwin Schrödinger.

Who, today, could directly collaborate, as did theoretician Gauss and experimentalist Weber, in their studies on magnetism: formulating an hypothesis on the unfolding of a phenomenon; preparing devices for targetted experiments, then brainstorming on a crucial experiment, designed to prove that hypothesis; and, finally, after many attempts, formulating a new law, which possibly supersedes current science?

Because of James Clerk Maxwell and Hermann Helmholtz's campaign against Weber (and through him, against Gauss as well), and because of Niels Bohr's arrogance in quantum physics, one cannot speak of real science today. Experimental physicists look for quarks, but they do not really know why, and mathematicians have long since locked themselves in the ivory towers of numerology or logic.

We need a modern Gauss to intervene and say that "logical means by themselves cannot perform anything and produce only sterile germs, unless the fertilizing, living view of the matter reigns everywhere."



After Planck discovered the quantization of energy transmission, the Copenhagen Interpretation of Niels Bohr, Wolfgang Pauli, and Werner Heisenberg decided on one of many possible interpretations of the data on atomic processes, and defended it with polemical and vicious attacks on all other hypotheses that might explain the phenomena.

Bohr ruled the world of physicists from his position in Copenhagen. This Copenhagen version of quantum mechanics, which today is taught as law in every university, has the disadvantage that one cannot, at the same time, determine the precise location and momentum of a particle. Heisenberg's uncertainty principle states that at the subatomic level, nature limits the accuracy of such measurements: One can have either the exact location, or the exact momentum, but not both.

Because electromagnetic beams change behavior according to the standpoint of the observer, such beams apparently behave as a wave or as a particle, depending on experimental conditions, and, therefore, according to this theory, we should forget about modelling nature. Supporters of this interpretation have consciously adopted this indifference to what really is going on in their theory.

Schrödinger, Einstein, and, above all, Planck, promoted the view that one should explain those processes from the standpoint of a *higher causality,* and that "probability theory," in which the outcome of the experiment depends on accidental factors, should not be accepted, for any reason. Schrödinger, therefore, developed his wave mechanics, in which he described the electron as a sort of matter wave, thus moving a gigantic step forward in understanding. But Bohr's brutally promoted doctrine made sure that such ideas would never be accepted or further developed by the scientific community.

Bohr fought for his doctrine with no holds barred. Although the young Heisenberg was one of his closest followers and admirers, Heisenberg was treated ruthlessly if he disagreed. Heisenberg had worked out an experiment for demonstrating his uncertainty principle. If an electron's momentum and position cannot both be defined exactly at one instant, then physicists will be unable to compute its path. He imagined an experiment to measure the exact path of an electron: An ordinary microscope, one that makes use of visible light, would be too gross to determine the position of an electron, but suppose this microscope used gamma rays of exceptionally short wavelength, Heisenberg hypothesized.

With this hypothetical microscope, it would be possible to determine the electron's position with a great degree of accuracy. But when a gamma-ray photon hits the electron, it alters its momentum in an uncontrollable and unpredictable way. The shorter the wavelength of the gamma ray, and the more accurately it determines the electron's position, the greater is its unpredictable disturbance of the electron's momentum.

With this imagined experiment, Heisenberg was able to show that any attempt to measure momentum, or position, of an elementary particle produces an uncontrollable and unpredictable disturbance. So, he concluded, does nature prevent us from ever knowing the precise value of these variables simultaneously and, consequently, the trajectory of the electron's path.

Bohr rejected the whole tenor of this example. Indeed, so forceful were his objections that they reduced Heisenberg to tears. Bohr pointed out that in setting up this mental experiment, Heisenberg had tacitly assumed that the electron actually has a path and actually possesses a precise position and momentum at each instant. Interestingly enough, Bohr, Heisenberg, and Pauli did not always agree over their own theory, which they imposed on the rest of the world!

Bohm Meets Bohr's 'Doctrine'

The work of physicist David Bohm, as told by his friend and colleague, David Peat, in this first biography of Bohm, shows, however, that the ideas of Schrödinger and Einstein and Louis de Broglie have survived despite Bohr's tyranny, and today the discussion of the reality lying behind the appearances of physics can start afresh. As in the past, there are still a few scientists who are committed to searching for truth and, especially, to learn Bohm's physics, which stands fully in the tradition of Planck, Einstein, and Schrödinger.

David Bohm was born on Dec. 20, 1917, in Wilkes-Barre, Pennsylvania, the son of Frieda Popky and Samuel Bohm. As a child, Bohm cultivated a love of elaborate speculative thoughts, and in high school, he followed the heated discussions around questions generated by Planck's discovery, as he began to make up his own mind on electron motion. When Bohm entered Caltech in Pasadena as a graduate student, he had already developed an aversion to the probability theory of the Copenhagen Interpretation.

At Caltech, Bohm learned Schrödinger's wave mechanics and developed the beginning of a theory in which electrons are wave-mass, which acquires a stable character in proximity to the nucleus. Bohr's Copenhagen Interpretation had also become orthodox teaching in American colleges, and so Bohm had countless discussions of quantum theory with his colleagues, in which he always refuted the arguments used to support this interpretation.

After finishing his studies at Caltech, Bohm went to the University of California at Berkeley, where J. Robert Oppenheimer had founded the Institute for Theoretical Physics. For 13 years, Oppenheimer was Bohm's much admired teacher. Oppenheimer came from a wealthy family and had had the opportunity to study with Max Born at Göttingen University, and to meet Heisenberg, Pauli, and Paul Dirac. Because of his charismatic style of teaching, many students gathered around him. His parties always ended with the playing of Beethoven's late string quartets, and Bohm's love of classical music, especially Mozart and Beethoven, developed from this time on.

Only later, when Oppenheimer had caused Bohm great political trouble, did Bohm think about Oppenheimer's character—how he needed the admiration of his pupils and collaborators, but was jealous of them and was more likely to exploit than to promote them.

At Berkeley, Bohm also started a friendship with Richard Feynman, who later supported Bohm's ideas and works, elaborating and using many of Bohm's ideas in his own *Lectures on Physics.*[3]

Trying to Understand Causality

Berkeley is where Bohm began his theoretical investigations of plasma, the fourth state of matter. More than 99 percent of the matter in the universe is in this fourth state, but on Earth, plasmas are artificially created in the laboratory, such as in the cyclotron, where Bohm studied them. Bohm was especially interested in the relationship between the single particle and its environment.

