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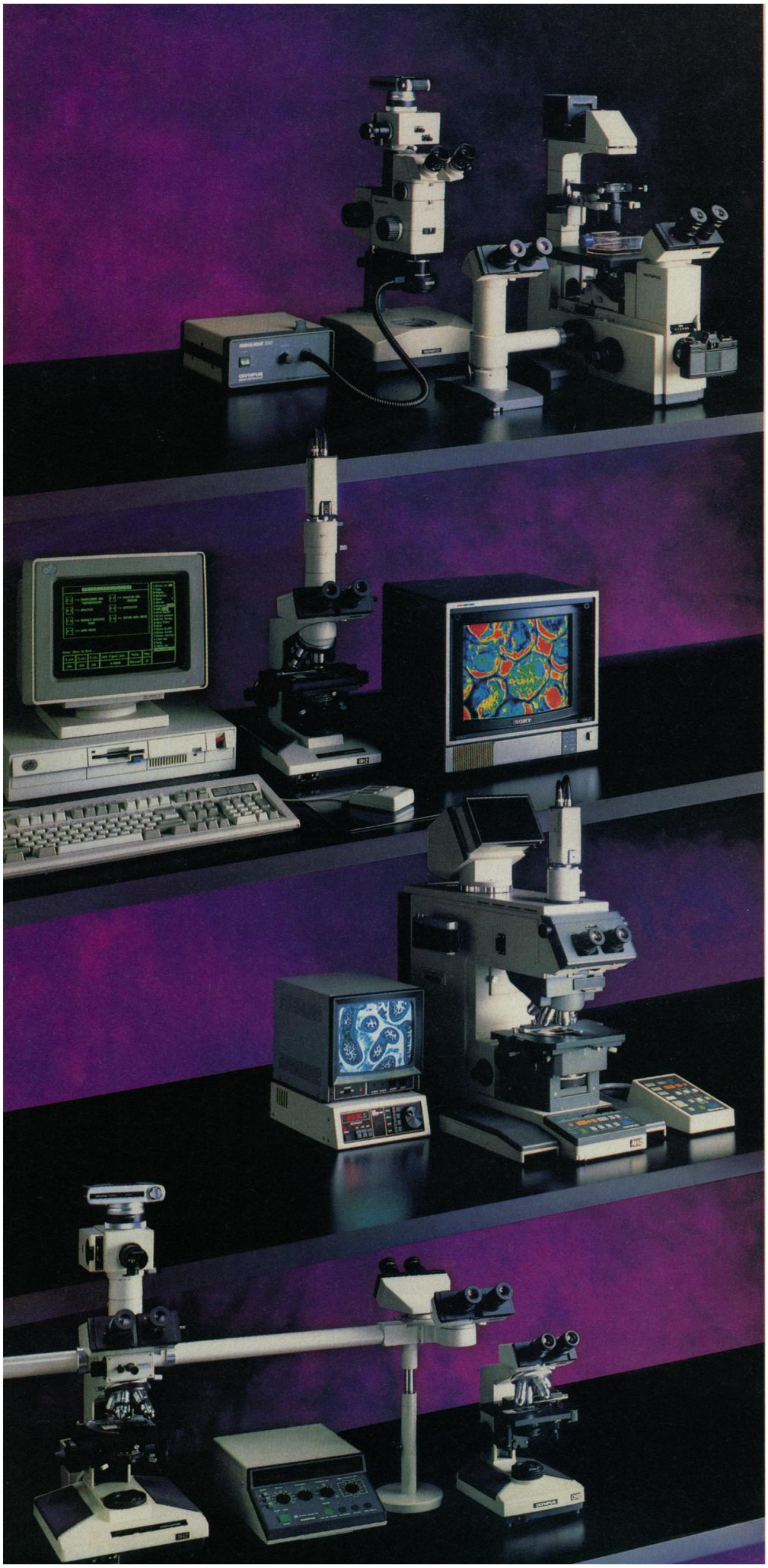
COVER Three-dimensional structure of a single zinc finger domain showing backbone fold, cysteine and histidine ligands, and zinc atom, determined by the use of distance and dihedral angle constraints derived from nuclear magnetic resonance spectroscopy. See page 635. [Illustration by Michael Pique, Research Institute of Scripps Clinic, computed on Ardent Titan and Sun TAAC-1 with software from Ray Tracing Corporation and Sun Microsystems]

