Identical Twins Reared Apart

Minnesota researchers are conducting exhaustive study to identify differences; so far, it is the similarities they find fascinating

Bridget and Dorothy are 39-year-old British housewives, identical twins raised apart who first met each other a little over a year ago. When they met, to take part in Thomas Bouchard's twin study at the University of Minnesota, the manicured hands of each bore seven rings. Each also wore two bracelets on one wrist and a watch and a bracelet on the other. Investigators in Bouchard's study, the most extensive investigation ever made of identical twins reared apart, are still bewitched by the seven rings. Was it coincidence, the result of similar influences, or is this small sign of affinity a true, even inevitable, manifestation of the mysterious and infinitely complex interaction of the genes the two women have in common?

Investigators have been bemused and occasionally astonished at similarities between long-separated twins, similarities that prevailing dogma about human behavior would ordinarily attribute to common environmental influences. How is it, for example, that two men with significantly different upbringings came to have the same authoritarian personality? Or another pair to have similar histories of endogenous depression? Or still another pair to have virtually identical patterns of headaches?

These are only bits and pieces from a vast amount of data, none of it yet analyzed, being collected by the University of Minnesota twin study that began last March. So provocative have been some of the cases that the study has already received much attention in the press, and it is bound to get a lot more. The investigation is extremely controversial, aimed, as it is, directly at the heart of the age-old debate about heredity versus environment. Identical twins reared apart have been objects of scrutiny in the past, notably in three studies conducted in England, Denmark, and the United States. An indication of the sensitivity of the subject is the fact that the last one in this country was completed more than 40 years ago,* although the rarity of cases has also made this type of research rather exotic. The Minnesota investigators, however, have been able to locate more twin pairs than they expected. So far they have processed nine pairs of identical or monozygotic twins (as well as several pairs of fraternal or dizygotic twins used as controls) and, owing to the publicity given the project, have managed to locate 11 additional pairs to take part in the study.

The Minnesota study is unprecedented in its scope, using a team of psychologists, psychiatrists, and medical doctors to probe and analyze every conceivable aspect of the twins' life histories, medical histories and physiology, tastes, psychological inclinations, abilities, and intelligence. It began when Bouchard, a psychologist who specializes in investigating individual differences, heard of a pair of twins separated from birth, both coincidentally named Jim by their adoptive families, who were reunited at the age of 39. Bouchard did not have to look far to set up his study team, as Minnesota is a hotbed of twin research. There, ready to go to work, were Irving Gottesman, a behavioral geneticist who has spent his career studying twins and whose particular interest is the etiology of schizophrenia; psychologist David Lykken, who has been looking at the brain waves of twins for 10 years; psychologist Auke Tellegen, who recently completed a new personality questionnaire that is being used on the twins; and psychiatrist Leonard Heston, who has studied heritability of mental disorders with adopted children.

> "... native ability will show ... over a broad range of backgrounds."

Bouchard has taken an eclectic approach in developing the battery of exercises through which the twins are run. Each pair goes through 6 days of intensive testing. In addition to detailed medical histories including diet, smoking, and exercise, the twins are given electrocardiograms, chest x-rays, heart stress tests, and pulmonary exams. They are injected with a variety of substances to determine allergies. They are wired to electroencephalographs to measure their brain wave responses to stimuli in the form of tones of varying intensity, and given other psychophysiological tests to measure such responses as reaction times. Several handedness tests are given to ascertain laterality.

The physiological probes are interspersed with several dozen pencil-and-paper tests, which over the week add up to about 15,000 questions; these cover family and childhood environment, fears and phobias, personal interests, vocational interests, values, reading and TV viewing habits, musical interests, aesthetic judgment tests, and color preferences. They are put through three comprehensive psychological inventories. Then there is a slew of ability tests: the Wechsler Adult Intelligence Scale (the main adult IQ test) and numerous others that reveal skills in information processing, vocabulary, spatial abilities, numerical processing, mechanical ability, memory, and so forth. Throughout the 6 days there is much overlap and repetition in the content of questions, the intent being to "measure the same underlying factor at different times," says Bouchard. Mindful of charges of investigator bias in the administration of IQ tests in past twin studies, Bouchard has contracted with outside professionals to come in just for the purpose of administering and scoring the Wechsler intelligence test.