In 1942, Oppenheimer was appointed as the chief of the Manhattan Project and left Berkeley. In those war years, when the United States and the Soviet Union were partners against Hitler, there were many American scientists who sympathized strongly with Marxism-Leninism, in reaction to the growing anti-Semitism and the support for fascism that had developed in the 1930s among sections of the elite.

Oppenheimer also had close contacts with Communist groups. (His wife and his lover were both active members of the Communist Party, and he belonged to party-associated organizations.) When these ties were discovered, therefore, Oppenheimer was subjected to

long interrogations and hearings with the security department of the Manhattan Project. But, instead of being honest about actual individuals with ties to the Communist Party, he lied about idealistic students and colleagues who were simply interested in social justice and sympathized with Marxism. He mistakenly thought that this great openness would protect him, but instead it created enormous problems for Bohm and others.

Oppenheimer's alleged naiveté is presented in a different light in the 1994 publication of the book by Pavel and Anatoli Sudoplatov: *Special Tasks: The Memoirs of an Unwanted Witness—A Soviet Spymaster.* There, Oppenheimer is named as one of the leading figures who functioned (together with Pauli and Bohr) as decisive informants on the development of the atomic bomb for the Soviets.

Because of Oppenheimer's statement that Bohm was "dangerous," Bohm—who belonged to the Communist Party for nine months before dropping out in disgust—also came under scrutiny by the intelligence service. Many scientists were dismissed after 1943, or held back from responsible teaching jobs. Bohm, who had started teaching in 1942, when Oppenheimer left (and who was remembered by his students for his very lively teaching style), was increasingly isolated at Berkeley. Finally, in the 1950s, he was put under pressure by hearings and around-the-clock surveillance.

The Princeton Years

Some years later, thanks to Einstein's former assistant John Wheeler, Bohm obtained a job at the Institute for Advanced Studies in Princeton, where Wheeler himself was working. Supported by Wheeler, Bohm began to distance himself from the general thinking and usual teaching methods of other physicists. He connected general physical questions to philosophical thoughts, something that gained him the reputation of being a little crazy.

Students were used to lectures in which the professor talked 10 minutes about the problem he wanted to present, and then they had to take out their notebooks, because for the rest of the time he would stand at the blackboard writing down mathematical formulas and equations. But Bohm was totally different. In his first lectures he would start to talk 20 minutes; then it became 30, and 40 . . . until in the last 10 minutes the students would realize with terror that he wasn't going to write any equations on the blackboard!

It was already common practice not to ask questions about the reasons for plausible ways of describing occurrences in nature, especially not for a higher sufficient cause. Bohm vehemently attacked this standpoint or attitude. When the mathematician John von Neumann, who was a big defender of Bohr's "physics by chance," the so-called probability calculus, once suggested that physics is organized like a church, Bohm replied that Bohr would then be the Pope, and von Neumann fancied himself as one of the cardinals!

Many students joined Bohm's lectures, however, exactly for this reason: that he asked questions about the causes that might lie behind phenomena.

At Princeton, Bohm wrote his first important book, *Quantum Theory,* which was published in 1951. In this work, he tried to make the Copenhagen explanation of quantum mechanics clearer and more plausible. Einstein was present at the seminar in which Bohm gave the first presentation of his book, and the most important reaction came from him. He told Bohm that he described his view very clearly, but that he, Einstein, still could not agree with this thinking. After the seminar, Einstein invited Bohm to visit him in his office. There he explained his doubts about the Copenhagen Interpretation, and he strenuously defended the principle of a higher causality in nature! Only then did Bohm become totally aware of his own inconsistencies.

Einstein later called Bohm his "intellectual son," and whenever the question was raised of whether someone could find a new interpretation of quantum physics, Einstein would say: "If somebody can, that is Bohm."

The Hypothesis of 'Nonlocality'

After this discussion with Einstein, Bohm made a decisive change in his work. Until then he had always tried to find a causal explanation for the existing quantum mechanics. But now, he acknowledged its total incompatibility with the truth. Truth cannot be described by accidents, or by counting probabilities—even if they seem to be totally exact.

This problem is similar to the method often used by Nicholas of Cusa, the "squaring of the circle." Actually, the very term "squaring of the circle" is ambiguous. It is impossible to construct the circumference of a circle in a "linear" or "algebraic" way. The reason for this impossibility, and the solution to the problem, is described by Cusa in his work *De Circuli Quadratura.*[4]

In fact, the inscribed and circumscribed polygons, as they approach more and more closely the circumference of the circle, have a greater and greater number of edges, and thus the polygons move further and further away from the idea of a circle (Figure 1). This is a paradox: As the sides of the polygon are further divided, the inscribed and circumscribed polygons approximate the circumference of the circle more closely, but, at the same time, they move away from the conception of the circle, which is *curved,* even in any arbitrarily small part of it.

Bohm, at this point, began to develop his own interpretation of the quantum processes. He started from Schrö-dinger's wave equation, and talked for the first time about his idea of the principle of "nonlocality" in nature, the idea that distant objects are correlated instantaneously: Quantum processes, he said, include the fact, that the world functions as an indivisible unit, in which even the characteristic nature of each single part (be it wave or particle) depends on its relationship to its neighborhood.

The effects of Bohm's quantum potential do not fall off with distance. The effect of the field depends not upon its strength but upon its "form," which means that quite distant objects can still affect each other. In other words, even distant parts of quantum systems are intimately linked through the quantum potential.

Like Einstein, Bohm was clear about the fact, that Newton's mechanics collapse on the quantum level, and that science needs a new description of the processes. But it doesn't work in the way Einstein had thought, which is expressed in the EPR paradox. (EPR stands for Einstein, Boris Podolsky, Nathan Rosen.) The EPR thought experiment *unsuccessfully* attempted to prove that the transmission of information between particles can function only through the transmission of radiation.

