The Ice Age Cometh

GLACIERS ARE GROWING, WARMTH-LOVING ANIMALS ARE MOVING SOUTH, AND WE ALL MAY BE GETTING COLDER BY AND BY.

BY JAMES D. HAYS

This January the temperature in the country's heartland seemed colder than anyone could recall, aggravating an already chronic fuel shortage. Schools closed in Denver, factories shut down in the Midwest, and thousands of workers were laid off as fuel supplies ran out. The suspicion that winters simply are getting colder is no longer merely a suspicion among climatologists. Over the last 30 years permanent snow on Baffin Island has expanded. Pack ice around Iceland in the winter is increasing and becoming a serious hazard to navigation. Warmth-loving armadillos that migrated northward into the Midwest in the first half of this century are now retreating southward toward Texas and Oklahoma. Russian crop failures are on the increase.

These are just some effects of a global cooling that has been recorded by the world network of weather stations. If all indications are correct, worse is yet to come. Judging by what has happened in the past, it may very well get cold enough to allow great glaciers thousands of feet thick to cover North America as far south as Long Island, burying the highest peaks of the White Mountains and Adirondacks.

The last such glacial advance—the last great Ice Age—ended only 17,000 years ago, when the ice sheets in the mid-latitudes retreated, leaving only some smaller mountain glaciers as they crept back to the poles (where now all that remains are the ice packs on Antarctica and Greenland). As the ice melted, the earth then rapidly warmed until sometime between 3,000 and 5,000 B.C., when it was probably warmer than today—in fact, warmer than it had been for 100,000 years. But these balmy conditions were not long lasting, and the climate gradually cooled until about 900 B.C., during the archaeological Iron Age. It then rebounded again, as evidenced by records of flourishing vineyards in England from 1000 to 1200 A.D. Thus, the great Viking conquests were favored by slightly warmer conditions than today's. This time of mild climate and flourishing agriculture saw the spread of Christianity over northern and eastern Europe and the most active period of cathedral and abbey construction.

The climate again cooled from the late fifteenth through early nineteenth centuries. This interval, the so-called Little Ice Age, was a refrigeration of considerable intensity, although still a far cry from a full ice age. It saw the greatest advance of mountain glaciers, and probably of ice on the polar seas, since the last great Ice Age. In some degree it touched every aspect of human life.

The effects of the Little Ice Age have commonly been overlooked, presumably because they were overshadowed by the devastation caused by the Black Plague. The late 1500s and the 1600s were probably the coldest time of the four-century period. The 1690s saw the last serious famine anywhere in Great Britain, the result of an eight-year run of harvest failures in the upland parishes of Scotland, where the proportion of the population that perished from hunger rivaled the toll caused by the

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Black Plague. The consequent weakening of the Scottish nation may have made union with England inevitable.

In England the fifteenth through nineteenth centuries also were significantly colder than now. The Thames River at London had frozen only occasionally prior to the sixteenth century; however, in that century, and during the two that followed, the river froze on numerous occasions. In the late 1600s the river froze repeatedly, and for weeks on end in the winter of 1683–84, Charles II, his court, and just about everybody else in London were able to tread clear across the ice-encrusted Thames. The river froze on only one occasion in the nineteenth century, but what prevented it from freezing more often probably were man-made changes of the river banks and subsequent industrial thermal pollution, rather than climatic warming. The Little Ice Age also affected the Scandinavian colony on Iceland, where grains introduced by the Vikings refused to grow.

On this side of the Atlantic, good historical records don't go back as far, but there is some striking evidence from the eighteenth and early nineteenth centuries that conditions were significantly colder in eastern North America than they are today. In the winters of this period New York Harbor repeatedly froze, allowing Staten Islanders to walk across the narrows to Brooklyn. In 1816 there was frost every month in northern New York and New England, and for this reason it was dubbed "the year without a summer." From the sixth to the nineteenth of June subfreezing temperatures were recorded in upstate New York and New England, and a foot of snow fell on Quebec City. The crop losses that occurred because of this late-spring cold and the following late-September black frost posed serious problems for Americans recovering from the ravages of the War of 1812. Admittedly, 1816 was unusual, even for the Little Ice Age, but the possibility of the recurrence of such anomalous years increases as the world's mean climate cools.