Book Reviews

Products & Materials



This Week in SCIENCE

Visual cortex development

As the visual system matures, competing inputs engage the attention of the left and right eyes, affecting the ultimate composition of the visual cortex. Initially, the signals from the optic nerves of the two eyes are relayed through the thalamus and are distributed to a layer of the visual cortex, where the connections representing the two eyes overlap completely. During development, competition between the activity patterns of the two eyes yields patches of cells in the visual cortex that receive information only from the right eye alternating with patches that receive information only from the left eye. Miller *et al.* construct a mathematical model of several biological mechanisms in an effort to account for the development of these ocular dominance patches (page 605). They consider, among other mechanisms, the initial connections onto the cortical cells and influences acting laterally within the cortex, whereby synapses on one cell can affect competition occurring on nearby cells. An analysis of their model yields the conditions necessary for ocular dominance segregation and determines the resulting patch width.

HIV-1 protease structure

In order to inhibit replication of the human immunodeficiency virus (HIV), accurate structures of an enzyme necessary for the proper formation of the virus must be determined. Wlodawer *et al.* substantiate their earlier model of the HIV-1 protease structure (page 616), which was based on the structure of the Rous sarcoma virus (RSV) protease—and which differs in several ways from a model reported by others. They now describe the existence of helical structures in residues 86 to 94 of a synthetic HIV-1 protease; the helix is in close agreement with that in the model structure derived from the RSV protease. They also find that the topology of the dimer interface is similar to that present in the RSV protease. This interface is a possible target for inhibitory drugs. Marx (page 598) discusses in detail the significance of the findings and their possible consequences.

Nonlinear optics

Under intense laser light, the higher harmonics of electrons' natural steady oscillation patterns start to stand out. The strongest of these harmonics are usually those with twice the frequency of the original, or second-order harmonics. Useful tools can spring from the control of these second-order nonlinearities. In optics, nonlinear devices have flourished in areas such as telecommunications, optical data storage, and optical information processing. The utility of lasers can be enhanced by "doubling" the frequency of their monochromatic light with the right nonlinear material. It has been found that optical devices characterized by symmetric environments (such as a symmetric crystal lattice) make it impossible for the appearance of strong second-order nonlinearities. Several methods are used to generate the necessarily asymmetric environments; Marder *et al.* have synthesized a series of organic salts with large second harmonic generation efficiencies by substituting counterions in the salts (page 626). The highest efficiency was roughly 1000 times that of a reference standard.

Glaciation and atmospheric CO_2

Which came first, a decrease in CO_2 or expansion of ice sheets? Core samples from ice sheets in the Antarctic yield ancient air pockets that reveal that atmospheric CO_2 concentrations were low during Pleistocene glaciation. It is not known whether a depletion of CO_2 in the atmosphere caused a cooling and thus the advance of the ice sheets, or whether instead extensive glaciation drove the changes in CO_2 concentration. Lindstrom and MacAyeal have investigated this chicken-and-egg problem by coupling a model that predicts horizontal flow, mass balance, and three-dimensional temperature distribution of an ice sheet with a general circulation model simulating the effect of CO_2 on global temperatures (page 628). Based on the models, they first found that levels of CO_2 were low enough to stabilize large glaciers. Then they varied the CO_2 concentration as shown in the ice core record, starting with an ice distribution on par with that of the last glacial maximum. As the model was integrated over 18,000 years, the ice sheets gradually collapsed, arriving finally at a distribution similar to that of present-day distribution, with a Greenland ice sheet and thin Arctic Ocean sea ice. Although not proof, these results are consistent with the notion that glaciation responded to changes in CO_2 concentration.

Controlling parasitic mites

Parasitic mites that attack honey bee drone larvae have been spreading throughout the world (excluding Australia) since 1965, when they were detected as a threat in the Soviet Union. Destroying hundreds of thousands of honey bee colonies in eastern Europe in the 1970s and moving through western Europe in the 1980s, *Varroa jacobsoni* has been discovered in 18 U.S. states in the past 2 years. The mite clings to the bees and sucks their hemolymph, shortening their lives and generating physical, functional, and behavioral abnormalities. Chemical pesticides, which must be used frequently enough to discourage reinfestation from wild swarms or from untreated neighboring colonies, might produce more resistant strains of the mite and contaminate honey and other beehive products. LeConte *et al.* have isolated fatty acid esters from extracts of bee larvae that attract *Varroa* females (page 638). In preliminary tests, compounds containing the esters caused the parasites to leave the worker bees on which they were feeding. From there they fell to the floor of the hive, where they were easily trapped and destroyed, indicating a possible way to control the mites with natural compounds.