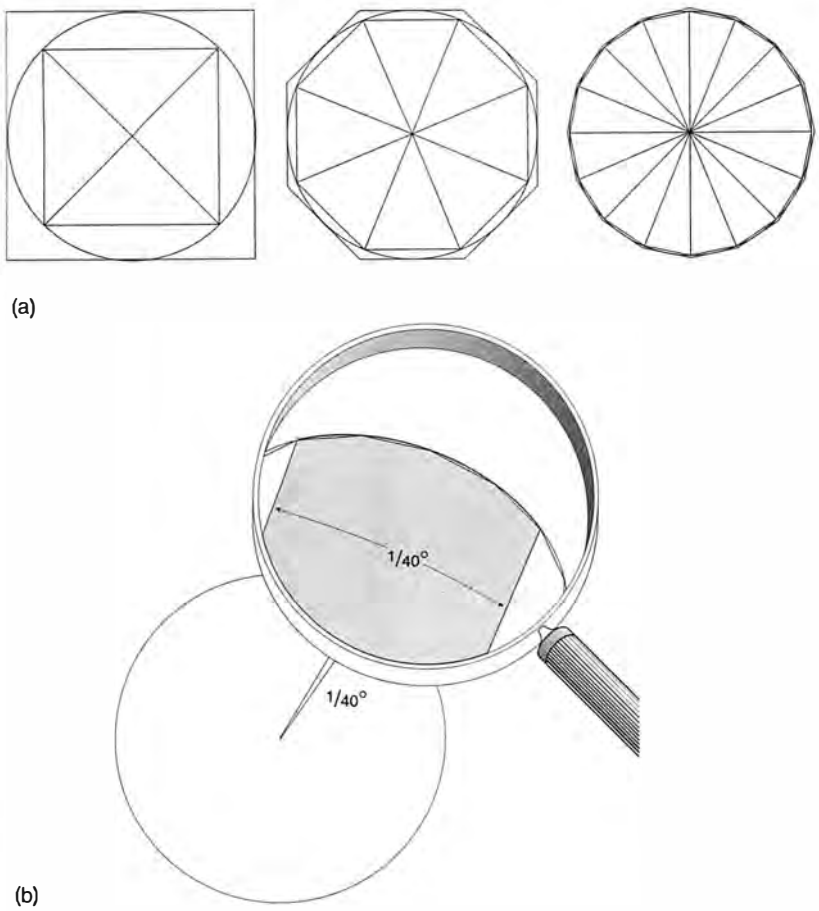


Figure 1
SQUARING THE CIRCLE

The more you try to make a polygon take on the shape of a circle (a), the more it becomes less like the circle. And no matter how much more closely the inscribed polygons seem to resemble the circle, the circle remains curved in any arbitrarily small part (b).

Bohm's hypothesis of nonlocality states that there is a simultaneity of reactions from one particle to another, without the transmission of light; activities are nonlocally influenced by a higher lawfulness, which is not dependent on the distance between the particles.

In 1952, Bohm published his new ideas in a two-part *Physical Review* article, "A Suggested Interpretation of the Quantum Theory in Terms of Hidden Variables."[5] The reactions from physicist circles, for instance from the supporters of the Copenhagen Interpretation, were skeptical. Bohm commented on this in a letter to Einstein, whom he thanked for his help: "It may interest you to know that Pauli has admitted the logical consistency of my interpretation of the quantum theory in a letter, but still rejects the philosophy. He states that he does not believe in a theory that permits us even to conceive of a distinction between the observer's brain and the rest of the world."[6]

With the exception of a very interested reaction from the young physicist Richard Feynman, the physics community remained silent. Even de Broglie, in the scientific publication *Comptes Rendus*, simply repeated the doubts expressed by Pauli.

Oppenheimer's reaction to Bohm's work was similarly negative. Although he admitted to not having read the *Physical Review* papers on hidden variables, he characterized Bohm's theory as "juvenile deviationism" and even stated, "If we cannot disprove Bohm, then we must agree to ignore him."[7]

Such ignorance made Bohm furious, but he "had a passionate desire to fight this stupefying spirit of formalism, and pragmatism in physics," that insisted on immediate, practical results.[8] Bohm said that although others took 20 years to produce results, he alone was "supposed in a year or two to produce a scientific revolution comparable to that of Newton, Einstein, Schrödinger, and Dirac all rolled into one."[9]

Regarding the Princeton Institute, where Oppenheimer was active again, Bohm wrote: "As for Pais and the rest of the 'Princetitute' what those little farts think is of no consequence to me. In the past 6 years, almost no work at all has come out of that place. . . . I am convinced that I am on the right track."[10]

Later, de Broglie changed his mind about Bohm. When his assistant, Jean-Paul Vigier, reported to him on a lecture given by George Yevick on Bohm's theory in Paris, de Broglie was so excited and happy about it, that he sent Vigier to Bohm in Brazil to find out what was going on. A few years later, when Bohm was invited to the Technion Institute in Israel, he spent three weeks in Europe with de Broglie and Vigier; later, when he left Israel, he was offered a professorship by de Broglie in Paris.

During this European trip, Bohm met the young physicist John Bell, who was also concerned with the problem of how causality should be understood in quantum physics. Bell used Bohm's work on hidden variables to develop his "Bell Theorem," in which he proves that there are no "independent elements of reality," as posited by Einstein's EPR paradox, which states that observing one of two correlated but widely separated particles would have no effect on the second. Rather, Bell said, quantum mechanics is inherently nonlocal and outside classical limitations. Such nonlocality challenges everything in classical mechanics.

In his position as theoretical physicist at the Birkbeck College in London, where he worked for the rest of his life, Bohm occupied himself with plasma processes. Above all, he constantly dealt with the question of how, out of a seemingly chaotic and complex state, an ordered state is suddenly produced, as is the case with plasmas. He also started to develop thoughts on the motion of elec-

Bohm, Eddington, and the Devil

When Bohm was in his first year at Caltech, he came across Arthur Eddington's *Relativity Theory of Protons and Electrons,* written in 1936, which "offered a unified theory that linked relativity to the world of elementary particles." As Peat tells it, Bohm was initially attracted to this "all embracing theory of the universe," but it was "so highly mathematical" that he had to struggle to understand the theory. When a professor dismissed Bohm's attempt to understand Eddington, saying that "no one really understood Eddington, and anyway it was not at all clear that there was anything to his theory," Bohm and a friend wrote a satirical story about Eddington. As Peat describes the story:

"It took as its starting point Eddington's dramatic claim that he could deduce the nature of reality unambiguously from epistemological considerations alone. This caused such concern in Hell that the Devil paid a visit to Eddington and made an offer for the scientist's soul. The Devil was generous, proposing money, power, and women.

"Eddington refused, which came as a great surprise to the Devil, for 'most scientists will sell their soul for something smaller, like a navy contract. We're offering you the whole works and still you won't sell. Can you at least explain yourself?'

"Eddington replied that he had deduced the nature of the universe unambiguously on epistemological grounds alone—if he wanted anything he could have it.