Our knowledge of climatic conditions before the late 1600s, when the thermometer was invented by Gabriel Fahrenheit, is based mainly on observations included in diaries and historical accounts. For the next 150 years we have a temperature record for western Europe and, during the latter part of this period, for North America. By the end of the last century a sufficient number of weather stations had been set up around the world to provide a good indication of global climatic trends.

This climatic record clearly shows the end of the Little Ice Age, with temperatures rising from the late 1800s until about 1940. Since then the trend has reversed, and a steep decline is now clearly underway. Already the climate has reverted to the levels of the 1920s, and the cooling continues.

The effects of the present cooling trend will be most strongly felt in temperate climatic zones, while the tropics will be least affected. Not only will the temperate regions become cooler, but we may also expect an increase in "anomalously" cold years—years with late-spring frosts or early-fall frosts—and a general increase in storminess. Thus, the grain fields of the Canadian prairies and the Russian steppes are vulnerable to a shortening of the growing season; however, the sugar cane harvest of Cuba or the banana crops of Guatemala would probably survive even a fully glacial climate in the north.

It is the vast industrial and grain-producing areas that will undergo the greatest change. The main grain (primarily wheat) exporting nations—the United States, Canada, Argentina, and Australia—all lie in temperate latitudes. A large number of nations, most notably the Soviet Union and China, rely upon these exports. Any reduction of grain production could cause an immediate problem, for the large grain surpluses of some years ago have now been vastly reduced, and most of the world's production is consumed within a year of the harvest. The continuing population growth may put a strain on our food resources even without a marked modification of climate, but a shortening of the growing season in temperate latitudes could easily aggravate this situation.

As climate cools, the demand for more heat will put an ever-increasing strain on our energy resources, causing natural gas, oil, and electricity prices to rise. The present "energy crisis," though partially caused by archaic regulatory procedures, points out how narrow our tolerances are and how closely we regulate our energy supplies to the level of so-called normal winters. However, what was considered an abnormally cold winter is becoming normal, and it is expected that winters will be getting even colder. Some scientists, such as the Czechoslovakian climatologist Jiri Kukla, think we may be on the verge of another Great Ice Age. They point to the fact that previous interglacial mild intervals, which are comparable in warmth to the present one, lasted only about 10,000 years. The present interglacial period already has lasted 10,000 years, so if it is truly similar to earlier ones—and if man's activities do not alter the natural trends—it should be nearly over.

If we indeed have reached the critical point in the climatic cycle where an interglacial changes to a glacial, there is some difference of opinion as to how long this interim period will linger. Recent evidence suggests a shorter time for the transition than was previously thought. Pollen grains preserved in the peat bogs of Macedonia, Greece, reveal that the change from the last interglacial forest to glacial grassland probably took no more than a few hundred years. A comparable length of time was required for the temperate forests of England, the Netherlands, and Denmark to be replaced by subarctic tundra. However, the magnitude of the change from an interglacial to a glacial is such that noticeable changes, even greater than those observed in the Little Ice Age, would probably occur in fewer than 100 years.

Other scientists, such as the British climatologist Hubert Lamb, propose that the present climatic trend may lead us only into another Little Ice Age. They argue that climate appears to oscillate periods of about 200 and 400 years. The coldest part of the Little Ice Age was in the late sixteenth and seventeenth centuries. Another cold spell, though less severe, came in the early nineteenth century. If the system continues to cycle as it has in the past, we can expect substantial cooling in the late twentieth and early twenty-first centuries, perhaps to a degree comparable with the Little Ice Age. On the conservative side, the Danish physicist W. Dansgaard, from his re-