And the upshot of all this probing? Although the data have not yet been interpreted, there have already been some real surprises. Bouchard told *Science*: "I frankly expected far more differences [between twins] than we have found so far. I'm a psychologist, not a geneticist. I want to find out how the environment works to shape psychological traits." But the most provocative morsels that have so far become available are those

*A. H. Newman, F. N. Freeman, and K. J. Holzinger wrote up their study of 19 twin pairs in a 1937 book, "Twins: A Study of Heredity and Environment."

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that seem to reveal genetic influences at work.

Take the "Jim twins," as they have come to be known. Jim Springer and Jim Lewis were adopted as infants into working-class Ohio families. Both liked math and did not like spelling in school. Both had law enforcement training and worked part-time as deputy sheriffs. Both vacationed in Florida, both drove Chevrolets. Much has been made of the fact that their lives are marked by a trail of similar names. Both had dogs named Toy. Both married and divorced women named Linda and had second marriages with women named Betty. They named their sons James Allan and James Alan, respectively. Both like mechanical drawing and carpentry. They have almost identical drinking and smoking patterns. Both chew their fingernails down to the nubs.

But what investigators thought "astounding" was their similar medical histories. In addition to having hemorrhoids and identical pulse and blood pressure and sleep patterns, both had inexplicably put on 10 pounds at the same time in their lives. What really gets the researchers is that both suffer from "mixed headache syndrome"—a combination tension headache and migraine. The onset occurred in both at the age of 18. They have these late-afternoon headaches with the same frequency and same degree of disability, and the two used the same terms to describe the pain.

The twins also have their differences. One wears his hair over his forehead, the other has it slicked back with sideburns. One expresses himself better orally, the other in writing. But although the emotional environments in which they were brought up were different, the profiles on their psychological inventories were much alike.

Another much-publicized pair are 47-year-old Oskar Stöhr and Jack Yufe. These two have the most dramatically different backgrounds of all the twins studied. Born in Trinidad of a Jewish father and a German mother, they were separated shortly after birth. The mother took Oskar back to Germany, where he was raised as a Catholic and a Nazi youth by his grandmother. Jack was raised in the Caribbean, as a Jew, by his father, and spent part of his youth on an Israeli kibbutz. The two men now lead markedly different lives: Oskar is an industrial supervisor in Germany, married, a devoted union man, a skier. Jack runs a retail clothing store in San Diego, is separated, and describes himself as a workaholic.

But similarities started cropping up as soon as Oskar arrived at the airport. Both were wearing wire-rimmed glasses and mustaches, both sported two-pocket shirts with epaulets. They share idiosyncrasies galore: they like spicy foods and sweet liqueurs, are absentminded, have a habit of falling asleep in front of the television, think it's funny to sneeze in a crowd of strangers, flush the toilet before using it, store rubber bands on their wrists, read magazines from back to front, dip buttered toast in their coffee. Oskar is domineering toward women and yells at his wife, which Jack did before he was separated. Oskar did not take all the tests because he speaks only German (some are scheduled to be administered to him in German), but the two had very similar profiles on the Minnesota Multiphasic Personality Inventory (the MMPI was already available in German). Although the two were raised in different cultures and speak different languages, investigator Bouchard professed himself struck by the similarities in their mannerisms, the questions they asked, their "temperament, tempo, the way they do things"—which are, granted, relatively intangible when it comes to measuring them. Bouchard also thinks the two supply "devastating" evidence against the feminist contention that children's personalities are shaped differently according to the sex of those who rear them, since Oskar was raised by women and Jack by men.

Other well-publicized twin pairs are Bridget and Dorothy, the British housewives with the seven rings, and Barbara and Daphne, another pair of British housewives. Both sets are now in their late 30's and were separated during World War II. Bridget and Dorothy are of considerable interest because they were raised in quite different socioeconomic settings—the class difference turns out mainly to be reflected in the fact that the one raised in modest circumstances has bad teeth. Otherwise, say the investigators, they share "striking similarities in all areas," including another case of coincidence in naming children. They named their sons Richard Andrew and Andrew Richard, respectively, and their daughters Catherine Louise and Karen Louise. (Bouchard is struck by this, as the likelihood of such a coincidence would seem to be lessened by the fact that names are a joint decision of husband and wife.) On ability and IQ tests the scores of the sisters were similar, although the one raised in the lower class setting had a slightly higher score.