"At this the Devil admitted that he did not understand Eddington's book. 'I have had my best scientists working on it, and they can't understand it. It is very urgent that I should understand the nature of reality in God's world.' He asked Eddington to explain the meaning of his book. So insistent was the Devil that he finally offered the scientist his own soul. Eddington agreed. And so, Bohm concluded, if you want to understand Eddington's theory, you can go to the Devil."

F. D. Peat, *Infinite Potential: The Life and Times of David Bohm,* pp. 37-38.© F. David Peat. Reprinted by permission of Addison Wesley Longman.

trons, and he abandoned the belief in time and space as absolute coordinates, in which all other things develop; on the contrary, time and space are produced out of the activity of matter, under the influence of natural laws. Such an activity existed before time and space.

In this context, Bohm attacked Cartesian, three-dimensional ordering, and pointed to the fact that both Newton's physics and Einstein's relativity theory are based on the same assumption: that is, a continuous, three-dimensional space. However, Bohm said, this Cartesian approach is irreconcilable with the discoveries made in quantum physics. Bohm realized that we need a completely new theory, instead of the Copenhagen Interpretation, which merely poured the new quantum wine into the old bottles of Cartesian three-dimensional ordering.

Bohm's reflections and works were theoretical, not experimental. Even if he developed ideas on how better experiments could be done within quantum physics, conditions at universities did not allow theoretical physicists a direct access to the practical sphere, where they could organize their own experiments.

The Political Witch-hunt

In the 1930s and 1940s, political conditions in the United States were polarized in the extreme. On one side, anti-Semites and Hitler fans received a wide audience; for instance, Father Coughlin's radio broadcasts, in which he raved against "Jewish bankers," the New Deal, and communists, were listened to by 5 million people in 1934, and some said that he was "more popular than the President."

On the other side, many of those who felt threatened, including David Bohm, turned to Marxist-Leninist propaganda. Bohm tried to reconcile the ideas of dialectical materialism with his physical ideas, and saw through them a possibility of improving the life of mankind. He attacked bourgeois society, as accepting only what is fixed or changing very little.

The House Un-American Activities Committee was not an honest effort, but an operation to induce terror in the American people, and to destroy the lives of those whom it smeared—regardless of "guilt" or "innocence"—including many scientists.

After Oppenheimer's statements before the security investigation in Los Alamos, Bohm was constantly under surveillance; he was photographed, and even filmed. In May 1949, Bohm was subjected to a series of interrogations, in which he refused to give information on his friends at Berkeley, who were suspected of passing information on the atomic bomb to the Soviets. Because of his silence, Bohm was eventually indicted for contempt of Congress, along with 56 other defendants.

On Dec. 4, 1949, Bohm was arrested in his Princeton office, and was freed only after paying $1,500 in bail. The bitterest surprise was waiting for him: Princeton's new president, Harold W. Dodds, released a statement barring him from teaching, or even setting foot on campus, for the duration of the trial.

Nearly two years later, Bohm was acquitted on all counts on May 31, 1951. Yet, despite his acquittal, and despite the fact that many students openly sided with Bohm, Princeton University refused to reinstate him, and the FBI continued to keep him under surveillance. Attempts of friends to find Bohm a new position were also thwarted by this political taint. The constant psychological pressure and inability to teach hit Bohm particularly hard, and he seriously considered leaving America.

Finally, in October 1951, after the general political situation in the United States had become even more tense, Bohm decided to go to Brazil to head a university physics department. But things did not improve for him. A few weeks after his arrival, his passport was withdrawn under some pretext, and he was told he could have it back only when he

AP/Wide World Photos

David Bohm (right) entering the Un-American Activities Committee hearing room in Washington in May 1949, where he refused to answer the committee's question of whether he was then or ever had been a Communist.

decided to return to the United States. Furthermore, surveillance went on in Brazil as well.

These developments increased Bohm's bitterness toward the United States, which he thought was moving toward fascism. He continued to work in Brazil until spring 1955, when he accepted an offer from Israel. But in order to be able to travel to Israel, he had to become a Brazilian citizen to gain a passport. Years later, when he applied for a visa to visit his dying father in the United States, he discovered that he had lost his American citizenship, and he had to travel on a tourist visa with a waiver as a former member of the Communist Party. (His U.S. citizenship was restored retroactively in the 1980s, however, because its loss had never been valid.)

In Israel, Bohm met his future wife Saral Woolfson, and in 1957, he moved with her to England, to take a position as research assistant at Bristol University. Later, he became chairman of theoretical physics at Birkbeck College of the University of London, where he worked until his death on Oct. 27, 1992.

In London, Bohm fell prey to cultist New Age circles. He developed a fascination for the teachings of Indian Guru Jiddu Krishnamurti, who had been promoted by the Theosophical Society's Madame Blavatsky and Annie Besant as the coming "world teacher." In his autobiography, Bohm seems unaware of the mystical-Satanist connections of these circles.

Bohm had many philosophical discussions with Krishnamurti, and became a co-founder of a school for his teachings, where Bohm and his wife spent many weekends. It is possible that Krishnamurti, who after the war needed a new "image," saw in Bohm somebody whose ideas he could exploit. This impression is confirmed by the fact that, when a book was made from audiotapes of Krishnamurti's discussions with Bohm, Krishnamurti decided not to publish it, because Bohm did most of the talking!

Bohm's work in physics, however, was influenced by these contacts, for he never again did fundamental work in quantum physics. As his close collaborator Basil Hiley commented, Bohm was always open to new ideas and willing to talk with people, and therefore often had to be rescued from idiots. Even the Israeli magician Uri Geller, who claimed to bend spoons with his mental power, once attracted Bohm.

Despite his New Age connections, David Bohm remains important in any future discussions of quantum physics and the role of causality, most especially because of his hypothesis of nonlocality. After the death of Einstein and de Broglie, who had recognized Bohm's talent and showed the courage to work with him and accept his ideas, Bohm was virtually in isolation. Nevertheless, his teaching method has been decisive in the education of several good physicists today.

In this light, the biography of Bohm by F. David Peat, *Infinite Potential,* has the ability to disturb the "peace of the graves" reigning on today's campuses.