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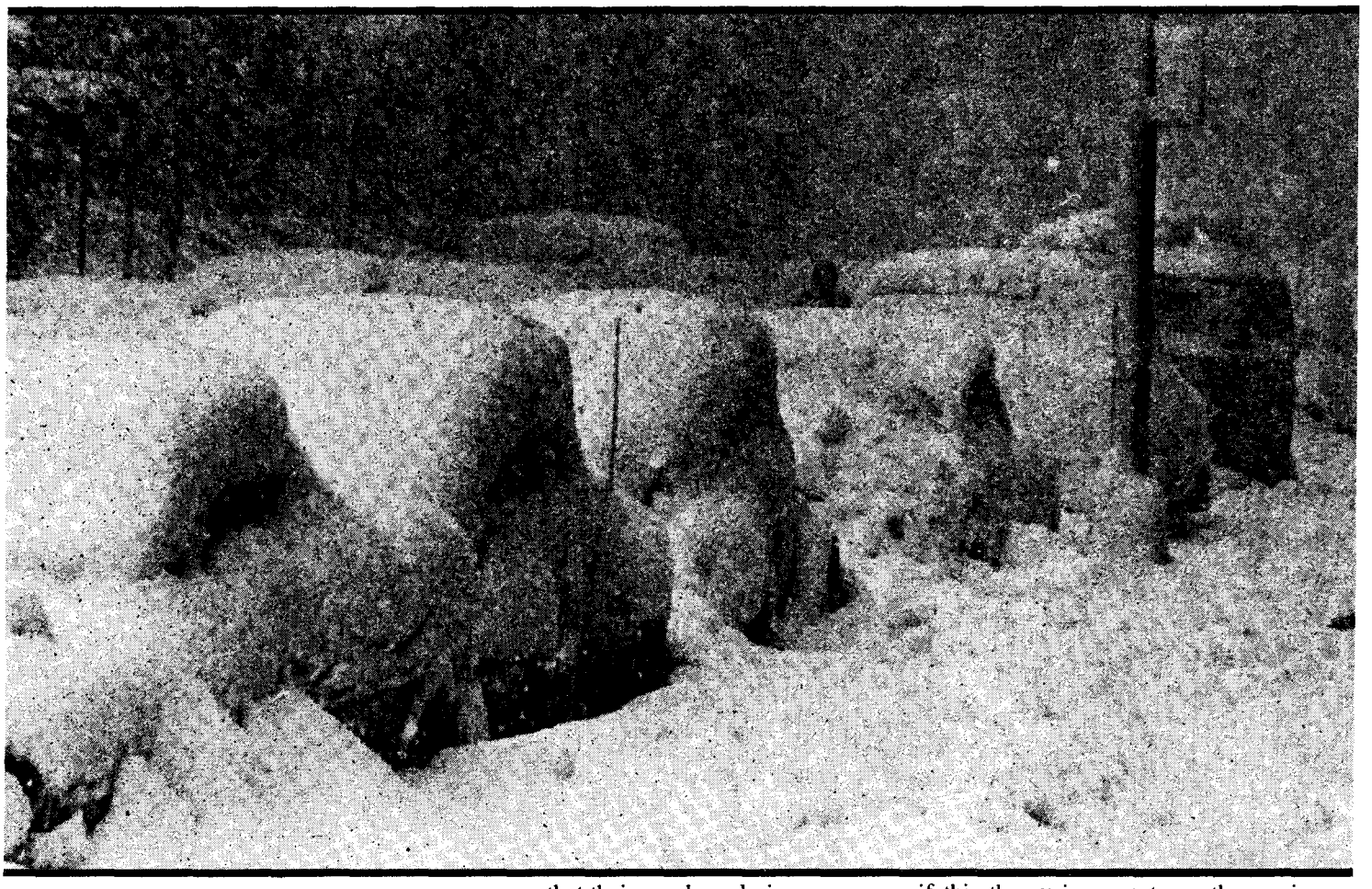
search into the climatic record of long columns of ice removed from the Greenland ice cap, predicted that the present cooling trend will probably continue for only another 10 to 20 years.

The most reasonable explanation for the current global cooling is that the amount of solar energy reaching the earth's surface is decreasing. Since the sun is the source of all the energy in natural climatic processes, anything that interferes with the amount of solar energy received and retained at the earth's surface or the distribution of that energy could cause a change of climate. An obvious way this could happen is through a fluctuation of the strength of solar radiation at the sun's surface. However, evidence to document this fluctuation is difficult to come by. Since atmospheric variations cause changes in the strength of solar radiation at the earth's surface, we must either monitor the sun's strength above the atmosphere (which has yet to be done) or rely on observations of solar disturbances that may reflect changes in solar intensity.

Sunspots, one of several kinds of solar disturbances, have the longest record of reliable observations, dating back to the 1600s. Some correlation has been found between large numbers of sunspots and warmer conditions on earth, and a dearth of sunspots and cooler conditions. It has not been established, however, that their numbers during any year are an accurate measure of solar energy output. Solar disturbances other than sunspots have not been measured over a long enough period for scientists to say how important these changes in solar intensity may be to the overall process of climatic change. It seems incredibly shortsighted that, during our entire space program, no instrument was placed outside the earth's atmosphere to monitor long-term variations of the sun's total strength.