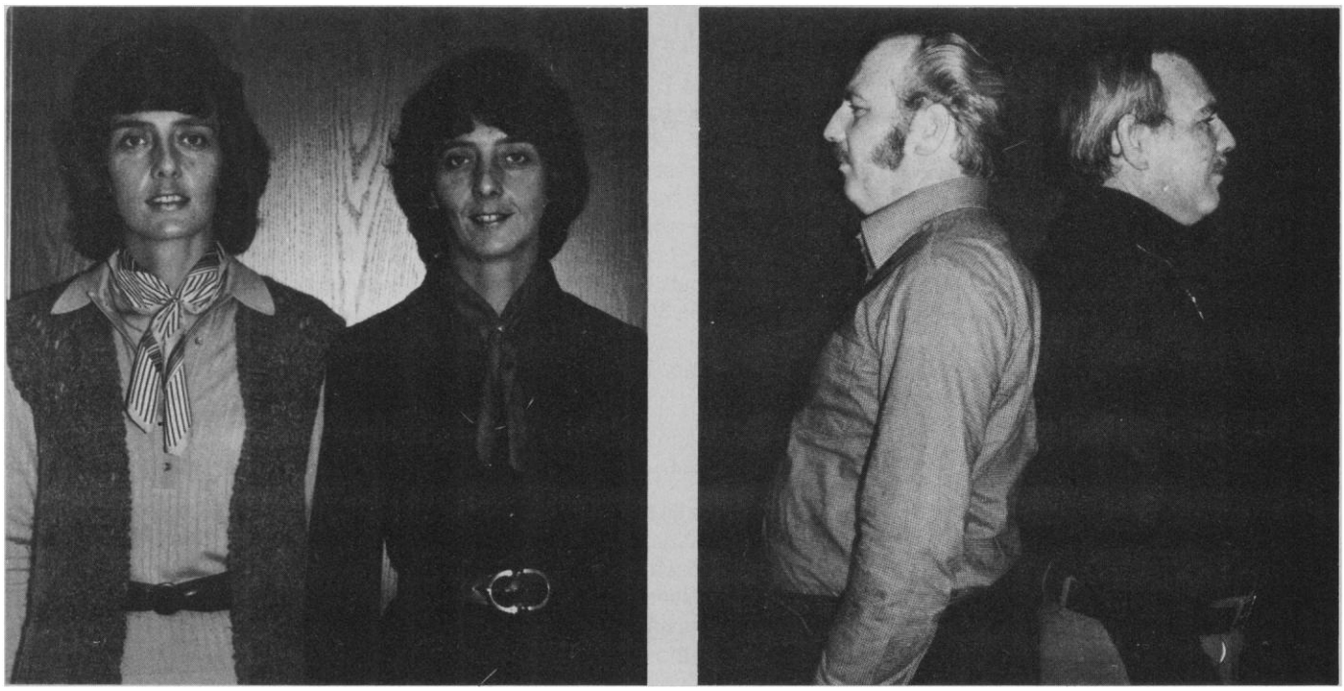
The other British twins, Daphne and Barbara, are fondly remembered by the investigators as the "giggle sisters." Both were great gigglers, particularly together, when they were always setting each other off. Asked if there were any gigglers in their adoptive families, both replied in the negative. The sisters also shared identical coping mechanisms in the face of stress: they ignored it, managed to "read out" such stimuli. In keeping with this, both flatly avoided conflict and controversy—neither, for example, had any interest in politics. Such avoidance of conflict is "classically regarded as learned behavior," says Bouchard. Although the adoptive families of the two women were not terribly different, "we see more differences within families than between these two."

Only fragmentary information is available so far from the rest of the nine sets of twins, but it supplies abundant food for new lines of inquiry. Two 57-year-old women, for example, developed adult-onset diabetes at the same time in their lives. One of a pair of twins suffers from a rare neurological disease that has always been thought to be genetic in origin. Another area where identical twins differ is in their allergies.

Psychiatrically, according to Heston, who conducts personal interviews with all the twins, there has been remarkable agreement. "Twins brought up together have very high concordance in psychiatric histories," he says. (For example, if one identical twin has schizophrenia, the other one stands a 45 percent chance of developing it.) But what is surprising is that "what we see [with the twins in the study] is pretty much the same as in twins brought up together." By and large, he says, they share very similar phobias, and he has noted more than one case where both twins had histories of endogenous depression. In one case, twins who had been brought up in different emotional environments—one was raised in a strict disciplinarian household; the other had a warm, tolerant, loving mother—showed very similar neurotic and hypochondriacal traits. Says Heston, "things that I would never have thought of—mild depressions, phobias—as being in particular genetically mediated . . . now, at least, there are grounds for a very live hypothesis" on the role of genes not only in major mental illnesses, where chemistry clearly plays a part, but in lesser emotional disturbances.