Notes

1. From *A Family Matter* by James Roosevelt. Copyright © 1980 by James Roosevelt and Sam Toporoff. Reprinted by permission of Simon and Schuster.
2. Carl Friedrich Gauss, *Gesammelte Werke IV,* p. 366.
3. Richard Feynman, *The Feynman Lectures on Physics.* Vol. 3 (Redwood City, Calif.: Addison-Wesley, 1989).
4. In short, the method works as follows: Inscribe a square in a circle. Inscribe this circle in another square. Double the sides of each square, so as to originate two regular octagons, which have the same relationship to the circle as the two squares. Repeat the doubling until a number of sides equals 2 to the n power. Consider that section of the circle, defined by three sides of the many-sided, inscribed polygon (Figure 1a). Through the calculation of the surface of both polygons, the inscribed as well as the circumscribed one, and by establishing the average between the two, we obtain more or less the surface of the circle; but the surface of either of the many-sided polygons can never correspond to the one of the circle.
5. David Bohm, "A Suggested Interpretation of the Quantum Theory in Terms of Hidden Variables I," *Physical Review,* Vol. 185, pp. 166-179 (1952); "A Suggested Interpretation of the Quantum Theory in Terms of Hidden Variables II," *Physical Review,* Vol. 185, pp. 180-193 (1952).
6. David Bohm, undated letter to Einstein, probably December 1951, quoted in *Infinite Potential,* pp. 116-117.
7. Max Dresden, remarks from the floor at the American Physical Society Meeting, Washington, May 1989. Quoted in *Infinite Potential,* p. 133.
8. David Bohm, letter to Miriam Yevick, Jan. 9, 1952. Quoted in *Infinite Potential,* p. 130.
9. David Bohm, letter to Miriam Yevick, Jan. 13, 1952. Quoted in *Infinite Potential,* p. 131.
10. David Bohm, letter to Miriam Yevick, n.d. Quoted in *Infinite Potential,* p. 134.

Will Science Discover Life on Mars?

by Marsha Freeman

Mars: The Living Planet
Barry E. DiGregorio
Berkeley, Calif.: Frog, Ltd., 1997
Hardcover, 365 pages, $25.00

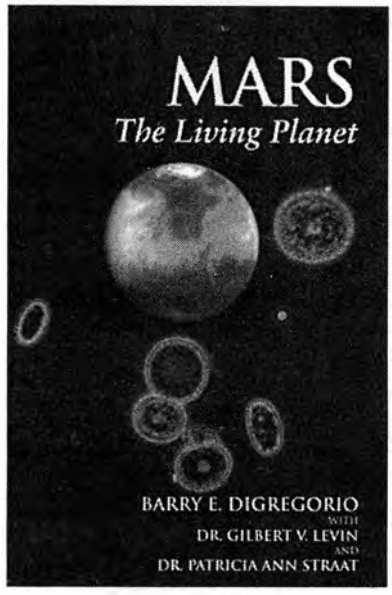
A longstanding example of the deterioration of a commitment in science to the search for truth, is the case of Dr. Gilbert Levin and his main collaborator, Dr. Patricia Ann Straat, regarding the results obtained from an experiment they built and flew on the 1970s Viking missions to Mars. Of the three principal instruments aboard the two Viking landers, which had the mission to search for life on the red planet, theirs was the only one that indicated evidence of extant microbial life on Mars. Evidence, author Barry DiGregorio points out—not proof.

But with *any* evidence, one would expect to see great interest in a plan for an additional series of experiments, to prove, disprove, or, at least, to add evidence to the question of whether there is life on Mars. However, life science experiments have not even been included in the current series of U.S. missions to Mars.

That only one of the three life-seeking instruments aboard Viking should show evidence of life stumped the scientists. Alternative theories involving chemical and other non-biological agents were developed to try to account for the data received from Levin's Labeled Release experiment. It is certainly necessary to question results, and play devil's advocate to try to find any flaws or misinterpretations in an experiment. But 20 years later, after Levin has tried to reproduce in the laboratory the results his instrument produced on Mars, using the chemical and other agents that the scientific community insisted must be responsible for his results, he has been unable to find anything other than life that could account for the data his experiment on Mars sent back to Earth.

Does this mean there is life on Mars? Perhaps.

Does the fact that there was not unanimous agreement among all of the instruments that there is life on Mars mean



that the Viking mission found *no* life on Mars? One would not think so, but that is the way the history has been written, for two decades.

Will Scientists Reconsider?

DiGregorio's book provides the details of the Viking experiments, Gil Levin's background, his scientific work before and after Viking, and the reactions to the results of his experiment.

The author's impressive review of the recent discoveries that bear on Levin's views, strengthen the case that there may indeed be life on Mars. Whether or not those who have made the absolute statement in the past that there is no life on Mars are now willing to keep an open mind, will be a test of the integrity of the scientific community. In the past two years, additional evidence that there *has been* life on Mars in the past, and that life can and does exist in environments on Earth that are as extreme as today's environment on Mars, has added grist to Levin's mill.

One of the results from the Viking experiments that baffled scientists looking for life, was the lack of evidence of any organic material on the surface of Mars. DiGregorio reviews the problems that existed with the instruments that were deployed to find organics on Mars, and the fact that there are questions about their sensitivity.

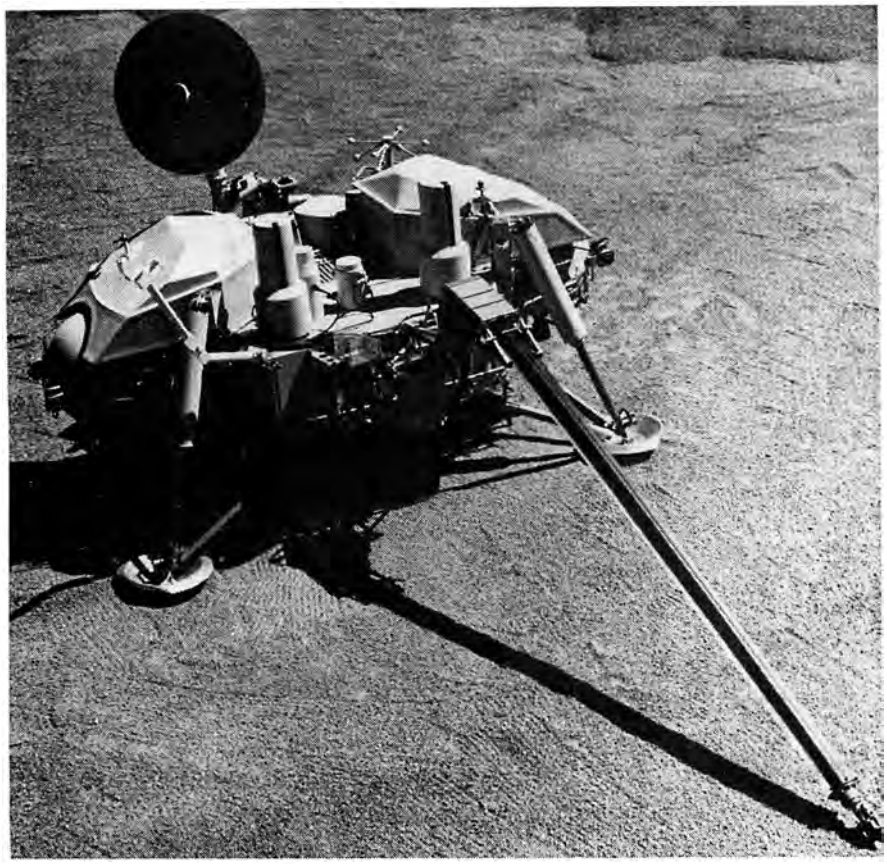
In addition, Levin points out in a paper he presented in July 1997, at the conference of the International Society for Optical Engineering, that an examination of Mars meteorite EETA79001, found that it contains not only organic material, but chiral (or "handed," as in left- or right-handed) amino acids, a characteristic only of biological material.