Gravitational interaction between the earth and other bodies in the solar system also causes periodic changes in the geographic and seasonal distribution of incoming solar radiation. This mechanism does not significantly alter the annual total radiation received at any given portion of the earth's surface. Nevertheless, the relative increase of radiation received in one season at the expense of others may be extremely important in the building and decay of glaciers. This theory is a popular explanation of the major advances of ice sheets. Over the last quarter-million years, glaciers have expanded during times when summers were cool and have retreated when summers were hot. At present, the northern hemisphere has passed from a time of sharp contrast among the seasons and is experiencing what is called a low seasonal contrast regime—possibly signaling, if this theory is correct, another major advance of ice.



The last climatic warming trend ended in the early 1940s. Our planet has been getting steadily colder ever since.

Alterations in the transparency of the earth's atmosphere also affect the amount of solar energy reaching the earth's surface. Large volcanic eruptions, such as the eruption of Krakatau in 1883, can inject tons of fine rock material and gases high into the upper atmosphere, 15 miles and more. Fine particles that reach such levels above the weather may take years to settle out. In general, temperatures for a year or so after such great eruptions are somewhat colder than the average for the decade in which the eruption occurred. Thus the extraordinarily cold summer of 1816 may be at least partially explained by the mighty volcanic eruption of Tamboro, Sumatra, in 1815. However, the long-

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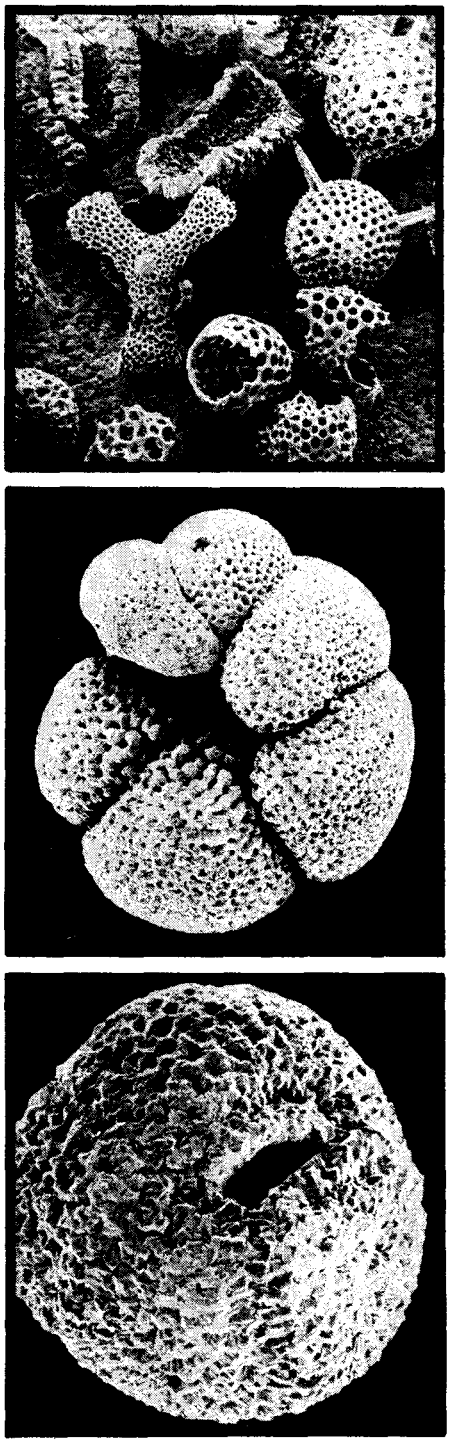
term development of climate seems to be only slightly modified by volcanic eruptions.

The problem of understanding the future course of climate is compounded by the possible disruption of climate's natural progression by man. Although the direct effect of man's activities on global climate is the subject of controversy, his effect on local climate is established, and his ability to affect global climate is at least probable. Man has altered local climate through construction of cities, deforestation of millions of acres, and the development and expansion of agriculture. His potential for wider alteration of climate lies primarily in modification of the atmosphere through the combustion of fossil fuels. Such combustion produces carbon dioxide and thus increases the carbon dioxide content of the atmosphere. This results in a blanket effect, reducing the heat loss from the earth to outer space and thus causing the earth to warm.