Other odds and ends:

• Two men brought up in radically different environments—one an uneducated manual laborer, the other highly educated and cosmopolitan—turned out to be great raconteurs. (They did, however, have very different IQ scores. The



Bridget Harrison (left) and Dorothy Lowe, the twins with the seven rings; and Oskar Stöhr (left) and Jack Yufe, raised, respectively, as German Catholic and American Jew.

numbers are confidential but the difference was close to the largest difference on record for identical twins, 24 points.)

• One of the greatest areas of discordance for twins was smoking. Of the nine pairs, there were four in which one twin smoked and the other did not. No one has an explanation for this. But, surprisingly, in at least one case a lifelong heavy smoker came out just as well on the pulmonary exam and heart stress test as did the nonsmoker.

• In a couple of cases, one of a twin pair wore glasses and the other did not. But when their eyes were checked, it was found that both members of each pair required the same correction.

• In the fascinating tidbit category: One pair of female twins was brought together briefly as children. Each wore her favorite dress for the occasion. The dresses were identical.

What is to be made of all this? As Tellegen warns, any conclusions at this point are "just gossip." The similarities are somehow more fascinating than the differences, and it could well be that the subjective impression they make on the investigators is heavier than is justified. Nonetheless, even the subjective impressions offer fertile grounds for speculation. Bouchard, for example, thinks that the team may discover that identical twins have a built-in penchant for a certain level of physical exertion. The latest pair to visit the laboratory, for example—23-year-old males—both eschew exercise (although both are thin as rails).

Lykken, who does the tests on the twins' central nervous systems, uses the case of the seven rings as an example for one of his tentative ideas. Fondness for rings is obviously not hereditary, but groups of unrelated genes on different chromosomes, producing pretty hands and other characteristics, may combine to result in beringedness. These traits, called idiographic—meaning particular to an individual rather than shared across a population—may not be as much a result of chance as has been thought. "There are probably other traits that are idiographic that may be almost inevitable given the [gene] combination. . . . More of these unique characteristics than we previously thought may be determined by a particular combination of genes." Lykken adds, "people get so upset when you suggest that the wiring diagram can influence the mind." But to believe otherwise "requires a naïve dualism . . . an assumption that mental events occur independent of the physical substrate."

Such talk begins to sound pretty deterministic, but Lykken insists that when the mass of data has been ordered "there will be material that will make environmentalists very happy and material that will make hereditarians very happy." One thing that will not make the environmentalists happy is the fact that IQ seems to have a high degree of heritability, as indicated by the fact that of all the tests administered to identical twins separately reared, IQ shows the highest concordance. It is even higher than the introversion-extroversion personality trait, a venerable measure in psychological testing that shows higher concordance than other conventional categories such as sense of well-being, responsibility, dominance, and ego strength.

As several investigators mentioned to *Science*, the scores of identical twins on many psychological and ability tests are closer than would be expected for the same person taking the same test twice. Lykken also found this to be true of brain wave tracings, which is probably the most direct evidence that identical twins are almost identically wired. Several researchers also felt that there is something to the idea that identical twins reared apart may be even more similar in some respects than those reared together. The explanation is simple: competition between the two is inevitable; hence if the stronger or taller of the two excels at sports, the other twin, even if equal in inclination and ability, will avoid sports altogether in order not to be overshadowed. Or one twin will choose to be a retiring type in order not to compete with his extroverted sibling. In short, many twins, in the interest of establishing their individuality, tend to exaggerate their differences.

Although the tentativeness of the findings so far must be repeatedly emphasized, at least one of the Minnesota researchers believes it may be safe to hypothesize that only extreme differences in environment result in significant differences between identical twins. Lyk-

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for sperm donations. Five said yes, and Graham made collections in the San Francisco and San Diego areas for the Hermann J. Muller Repository for Germinal Choice, as he calls his subterranean sperm bank on his 10-acre estate in Escondido, California.