Most people are aware that in August 1996, scientists announced that they believed they had found evidence of remains of microbial life in Mars meteorite ALH84001. But the materials in that meteorite are estimated to be 3.5 billion years old, when, most scientists would agree, Mars's environment was warm and wet, and, like the Earth's, conducive to the development of life.

EETA79001, however, is only 600,000 years old. If life developed then, at a time when most scientists believe Mars's climate would have already evolved to the cold, relatively dry planet it is today, Levin argues, it would mean that life was able to adapt to conditions on Mars comparable to those existing at the present time. It is, therefore, possible, that the life that existed on Mars 600,000 years ago, exists there today.

Detective work over the past few years, across numerous scientific disciplines, has broadened scientists' view of what extreme conditions can be tolerated by microbial life on Earth. DiGregorio does an impressive job in this book of summarizing a vast array of data on the existence of life in extreme environments, comparing them to the conditions that life would face today on Mars.

For example, rather than being a dead planet, could there be life in the lakes and rivers underneath the surface of Mars? Recent images from the Galileo spacecraft have led scientists to propose that there may well be liquid water under the ice surface of as faraway a place as the Jovian moon, Europa. But, one could argue, no organisms have been found on Earth that could exist without dependence upon organic material.



NASA

This full-size working model of the Viking Mars lander, at the Jet Propulsion Laboratory, shows the long arm of the soil sampler extended. On Mars, the arm scooped up samples of soil and delivered them to the three scientific experiments that were designed to look for life. Only Dr. Levin's experiment produced a positive response.

New Evidence

That appeared to be true until 1995, when Drs. Todd Stevens and James McKinley, from Pacific Northwest Laboratory in Richland, Washington, reported that at a depth of 1,500 meters, in the groundwater in Columbia River basalt aquifers, they discovered anaerobic bacteria living on nothing but the basalt rock and oxygen-free water. No photosynthesis or other organic material was required.

These rock-eating bacteria were named Subsurface Lithoautotrophic Microbial Systems, meaning an organism that manufactures organic nutrients from inorganic substances, such as volcanic basalt rock. According to DiGregorio, Stevens stated that the Viking life science experiments would not have been able to detect such life forms, if they exist, on Mars.

Another example is the case of radiation. The accepted belief is, that with no ozone shield, the surface of Mars is exposed to levels of ultraviolet radiation that would be lethal to all life forms. But, in *Mars: The Living Planet,* the author reports on a variety of methods that organisms have developed to protect themselves from ultraviolet radiation on Earth, including incapsulation in water, and biomineralization, where the incorporation of a small particle of iron, produced by the organism, protects it from ultraviolet light. It has also been shown that snow algae store dust and metals within their cell structure to use as nutrients, and as protection against solar ultraviolet.

DiGregorio reports that noted exobiologist Dr. Christopher McKay (an interview with McKay appeared in the Summer 1992 issue of *21st Century*) does not believe that in the end, cosmic rays or ultraviolet radiation would preclude the development of life, because organisms can bury themselves underground. McKay does think, however, that the radioactive decay of materials intrinsic to the soil would "do them in."

DiGregorio reports that in 1989, a radiation-resistant microorganism, known as Deiococcus radiodurans, was discovered living inside the core of the Three Mile Island nuclear reactor. These cells survive by producing enzymes that repair their DNA, doing "constant damage control," as they are metabolizing.

Many other fascinating examples of the existence of life in extreme environments on Earth are cited in this book. That there is life in numerous places on the Earth that were believed to be sterile, should surely cause scientists to revisit the question of whether or not there could be life on Mars.

Crucial Experiments

Gilbert Levin has proposed crucial experiments for the upcoming NASA unmanned Mars landers that could, if not answer the question, certainly add to our knowledge of the subject. One clever experiment, to use the chirality of living systems to distinguish biological from chemical reactions in the soil, was included on the Russian Mars '96 mission, which, unfortunately, failed before it left Earth orbit.

NASA is planning to send pairs of spacecraft to Mars in each 26-month launch opportunity over the next decade. Gil Levin has proposed specific life sciences experiments, which could be incorporated into the landers that are now being prepared. So far, his suggestions have gone unheeded.

Although DiGregorio tends to blame a conspiracy in NASA against Levin's work, numerous other examples of the same cultural pessimism and corruption of the scientific search for truth unfortunately make this phenomenon much more widespread than one government agency, or one discipline of science.

It can be hoped that the scientific community is at least curious enough to want to answer the question of whether or not there is life on Mars as definitively as possible, before human beings can go to search, in person. One important reason to do so, Levin and Barry DeGregorio insist, is to make sure the necessary precautions are taken before any material from Mars is brought back to the Earth, if it should be found that there are living organisms there.

Finding life on Mars would certainly be one of the most profound discoveries of science.

Was There Life on Mars?

Martian Fossils on Earth? The Story of Meteorite ALH 84001
Fred Bortz
Brookfield, Conn: The Millbrook Press, 1997
Hardcover, 64 pages, $21.40
Juvenile, ages 10 and up

When scientists announced at a press conference in Washington, D.C., on Aug. 8, 1996, that they believed a meteorite from Mars harbored remains of primitive life, science writers had their work cut out for them:

There was no "smoking gun." The scientists readily admitted that the complex clues they had found were only indirect evidence that there had been life on Mars. Other scientists disputed their interpretation that living organisms had produced what they had found. Writers struggled to understand what the scientists had presented, and to neither underplay nor sensationalize the announcement.