Industrial exhausts also add dust to the atmosphere. This industrial dust has a cooling effect; it screens out solar radiation just as volcanic dust does. The warming trend from the late nineteenth century to 1940 could have been caused by an industrial increase in atmospheric CO_2 and the cooling since 1940 by an increase in man-made atmospheric particles. However, it is hard to separate climatic changes that are induced by man from those that are natural. Murray Mitchell and Steven Schneider of the National Oceanographic and Atmospheric Administration have stated that, up to this point, the CO_2 warming effect and the maximum-particle cooling effect turn out to be very nearly equal and opposite, thus tending to cancel one another out. Therefore, the observed climatic trend is probably natural. Yet Mitchell and Schneider do not imply that this will continue to be the case in the future. Increased pollution or direct injection of pollutants into the stratosphere by such large high-flying aircraft as the SST could tip the balance.

To understand long-term climatic change, we first need to know how climate has changed globally in the past, not just for one hundred years but for thousands of years. As part of the International Decade of Oceanographic Exploration, which began in 1970, a unique research project called CLIMAP (Climate Long-Range Investigation Mapping and Prediction) has been started in order to fill this gap in our knowledge. A consortium of scientists working on this project is reconstructing the global pattern of climatic change through the last several hundred thousand years.

This multidisciplinary group, primarily from Columbia University's Lamont-Doherty Geological Observatory, Brown University's Department of Geology, and Oregon State University's Department of Oceanography, is reading the climatic record in layers of sediment that continuously collect on the ocean floor. Preserved in the long columns of these sediments raised from the ocean floor by oceanographic ships are the fossil remains of minute shells from microscopic organisms that once lived in the surface waters of the ocean. When alive, these organisms were delicately adapted to a narrow range of temperature and to other physical and chemical properties of the water they lived in. Climatically induced changes in these properties caused changes in the kinds of organisms that lived in any part of the ocean.



Sediments raised from the ocean floor contain fossilized skeletons of microscopic organisms from which scientists can determine the temperature of the ocean's surface thousands of years ago. The radiolarian shells, shown in the assemblage at top, once contained animals that were uniquely adapted to a narrow temperature range. Foraminifera, which have calcareous skeletons, are also useful in climate studies; the middle picture shows a warm-water "foram," and the lower enlargement is a cold-water counterpart. By studying which species prefer warm or cold temperatures, scientists can estimate past climatic conditions.

By means of mathematical techniques these fossil data can be transformed into estimates of past sea surface temperatures and other properties of the creatures' environment. These studies from all the world's oceans will, for the first time, accurately record past climatic change over thousands and hundreds of thousands of years. This detailed world record then can be used to test various theories of climatic change and to predict future trends, either theoretically or by analogy with the past. These data also may be used to predict which areas of the globe will be affected and to what degree they will be affected.

CLIMAP is an important step toward an understanding of climate, but much more is needed in both basic and applied research, particularly in such interlocking fields as meteorology and oceanography.

The possibility of a future significant climatic shift, with its consequent impact on our food and energy resources, emphasizes the pressing need to understand the causes and mechanisms of climatic change. Like many other environmental problems, climate is international, and the adjustments that must be made in order to deal with a changing climate will affect many nations. The manner in which we will adjust requires long-term planning. Perhaps this planning should logically fall under the jurisdiction of the new United Nations program for safeguarding the human environment headed by the Canadian industrialist Maurice Strong.

In any case, this past winter, when America shipped millions of tons of wheat to Russia and lowered its thermostats to conserve dwindling fuel reserves, should remind us, not only that we are living close to the limits of our resources under present climatic conditions, but also that our climate is changing—and could change substantially. □

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Memoirs of a Conference Voyeur

BY DANIEL S. GREENBERG

One of the least visible but most bitterly mourned consequences of the current drought in federal research funds is a recession on the international conference circuit, a social-professional institution as integral to science as the lab coat. As a longtime journalistic voyeur of the circuit, I appreciate the sense of loss.

That the practitioners and hangers-on of science must periodically communicate face to face is as incontestable to the trade as the second law of thermodynamics. However, the trappings of these confrontations provide some valuable insights into the lifestyle of science, which, in contrast to its substance—i.e., what scientists are doing in the lab and what it portends—is a matter infrequently discussed.