The only Nobel prize winner who has so far admitted having his sperm on ice is William B. Shockley of Stanford University, who shared the Nobel Prize in Physics in 1956 for work on the development of the transistor. "I don't regard myself as a perfect human being or the ideal candidate," he says, "but I am endorsing Graham's concept of increasing the people at the top of the population." Shockley, who has written several controversial papers suggesting that blacks are genetically inferior, has also backed negative eugenics. In an address to the American Psychological Association, for instance, he proposed that the government pay $1000 for every IQ point below 100 to welfare clients willing to submit to sterilization. This, he said, would shrink welfare rolls within a generation.

Many observers take a dim view of Graham's project, not the least of which is Thea Muller, the widow of Hermann J. Muller. She has demanded that the California sperm bank stop using her Nobel-winning husband's name. In 1971, she rejected a request from Graham for permission to name the sperm bank after Muller. "I wrote him saying I could not agree," she says, "but he's done it anyhow. The program has fallen into the wrong hands." She says her husband discussed with Graham the idea of a sperm bank emphasizing not only a donor's intelligence but also his "human" traits. She says, however, that he dropped out of the venture when the principles could not be agreed upon, and she now feels the program has been given the wrong slant.

Pressed by reporters, laureates across the country have expressed a variety of views on the Nobel sperm bank, the most frequent seeming to be bemused indifference. "On one hand," says Howard Temin, who won the 1975 Nobel prize for his work in genetics, "genes may directly control personality, and therefore progeny of Nobel laureates will be equivalent to Nobel laureates—which would be awful. Who would want a world full of such people? On the other hand, genetics may have nothing to do with it—so why bother? In either case, it's a no-win situation."

Do the children of Nobelists in fact ever amount to anything? Many, of course, do not. But there are at least five sets of laureate parents and offspring on the Nobel roster. In 1975, Aage Bohr won the Nobel Prize in Physics, while his father, Niels, did the same in 1922. In 1970, Ulf von Euler won the prize for his work on the chemistry of nerve impulses. His father, Hans von Euler-Chelpin, won the prize in 1929 for his research on the chemistry of fermentation enzymes. In 1937, the English physicist G. P. Thomson won the prize for his work on the diffraction of electrons by crystals, while his father, J. J. Thomson, received the prize in 1906 for work on the conduction of electricity through gases. In 1935, Irene Joliot-Curie shared the prize in chemistry with her husband, Frederic Joliot, for synthesizing new radioactive elements, while her mother, Marie, received the prize not only in 1911 in chemistry, but also with her husband in 1903 for discovering radioactivity. And finally, the father-and-son team of W. H. Bragg and W. L. Bragg won the prize in 1915 for their work on studying crystal structure by means of x-rays.

All of which, of course, says little about how children reared away from the intellectual and social influence of their Nobel parents will grow up. And there are other unknowns. Nobel sperm may be bright, but the donors are usually far along in years. Shockley, for instance, is 70, and recent studies suggest that the chance of having a Mongoloid child increases not only with the mother's age, but also with the father's. Then too, brighter may not necessarily be better. "There is no guarantee that high IQ people produce better people or a better society," says Daniel Callahan, director of the Hastings Institute of Society, Ethics, and the Life Sciences. "It is not the retarded kids of the world who produce the wars and destruction."

Despite mixed reviews, at least Temin has found a bright side to the Graham episode. "The world," he says, "can't be in such bad shape if a thing like Nobel sperm banks makes front-page headlines. Usually you only get something like this in the dog days of August. Maybe things aren't as desperate as I was afraid they were."

William J. Broad

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ken says, after observing so many similarities, that it is tempting to conclude that "native ability will show itself over a broad range" of backgrounds. So either a seriously impoverished or a greatly enriched environment is required "to significantly alter its expression."

Such an idea, if it gained broad acceptance, would have major impacts on social policies. But Bouchard wants to keep his study separate from politics, emphasizing instead that the research is "very much exploratory."

The data, once assembled and analyzed, should provide a gold mine of new hypotheses. If a great many pairs of twins are collected, says Bouchard, they may be able to present the findings quantitatively; otherwise, the findings will be in the form of case histories. Tellegen, however, whose main interest is the methodology, says "we want to invent methods for analyzing traits in an objective manner, so we can get statistically cogent conclusions from a single case." He points out that psychoanalytic theory was developed from intensive study of small numbers of people and that behavioral psychologist B. F. Skinner similarly was able to develop his theories by studying small numbers of animals. Take the twins with the identical headache syndromes: with just one pair of twins the door is opened to a new field of research.