■ PAT JANOWSKI

SCIENCE

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The Process of Publication

Interest in the process of scientific publication has most recently been kindled by the investigation of a paper that appeared in *Science* (see News & Comment, 14 July, p. 120, and 28 July, p. 349). The investigation, by a panel of the National Institutes of Health, concluded that the paper was plagiarized. A question was then raised by a congressman of whether the journal should have accepted the paper, which was later judged to have been flawed. Perhaps this is a good time to clarify how acceptance and publication of manuscripts proceed at *Science*.

When a manuscript arrives at *Science* it is given a "received" date and starts through the review process. The decision to publish or reject the paper is based on its merits and editorial criteria. If the manuscript is found to be outdated by information published before our received date, it is rejected. If a paper published elsewhere reporting the same results appears while our manuscript is under review, that published paper cannot be a factor in our decision-making. We expect the competing work to be cited for completeness and accuracy, but we treat the two papers as independent discoveries of the same finding.

There was no charge of plagiarism before publication of the manuscript in question, and the author did include a reference to the competing work. Our retrospective analysis does not indicate that any change in procedures is needed (unless editors could be granted precognition). Had a charge of plagiarism or fakery been made before publication, we would have responded in a different manner. However, we do not routinely assume that arguments over proper credit (a not infrequent event) are evidence of plagiarism (a rare event).

If charges of fraud, backed by documentation, were made against a manuscript under review, *Science* would cooperate in bringing the allegations to the attention of those better able to investigate them. This must always be done with care because journals have limited investigative capabilities as well as a clear responsibility to preserve confidentiality in the peer-review process. Our reviewers include some of the best and busiest scientists in the world, who generally act with honor and altruism. If we cannot protect the privacy of their written and verbal statements, we cannot perform the kind of selection that the readers of *Science* expect. Therefore, we find ourselves in difficult territory when asked to give detailed information to our readers, university committees, or others who may need the information. It would be comforting to say we have precise policies that are activated instantly like computer programs, but our experience indicates that each case is different and involves a tortuous pathway through a mine field of unpleasant alternatives.

At a recent hearing of the House of Representatives Science, Space and Technology Subcommittee on Investigations and Oversight, the possibility of granting some degree of immunity from libel litigation to journals and investigative committees was discussed. Immunity is a double-edged sword and, therefore, some safeguards will be necessary. However, if journals are asked to publish retractions in controversial situations in which some coauthors are willing to retract and others are not, they face legal problems. A university investigative committee that reaches controversial conclusions that need to be presented to relevant parties faces similar problems. Because the cost of a libel suit can approach $1 million even if the journal or panel is vindicated, cautiously worded libel legislation seems needed if scientific organizations are to make improvements as rapidly as some would like.

The incidence of fraud in scientific publishing is far too low to warrant the introduction of procedures that would undermine a system of publication that has served science and the public well for many years. *Science* will continue to expose misconduct when it occurs, but it will also assume good faith unless presented with evidence to the contrary. We will continue to publish research at the forefront and exciting news of science, warts and all—which means there may be the need for corrections at times. We must honor our obligations to authors, to readers, to reviewers, and to the public. Underlying all, we continue to believe that the overwhelming majority of scientists are honorable men and women, and certainly all of them deserve to be considered innocent until proven guilty—DANIEL E. KOSHLAND, JR.

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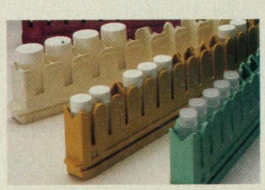

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Letters

"Electric" Airliners

I would like to correct a number of points in reaction to M. Mitchell Waldrop's article "Flying the electric skies" (News & Comment, 30 June, p. 1532).