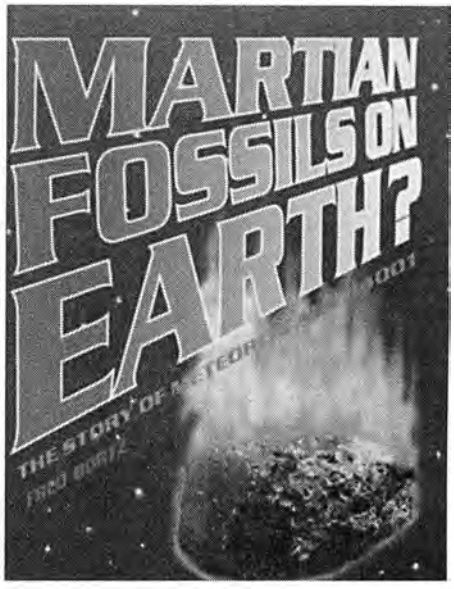
To accomplish such a task for young readers is a tall order, but Fred Bortz succeeds in conveying the excitement of the scientists, as well as the data they presented, in an engaging and descriptive way, while emphasizing that there are now more questions to answer than before.

Difficult concepts, such as the chemicals and crystals in the meteorite, which scientists propose are organic in origin, are made clearer through the use of photographs from this particular research, and similar phenomena that Bortz cites, and through the use of diagrams.

The first chapter of the book, "Why are scientists so excited about a rock?" is characteristic of the tone of the entire work. It begins: "Because scientists love the excitement of discovery, they sometimes love the search for answers even more than the answers themselves. That is why they are so excited about a rock."

This book deals with a work in progress, a scientific puzzle that may not be definitively sorted out in our laboratories on Earth, but only when people actually go to Mars.

The last chapter of the book summarizes the upcoming unmanned missions to Mars, and ends: "Chances are excellent that many of the young people reading this book—perhaps you—will compete for the opportunity to live on Mars for a year or more. If you go, you and your fellow pioneers will arrive on Mars loaded with questions. You will return home, like all the scientists and explorers before you, with many more."



For adults who did not take the time to grasp what David McKay and his team of scientists were presenting in their study of Martian meteorite ALH 84001, this book will provide a good refresher course. For young readers, Fred Bortz has presented a comprehensive look at a fascinating discovery, that is just beginning.

The only drawback to this book is its high price. If that cost is a deterrent to purchasing it for a young reader, this is a book worth a trip to the library.

—Marsha Freeman

Big Lies for Little People

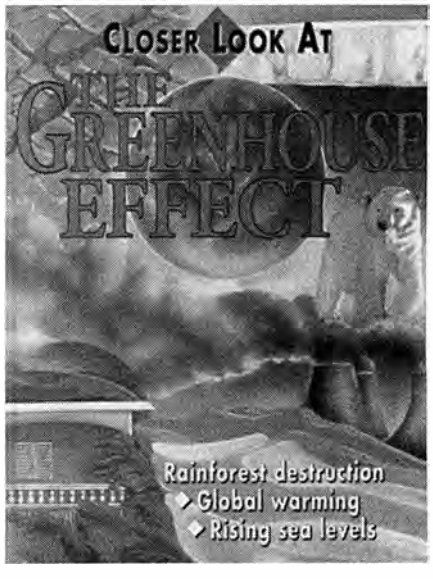
Closer Look at the Greenhouse Effect
Alex Edmonds
Brookfield, Conn.: Copper Beech Books
Hardcover, 32 pp., $19.90

It should be no surprise that today's environmental books for children, in this case, 9 to 11 year olds, convey the same disinformation as environmental books for adults. This book, first published in England by Alladin Books Ltd., is no exception. The overall message is one of impending danger caused by profligate human beings.

For example, on page 9, there is a box illustrated by two warring dinosaurs, one goring the other. The text reads: "Fragile lives. Why do we continue to risk disrupting the climate if climate changes can have drastic effects on life? The dinosaurs died out 65 million years ago due to a major natural change on the planet—possibly a climate change."

Like other journalistic coverage of issues, not all the information presented is wrong, but the context in which "facts" are presented, combined with gross omissions, make the total presentation into a big lie.

Equally appalling is the style. Instead of a continuous narrative, each two-



Kyoto Protocol

Continued from page 83

selling these low-tech systems will be like selling snake oil.

But what makes these so-called renewable systems non-competitive is not just the price of oil, but the fact that they are dispersed, non-dense sources of energy, that per pound and per square meter produce less energy than today's coal-fired or nuclear power plants.

If the President would take the $2.7 billion he is allocating for new energy technologies, and deploy it to finish the engineering work and then commercial development of a technology such as magnetohydrodynamics, each ton of coal that is burned could produce twice as much electricity, (and no pollutants) as today's coal-fired plants.

Were some of those funds also used to commercially develop next-generation nuclear systems, such as high-temperature nuclear reactors, the efficiency, maintenance, industrial applications, and lifespan of nuclear energy systems would be improved.

page spread is stuffed with five or six separate items, each item illustrated (in color, of course), and each with a different size or style of type. Perhaps the idea is to simulate moving images on a television screen or a video, but this dizzying array of items could not possibly help a child's concentration.

The book ends by telling the reader "Read all that you can about the subject to get a balanced view," but on the same page, presents its own off-balance conclusion. Under the title "To sum it all up," the author states: "The greenhouse effect is an important part of the Earth's natural balance, so we must learn how to avoid disrupting it. We should look toward using renewable energy sources for the future—ones that work in harmony with the Earth, not against it."

—Marjorie Mazel Hecht

"It happened in Kyoto, son, to get us ready for global warming."

If some of the money allocated for the promotion of fuel-efficient automobiles were deployed to design and build magnetically levitated transportation systems, the most efficient and only universal form of energy, electricity, would begin to entirely *replace* liquid fuels in passenger transport.

Every federal dollar wasted on promoting low-technology, pre-industrial energy systems takes resources away from the technologies for the next century that, rather than being a drain on the economy, would increase the efficiency and productivity of all of our economic activity.

Not Much Fight

There have been only a few lone voices at the hearings to question the assumptions that underlie the Protocol negotiated last December in Japan—that human economic activity is producing emissions that are, in turn, warming up the planet. There is no evidence to support such a contention. Actually, geological and astronomical evidence points to the near-term start of a new ice age.