The twin study may also make it clear that estimating the relative contribution of heredity and environment to mental and psychological traits can never be boiled down to percentages. Some people, for example, may have authoritarian personalities no matter what their upbringing; the authoritarianism of others may be directly traceable to their environment. Similarly, with intelligence, some people may be smart or dumb regardless of outside influences, whereas the intelligence of others may be extremely malleable. Theoretically, variations from individual to individual in malleability and susceptibility may be so great that any attempt to make a generalization about the relative contribution of "innate" characteristics to a certain trait across a population would have no meaning.

Twin studies have been regarded with suspicion in some quarters because, according to Gottesman, the behavioral geneticist who worked with James Shields in England, they were "originally used to prove a genetic point of view." The most notorious of these were the studies of Cyril Burt on intelligence of twins reared separately, which were sub-

sequently discredited. But, says Gottesman, "this study is a continuation of the efforts of Shields and Nielsen [Niels Juel-Nielsen, a psychiatrist at the University of Odense in Denmark] to challenge received wisdom about the roles of genes and environment." Everyone, observes Gottesman, "seems to have made up their minds one way or the other." With such a dearth of data of the kind that can only be obtained by studying persons with identical genes raised in different environments, people have been free to be as dogmatic as they please.

Bouchard had a devil of a time getting funding for his study. Various probes at the National Institutes of Health were discouraged on the grounds that the study was too multidisciplinary for any institute to embrace it. He finally got some money from the National Science Foundation.

Although the ultimate conclusions of the study may well be susceptible to sensationalizing, Gordon Allen of the National Institute of Mental Health, head of the International Twin Society, does not believe it will find any "new and unique answers." The sample will not be large enough for that, and besides, too few of the twin pairs were reared in environments so radically different as to bring genetically based behavioral similarities into stark relief.

The most solid and unequivocal evidence will be that supplied by the physiological findings. Although the similarities are the most titillating to most observers, it is the discordances that will be the most informative. For any difference between a pair of identical twins is "absolute proof that that is not completely controlled by heredity."

At this point, no one can make any generalizations beyond that made by James Shields, who died last year. Shields wrote that the evidence so far showed that "MZ [monozygotic] twins do not have to be brought up in the same subtly similar family environment for them to be alike." He concluded, "I doubt if MZAs will ever be numerous and representative enough to provide the main evidence about environment, or about genetics, but . . . they can give unique real-life illustrations of some of the many possible pathways from genes to human behavior—and so will always be of human and scientific interest."

—CONSTANCE HOLDEN

Marriage of Conservation and Development

By their new strategy, environmentalists seek to help the world's poor and abandon their "elitist western mould"

A "World Conservation Strategy" designed to make conservation and development mutally supporting instead of antagonistic was announced on 5 March in Washington and numerous other capitals around the world.

Clearing of a tropical rain forest may cause problems.

The strategy, set forth in a detailed statement prepared with the help of some 700 environmental scientists and other specialists, has resulted from an initiative taken 3 years ago by the International Union for the Conservation of Nature and Natural Resources with the cooperation of the United Nations Environmental Program, the World Wildlife Fund, the Food and Agricultural Organization, and Unesco. Altogether, some ten international organizations have endorsed the conservation strategy, which has three main objectives:

- To maintain essential ecological processes and "life-support systems," such as the regeneration and protection of soil, the recycling of nutrients, and the cleansing of waters.
- To preserve genetic diversity, on which depends "the functioning of many [ecological] processes" and the "breeding programs necessary for the protection and improvement of cultivated plants, domesticated animals and microorganisms, as well as much scientific and medical advance, technical innovation, and the security of many industries that use living resources."
- To ensure that use of fish and wildlife species and valuable ecosystems such as forests and grazing lands can be sustainable and thus available for the support of "millions of rural communities as well as major industries."

Secretary General Alejandro Orfila of the Organization of American States (OAS), in announcing the conservation strategy at a large ceremony held at the OAS headquarters in Washington, said that it is "motivated by the conviction that the integration of conservation and environmental consideration into the world development process is essential to the future expansion of a dynamic world society."

Orfila observed that the initial upsurge of interest in conservation came more than a decade ago but seemed to abate with such troubles of the 1970's as the escalation of world energy prices, "rampant global inflation interspersed with periodic recessions," and a general problem of protracted economic instability and insecurity. But it is evident, he said, "that had mankind paid equal attention to the parallel environmental and conservation challenges before it, the current world economic crisis might be less severe.

"Rational use of natural resources is of vital and equal importance to both the advanced and developing nations," Or-

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