- Pilots are at all times firmly in control of the Airbus A320. The many computers in the aircraft, including those in the "fly-by-wire" system, are there to relay pilot commands and to make their task easier, not to replace the flight crew.
- Airbus Industrie has equipped the Airbus A320 with flight controls driven by computers primarily to enhance safety. Savings in weight and maintenance are but a useful bonus. Our competitor's claim that we use "technology for technology's sake" is nothing less than "sour grapes," since its own aircraft, designed in the 1960s, is too old to enjoy the benefits of today's technology.
- The Airbus A320 is the most advanced airliner in the world—bar none. In addition to being the first civil aircraft with full digital fly-by-wire controls, the Airbus A320 is also the first to permit centralized maintenance. The concept of automatic diagnosis and corrective action of relatively minor equipment faults has been a part of the Airbus A310 and the A300-A600s since the early 1980s. Its introduction on McDonnell Douglas' MD-11 thus comes as no surprise. Many of our competitors' tomorrows are our yesterdays.
- All large, modern airliners—including the Airbus A320—have hydraulically powered flying controls. The hydraulics provide the "muscle" and, in conventional aircraft such as the Boeing 747, are signalled by mechanical cables. In the Airbus A320, they are replaced by electrical wires and a bank of computers. The A320's fly-by-wire computers provide a valuable safeguard against stalling, overspeeding, and overstressing the aircraft—all maneuvers that airline pilots are trained to avoid. These safeguards are based on experience gained with civil aircraft such as the *fully* fly-by-wire, 20-year-old Concorde and a partial use of fly-by-wire in the Airbus A310 and the A300-A600—rather than on military types of aircraft.
- All Airbus aircraft, since the very first entered service in 1974, feature protection against windshear. Again, Airbus Industrie led the way, and today the A320 offers greater protection against windshear than *any* other civil aircraft.
- All aircraft make extensive use of computers—in their navigation aids, systems and even their conventional flying controls. An aircraft's ability to fly a given route depends on the number and importance of serviceable computers—a minimum equipment list spells out exactly how many failures are tolerable, and only if this is exceeded is the aircraft unable to fly.
- All large airliners, including the A320, are designed to withstand a maneuver load of plus 2.5 G maximum. Pilots who, in emergency situations, have had to maneuver their aircraft suddenly, have often *assumed* that they had flown it close to its structural limits, when in fact they were still well within them. In the A320, the built-in flight envelope protection made possible by fly-by-wire enables the pilot to fly the aircraft right up to the design limits swiftly and confidently, *knowing* that he will not exceed them.
- There is no equivocation about the outcome of the independent investigation by the French authorities into the crash of an A320 in France in 1988: the aircraft, its engines, and its systems performed correctly. Indeed, an expert commissioned by the authorities notes that the sophistication of the fly-by-wire system, which prevented the aircraft from stalling and therefore crashing out of control, probably helped save the lives of 133 of the 136 passengers on board. Incidentally, the aircraft was being flown as low as 30 feet (9 meters) and not the 50 feet (15 meters) that is quoted.
- In short, the Airbus A320 represents a carefully thought out and extensively tested step forward in airliner technology and safety enhancement. The hundreds of pilots who have flown the Airbus A320, the 2 million or so passengers who have now experienced its comfort, the world's certification authorities, and the 25 customers that have bought more than 500 of the aircraft seem to agree.

ROBERT ALIZART
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It is right to question the potential safety of highly computerized airliners coming on the scene. When it comes to blithe spirits, the aeronautical engineering fraternity is light years ahead of any character out of a Noel Coward play. Their comfortable insouciance, especially when contemplating potential catastrophic failures, is the most bemusing.

Cockpit computers have eliminated the flight engineer and with him a critical set of

eyes, considered essential when a plane is in congested terminal areas. This loss is made all the more acute because these same computers need reprogramming whenever the preset flight plan is changed for any reason, which in turn calls for the pilot who is not flying to have his head "in the cockpit" punching numbers into the black box. The pilot in control will already have his head in the cockpit flying his instruments, so that more often than not no one is looking out of the cockpit window searching for conflicting traffic.

More insidious, however, is the prospect of a fallible piece of software controlling a critical flight path of the aircraft and which the pilot is barred from correcting. And I would rather not think about the demented introduction of a virus into all of this.

In my own continuing experience of more than four decades of professional flying, I have yet to flick on a light switch at home or an autopilot in airliner in which sooner or later those pesky electrons did not misbehave. So the manufacturer's insistence that the fly-by-wire controls on the Airbus A320 "makes it impossible" to create an error will bring nothing but cynical chuckles from even the neophyte pilot.

Their statisticians invariably get into the argument at this point and insist that these potential glitches only happen once in a trillion times, but they fail to add that there is no mathematical guarantee it will happen on the trillionth rather than the first time. But I can assure them it will probably happen on my flight, when I least need or expect it.