The difference between science and the rest of the world in this regard is that, while personal and societal benefits might ensue from the taxi drivers or delicatessen operators of New York, Paris, and Warsaw assembling to compare professional notes, governments do not stand ready to foot the cost of bringing them together. But since science is the ward of governments everywhere, the predilection of scientists for gathering together normally has been accepted as part of the price, though of late the stay-at-home scientific illiterates who dispense the travel funds have gotten crotchety and have been asking, "Is this trip really necessary?"

Well, the answer isn't simple, for the conference circuit is both more and less than it purports to be.

One of the cardinal propositions of conference circuitry is that, at best, someone else foots the bill for travel and lodging; at worst, the journeyer can write it off as a tax-deductible professional expense. But even more fundamental is the proposition that the assembly point must have delicious qualities, since a scientist who would not walk across campus to confer with an assemblage of visiting colleagues in many instances will feel impelled to be present if the meeting is set in the vicinity of the Adriatic Coast, the hills of Jerusalem, or the wintertime waters of the Caribbean.

Precise evidence of the drawing power of attractive sites can be found in the registration figures for the annual meeting of the American Association for the Advancement of Science (AAAS), the nation's largest scientific society. Assembling in Dallas in 1968, the AAAS drew 3,637 registrants; the following year, in Boston, registration totaled 7,891. Boston's large science-related population suggests some reason for the disparity but surely does not explain the more than doubling of registrants from one year to the next.

Researchers into these matters are alert to the imminence of a crucial test that will occur in June, when the AAAS assembles in Mexico City. Current forecasts of attendance run as high as 7,000. Considering the distance involved, this is an impressive figure when compared with the 6,607 that registered for last December's AAAS meeting in Washington.

One of the unresolved dilemmas of conference circuitry is that, while it is easy to draw the conferees to an attractive spot, it is often difficult to get them to sit still and pay attention to the purpose for which the conference was convened. Partial resolution has been achieved through a combination of attractive sites and isolation. Put simply, this amounts to luring them out and then locking them in.

One of the most heavily used sites on the circuit is the Airlie Foundation, some 40 miles from Washington, located on over 1,000 rolling acres near Warrenton, heart of Virginia's horsy-set country. Run by a storybook Texan, Murdock Head—who by age 32 held degrees in medicine, dentistry, and law—Airlie holds the lure of Washington for faraway conferees but is really too far away for a convenient night out in the capital. "Doc" Head calls it a "talent trap." Of course, Washington hotels abound with conference facilities, but even when the conferees are drawn mainly from the metropolitan area, many conference organizers prefer to spare them the temptation of showing up and then playing hooky.

Coming up fast on the conference circuit is Reisensburg Castle in the south of Germany, a meeting facility operated by Ulm University. Sounds fine, but once there, there's nothing to do but confer. Perhaps not unmindful that conferees get bored when they are confined to conferring, the castle's managers throw in a winetasting or two, plus a bus tour of nearby sights.

The formal business of most conferences is the recitation of papers that could just as easily be committed to print for interested readers. And in time they almost certainly will, whole or in bits and pieces, for the difficulties becoming visible in today's crowded and competitive world of science necessitate adoption of the first principle of the meatpacking industry—never throw anything away.

But far more important than hearing papers read is the opportunity for developing personal links, sniffing out the job market, placing graduate students, and exchanging gossip that no prudent scientist would commit to paper or the telephone. Scientists, in perhaps uncommon amount, possess the quality of praising in public and libeling in private. All of which accounts for the often-made comment that the conference wasn't very good but a lot of useful talk took place in the corridors and during coffee breaks.

Since conventions and conferences are widely celebrated as arenas for extracurricular personal relations that spouses might frown upon, the question arises as to whether the scientific fraternity makes extensive use of its travels for this purpose. The answer is that the "groupie" syndrome, personified by adulatory novices of science flocking around the luminaries of the frontiers of knowledge, is not unknown on the conference circuit; nor is it unknown for a grant-subsidized traveler to arrive at some distant meeting place with a woman not his wife. But by and large, one gets the impression that scientists tend to be among the "straighter" elements of American society. It has been privately confided, in fact, that a few years ago, when the officers of a major scientific society were seeking to make their usual booking of a large Washington hotel, the management there bluntly told them that the "girls" working the lobby had bitterly complained about the lack of business from the society's members.

Well, more and more grants are coming out with the provision that expenditures are not authorized for international travel without the granting agency's explicit permission—which is indeed hard to come by. Whether science will suffer is uncertain, but there is no doubt that its lifestyle is being crimped. □

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