At a hearing before the House Committee on Science held on Feb. 5, Rep. Roscoe Bartlett (R-Md.) was the sole voice to question the assumptions. "As a scientist," he said, "I'm not convinced that we are facing disaster." He reminded those present that 20 years ago, he was being told by scientists that we were facing a new ice age, and "the data have not changed."

At the same hearing, Constance Holmes, testifying for the Global Climate Coalition (GCC), included in her written statement a summary of the scientific opposition to global warming, with quotes from a wide variety of experts on the uncertainty of the science. But at the beginning of her remarks, representing the views of more than 230,000 companies in manufacturing, agriculture, transportation, energy, electric utilities, and mining, Holmes stated that "the members of the GCC accept that potential human climate change is a serious concern that needs to be addressed. The issue is not action versus no action. The issue is what constitutes responsible action. . . ."

Holmes said the proposed treaty will not be effective in slowing global warming, and documented the expected "dismantling of the U.S. economy," to meet the Kyoto goals. She urged the members of the committee that the U.S. should "set aside the Kyoto Protocol and start over."

Despite the fact that her proposal called for a "return to the science," when asked what action she would support to reduce so-called "greenhouse gases," Holmes abandoned her call for "starting over," and said it should be done "at the pace the economy can afford."

Although some congressional representatives have said that the "science" behind global warming, is "not sound," they have been unwilling to fight the Kyoto Protocol on that basis, but instead quibble with Administration witnesses over details. Many have been suckered by the idea—staunchly defended by environmentalists trying to rally support for their unpopular global warming program—that even if, years from now, it turns out that there is no global warming, the "no regrets" policy they are proposing will be good for the nation, anyway.

This is a lie. There is no such thing as a "no regrets" Kyoto program.

BOOKS RECEIVED

A Science Odyssey—100 Years of Discovery, by Charles Flowers. Companion to the PBS Series. New York: William Morrow, 1998. Hardcover, 316 pages, $30.00.

The Fusion Quest, by T. Kenneth Fowler. Baltimore: Johns Hopkins University Press, 1997. Cloth, 250 pages, $29.95.

Mining the Sky—Untold Riches from the Asteroids, Comets, and Planets, by John S. Lewis. Reading, Mass.: Addison-Wesley, 1997. Paperback, 274 pages, $14.00.

The Manic Sun—Weather Theories Confounded, by Nigel Calder. London: Pilkington Press, 1997. Hardcover, 211 pages, £24.95.

Cosmic Winds and the Heliosphere, edited by J.R. Jokipii, C.P. Sonett and M.S. Giampapa. Tucson: University of Arizona Press, 1997. Hardcover, 1013 pages, $100.

The Planet Mars—A History of Observation and Discovery, by William Sheehan. Tucson: University of Arizona Press, 1996. Paperback, 270 pages, $19.95.

Puzzling Questions About the Solar System, by Martin Gardner. Mineola, N.Y.: Dover, 1997. Paperback, 96 pages, $4.95. Reprint.

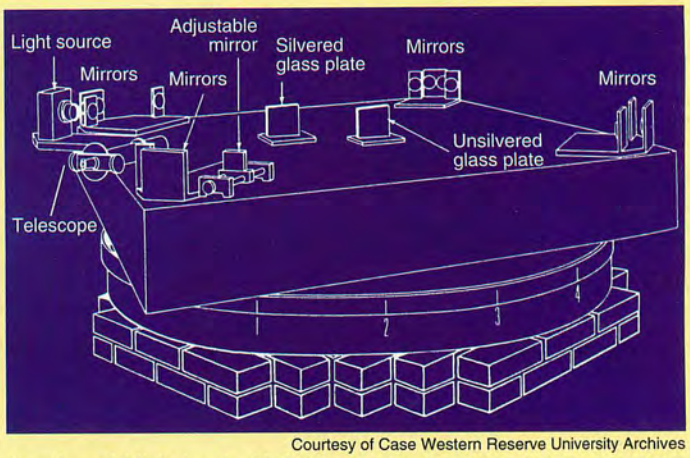
Principles of Geoarchaeology—A North American Perspective, by Michael R. Waters. Tucson: University of Arizona Press, 1996. Paperback, 398 pages, $24.95.

In This Issue:

UNCOVERING THE COVERUP: THE TRUTH ABOUT MICHELSON-MORLEY-MILLER

The startling truth about the Michelson-Morley interferometer experiments is that the results were not null. Further, Nobel Laureate Maurice Allais reveals, the follow-up interferometer experiments of the American scientist Dayton C. Miller produced *positive* results, thereby invalidating the foundation of the Theory of Relativity. As Allais notes, that Miller's findings have been ignored for 65 years is "one of the scandals of contemporary physics."

An accompanying historical article by Associate Editor Laurence Hecht sets the stage for understanding the significance of the ether drift measurements, reviewing the discoveries of Augustin Fresnel on the wave theory of light and the subsequent development of these ideas in the 19th and 20th centuries.



Courtesy of Case Western Reserve University Archives

Drawing of Michelson's 1887 interferometer, designed to detect the motion of the Earth through the ether by measuring the interference of light waves travelling in the direction of the Earth's orbit, and travelling in the perpendicular direction. *For details, see pp. 39-43.*

Sea Launch

THE REAL CHERNOBYL CASUALTIES: VICTIMS OF FEAR

Fear, not radiation, has claimed the most victims in the aftermath of the 1986 nuclear accident. One of the world's foremost experts on radiation, Polish scientist Zbigniew Jaworowski, evaluates the early and late health effects of the accident, and demonstrates that no increase in cancer has been found that could be related to Chernobyl radiation. The real victims, he shows, are those people in Ukraine, Belarus, and Russia who suffer real, but psychosomatic health effects, caused by scare stories. Jaworowski pins much of the blame on the radiation regulatory agencies, which have made policy based on the myth that radiation at any level is harmful.

LAUNCHING ROCKETS FROM THE SEA

Soon, for the first time, satellites will be launched into space from the sea. Russian engineer Oleg Sokolov traces the history of sea launches from the amateur tests of the German Rocket Society in 1933, to the Soviet and U.S. postwar research, to the current projects to convert ballistic missiles to launchers.

Artist's conception of the preparation for a Zenit Rocket launch from the Sea Launch platform. At the launch site near the equator, a connecting bridge is extended between the launch platform (foreground) to the assembly command ship, in order to allow operations personnel to ready the rocket.