This sort of sophistication should be left to the single-seat fighter, where it appropriately belongs and where the pilot can bail out in a hurry when the inevitable occurs—a privilege neither I nor my passengers enjoy.

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*Pilot, United Airlines

Animal Experimentation

For more than a century, as so deftly illustrated by the recent attack on my work by Charles S. Nicoll and Sharon M. Russell of the University of California, Berkeley Department of Physiology (Letters, 26 May, p. 903), physiologists have been using the antivivisection movement as a "straw man." Historian Gerald Geison has shown that many physicians expressed skepticism about the value of animal experimentation as a therapeutically effective method of discovery during the 19th and early 20th centuries (as many do today) (*1*). In that inhospitable environment, laboratory physiologists were able to survive as a profession by mounting the most successful propaganda campaign in medical annals: They convinced much of the medical community, the public, and the media that the dramatic advances in 20th century therapeutics were a result of animal research.

It is therefore particularly ironic that the physiologists accuse me of concocting "written distortions of medical history." My work demonstrates that the real threat to animal researchers was never the antivivisection movement, but physician-scientists who do not agree with the provivisection propaganda. The list of elite physicians who have decried the exaggerated claims of bench scientists reads like a Who's Who of outstanding physician-scientists of the 20th century. In 1919, no less a clinical investigator than Archibald Garrod, who himself discovered the one gene–one enzyme hypothesis by brilliant clinical deduction, warned against "a tendency to ascribe almost all advances of medicine to the workers in pathological laboratories [animal experimenters and microscopists] and to represent the members of the clinical branch as merely applying in practice knowledge which has been gained in the laboratories" (*2*). In 1952, the epidemiologist who finally overturned the dogma that cancer is a purely genetic disease, wrote, "The overestimation of animal experiments is so rampant that the issue is of general interest" (*3*). In 1967, the physician who ushered in the New Immunology by interpretation of incisive natural experiments on the human body, disputed physiologist Julius Comroe's contention that heart transplantation was pioneered by laboratory physiologists (*4*). In 1979, Paul Beeson, the doyen of American internal medicine, wrote that "progress by the study of man is by no means unusual, in fact, it is more nearly the rule" (*5*).

The statements of such eminent authorities constitute a prima facie case that the historical importance of animal experimentation has been grossly exaggerated by physiologists.

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Washington, DC 20003

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In the inflammatory letter by Nicoll and Russell, I was used as an example of a " 'moderate' animal rights advocate" who had supposedly made the statement that "it is pointless to use animals for AIDS research." I made no such statement. There is a great difference between writing off an area of research as "pointless" and a reasoned discussion of its limitations.

The authors went on to describe as "anti-scientific and anti-intellectual" my statements that "there is no good animal model for AIDS. There are monkeys which have a disease similar to AIDS but it is caused by a different virus." In fact, this is supported by many others. Note, for example, the *Report of the Presidential Commission on the Human Immunodeficiency Virus Epidemic* (*1*).

> To date, adequate animal models have not been developed for human HIV-related research. An appropriate model is one in which the animal can be infected with HIV and can develop disease similar to that produced by HIV infection in humans. . . .Difficulties with animal models persist. Chimpanzees, for example can be infected with HIV, but, to date, have not developed AIDS. . . .The lack of appropriate animal models for HIV research makes the application of animal research to humans uncertain. . . .There is also a lack of adequate animal models for vaccine development.

This is not to say that animal research is pointless. But it is to say that the inadequacies of animal models, combined with the extraordinary stresses of isolation, confinement, and manipulation, which are routine in infectious disease research, should encourage a shift toward other methods. Or should the Presidential Commission also be labeled "anti-scientific and anti-intellectual"?

NEAL D. BARNARD
Physicians Committee for Responsible Medicine, Post Office Box 6322, Washington, DC 20015

REFERENCES

1. *Report of the Presidential Commission on the Human Immunodeficiency Virus Epidemic* (Government Printing Office, Washington, DC, 24 June 1988), pp. 39–47.

Shortage of Scientists

The article by Constance Holden, "Wanted: 675,000 future scientists and engineers" (News & Comment, 30 June, p. 1536), deals with an issue of vital importance to the nation. Holden's discussion of the topic is concise and thoughtful, but misleading in one respect. In the article she states: "White men now make up 47% of the total workforce and about 80% of the science and engineering workforce of 4.6 million. But they will constitute only 15% of the net number of 25 million people entering the workforce in the last 15 years of the century. By 2010, they will make us less than one-third of the college-age population." This statement and the accompanying pie-chart with the caption "The decline of the white male" can be misinterpreted unless they are examined carefully.

The figure of 25 million people is the estimated *increase*, from 115.5 million to 140.5 million, in the workforce between 1985 and 2000 and takes into account not only the number entering but also those who leave. White males, far from disappearing, increase their numbers by almost 4 million. Although their proportion falls from 47% to 41%, they remain the largest group (58 million in 2000). Despite a 10.5 million absolute increase by white women, their representation only rises from 36% to 37% (52 million in 2000). The total of all other groups, increasing by 10.7 million, rises in representation from 17% to 22% (30 million in 2000). The change in makeup of the workforce, while not insignificant, is not as startling as implied by Holden's article.

White males already constitute less than 50% of the workforce. Using the rates of percentage change (−0.4% per year for white males, +0.07% per year for white females), it would take until 2009 for the white male number to be equalled by white females, at which time each group would constitute about 38% of the workforce.

Although white males' dominance of the labor market is declining, it is a slow process and their numbers will remain significant for many generations. It is critical, for a variety of reasons, to increase the number of women and minorities entering the scientific workforce. But no matter how successful we may be in that regard, such efforts will not meet the nation's needs for technically trained people. Graduate fellowships and other incentive programs targeted only at women and minorities will miss the largest pool of potential recruits. The subtitle of Holden's article is "A shortage of technically trained workers is looming, unless more women and minorities can be attracted to science." That recommendation will not suffice. We need to attract more young people to science from all segments of the population.

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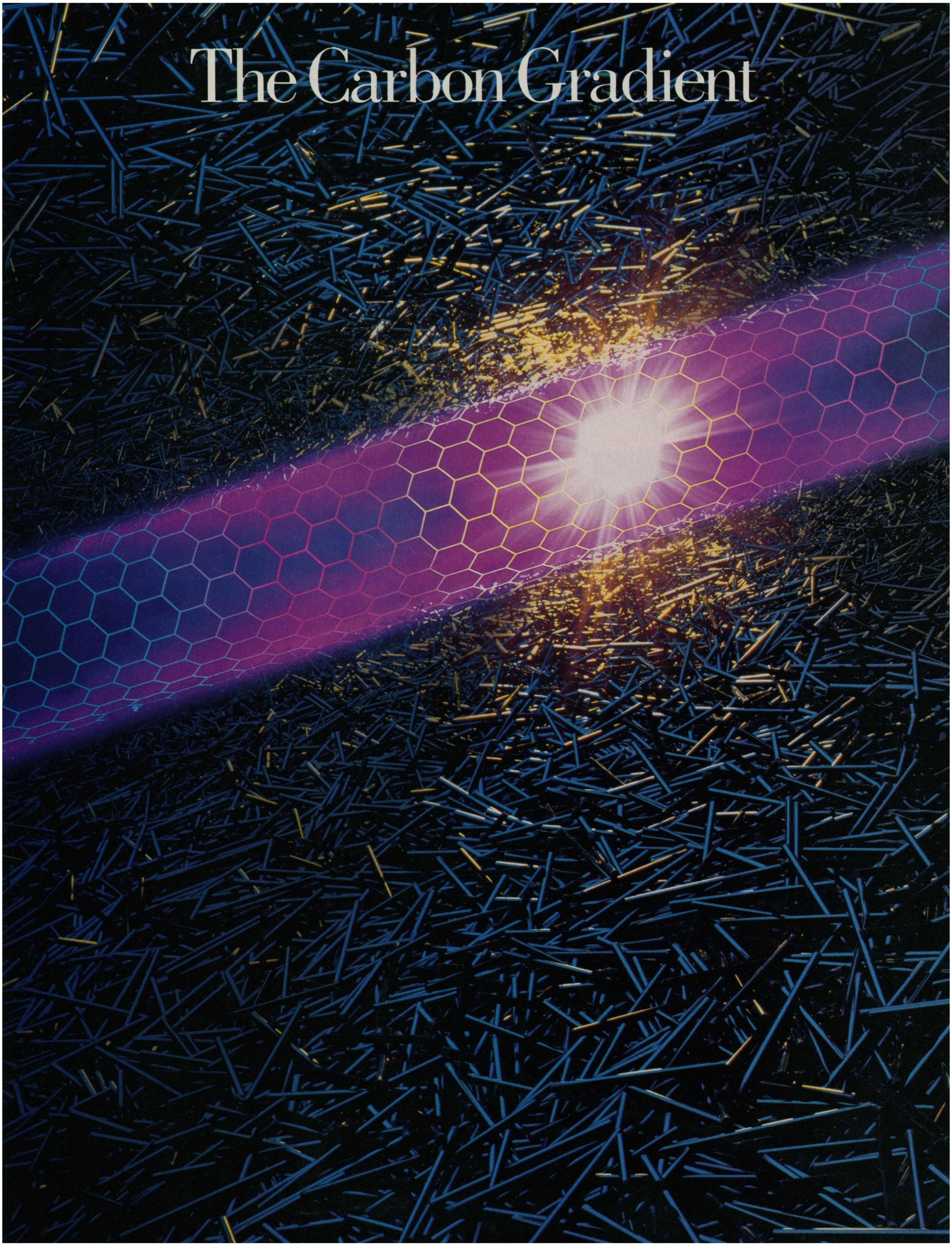

The Carbon Gradient

The Carbon Gradient

Hollow carbon filaments catalytically produced by submicron-size iron particles can be the template for larger carbon fibers used in composite structural materials. A scientist at the General Motors Research Laboratories has identified how these filaments grow and why they take their characteristic form.

Carbon Fiber Growth

Fig. 1

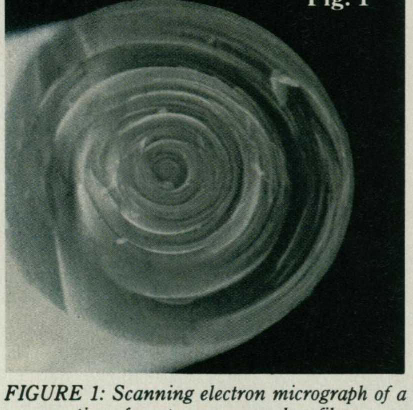


FIGURE 1: Scanning electron micrograph of a cross section of a vapor-grown carbon fiber.

FIGURE 2: Typical carbon filament grown from natural gas by an iron catalyst particle.

FIGURE 3: Schematic model showing inner and outer radii, the precipitation interface, and the nested basal planes of the outer surface.

Dr. Gary Tibbetts was measuring the diffusion rate of carbon in iron when his carefully planned experiment took an unexpected turn. Dr. Tibbetts, a physicist at the General Motors Research Laboratories, had been introducing carbon to the inside surface of a hot stainless steel tube while extracting carbon from the outer surface.

At the end of one particular trial, he found the inside surface covered with a mass of black "whiskers." His initial investigations verified that the fibers were made of carbon and that they had characteristics typical of the crystal structure of graphite. But the question of how they formed was not so easily answered. The search for an answer would change the course of his investigation and dominate his research for the next ten years.

Fig. 2

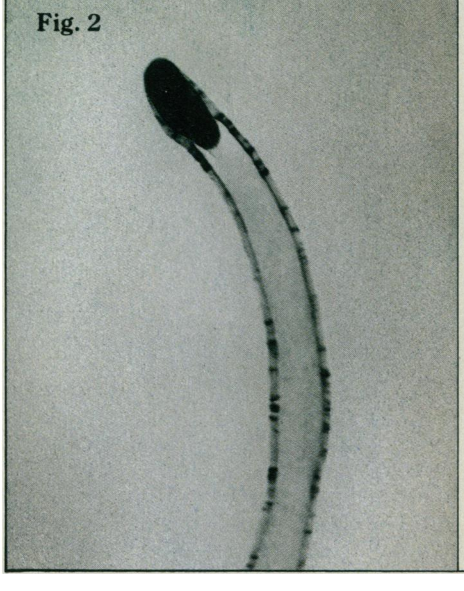
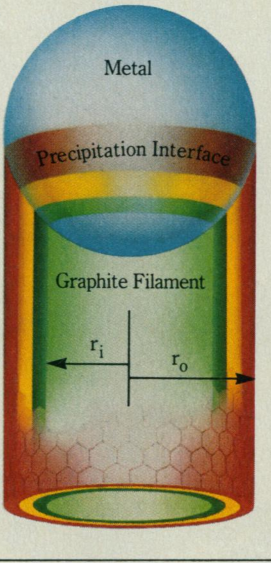


Fig. 3



The fibers that surprised Dr. Tibbetts were made up of concentric layers primarily composed of basal (0001) plane graphite, resembling in cross section the annular rings of a tree (Figure 1). Research showed that they were formed by vapor deposition of carbon on a hollow central filament. The central filament itself was grown by catalytic action on a small metal particle (Figure 2).

These long, slender, uniform filaments had been widely observed since the availability of the electron microscope. Still, no valid explanation had been advanced to account for their hollow structure. Many scientists thought that surface diffusion of carbon-containing molecules around the catalytic particle caused the hollow core.

Instead, Gary Tibbetts proposed a model in which carbon atoms from decomposing hydrocarbons diffuse through the bulk of the catalytic particle and precipitate as graphite in the growing filament. The diffusion process is driven by the carbon gradient–the difference between carbon concentrations at the adsorbing surface of the particle and at its opposite, precipitating surface (Figure 3).

The exterior surfaces of these carbon cylinders expose the basal plane of graphite because the (0001) plane has a surface free energy at 970°C of about 77 erg cm^{-2}, while a typical surface perpendicular to the basal plane has a surface energy in excess of 4000 erg cm^{-2}. The free energy required for filament growth, therefore, will be a minimum when the exterior surface is made up of basal planes–as observed in these filaments.

The entire filament, then, should consist of nested, rolled-up basal planes of graphite. Bending these planes into cylinders, however, requires that extra elastic energy be provided during the precipitation process. The core is left hollow because too much energy would be required to bend the planes near the axis into very small diameter tubes.

In describing the total energy necessary for filament formation, Dr. Tibbett's model takes into account the chemical potential change ($\Delta\mu_o$)when a carbon atom precipitates from the dissolved phase, as well as the energy required to form the surface, plus the energy needed to bend the basal planes into nested cylinders.

The change in chemical potential ($\Delta\mu$) driving the precipitation can be expressed as follows:

$$\Delta\mu = \Delta\mu_o - \frac{2\,\sigma\,\Omega}{r_o - r_i} - \frac{E\,a^2\,\Omega}{12(r_o^2 - r_i^2)}\ln(r_o/r_i)$$

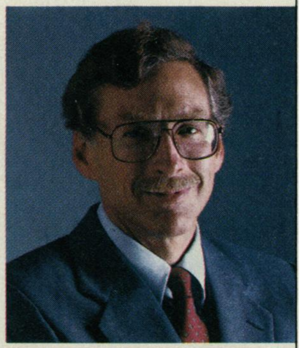
where σ is the energy required to form a unit area of (0001) graphite; Ω is the volume of a carbon atom in graphite; r_o and r_i are the outside and inside radii of the filament, respectively; E is the filament modulus; and a is the interplanar spacing.

A filament catalyzed by a particle of radius r_o will adjust its r_i to give the largest $\Delta\mu$–in fact, r_i may be directly calculated by maximizing $\Delta\mu$. Doing so yields results that compare nicely with experimental values.

Understanding the growth of the hollow core of the filaments was one key to producing them in abundance. "From there," says Gary Tibbetts, "it is a simple step to thicken the filament into a macroscopic fiber by vapor deposition of carbon on the exterior surface. The deposited carbon has a high degree of orientation parallel to the tube axis, giving the fiber exceptional stiffness.

"Fibers of this type should be excellent for making chopped-fiber composites using plastic, ceramic, metal, or cement matrices. GM's Delco Products Division is already building a pilot plant to develop a low-cost production process that would permit the use of vapor-grown fibers in high-volume applications."

THE MAN BEHIND THE WORK



Dr. Gary G. Tibbetts is a Senior Staff Research Scientist in the Physics Department of the General Motors Research Laboratories.

Gary received his undergraduate degree in physics from the California Institute of Technology. He holds both an M. S. and a Ph. D. in the same discipline from the University of Illinois.

Dr. Tibbetts joined General Motors after two years of postdoctoral work as Guest Scientist at the Technical University of Munich. Since coming to the Labs in 1969, Gary has pursued interests ranging from carbon filaments, to surface physics, to chemical vapor deposition. He has published almost forty papers on the results of his research.

Gary is a member of the American Physical Society, the American Carbon Society, and the Materials Research Society. In 1988, he was a GM Campbell Award Winner. Gary lives in Birmingham, Michigan, with his wife and their three daughters.