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ABSTRACT

This publication is intended to present science teachers with an opportunity to communicate to students the idea that science is an ongoing and never-ending process. The booklet contains supplemental materials, valuable as enrichment materials. A selection of ongoing research in the biological sciences, physics and astronomy, oceanography, meteorology, paleontology, anthropology and the social sciences is presented. Additional readings associated with the work of the scientists involved in the research projects are included. The articles are a part of a coordinated package of materials designed to include film as well as text, originally prepared by Warren Kornberg of the National Science Foundation and authenticated by the scientists directly involved in the research. (EB)

accounts of ongoing scientific research

SCIENCE SELECTIONS

THE
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SCIENCE SELECTIONS

Warren Kornberg
National Science Foundation, editor

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FOREWORD

For all that the average layman knows, science is a string of "breakthroughs" and surprise announcements that spring full blown from the front pages of the newspapers like Athena, fully armed, from the head of Zeus. We who teach science know better. We know that scientific research is a process. It has a beginning, a middle and, while individual research projects may end, each such end is really another beginning.

How well do we communicate to our students that sense of science as an ongoing and never-ending process? How well do the materials with which we work convey the sense of continuum rather than of progress by fits and starts? We as science teachers are fortunate to have made available to us the supplemental material in this small collection of accounts of research in progress. These and others which we hope to issue in the future are not accounts of "breakthroughs." They testify to the continuum. They are an effort to examine research during that long period between its beginning and its often dramatic conclusion. That middle realm, in which questions are still as important as answers, and answers and the new questions they spawn may be beginning to emerge, is, after all, where scientists spend most of their lives. It is also where the real excitement of science lies, as these accounts demonstrate.

The articles in those booklets are part of a coordinated package of materials, designed to include film as well as text. They were originally prepared by Warren Kornberg of the National Science Foundation and authenticated by the scientists directly involved in the research. We think they are valuable in themselves, as well as important, as enrichment materials. Their value, especially to teachers, is additionally enhanced by the bibliography of additional readings (see p. 61) recommended by the researchers themselves, and by the fact that the more important of the articles are also the subject of the films which are being distributed along with Science Selections by the National Science Teachers Association. We and our students are richer for having them made available to us.

Robert H. Carleton
Executive Secretary
National Science Teachers Association

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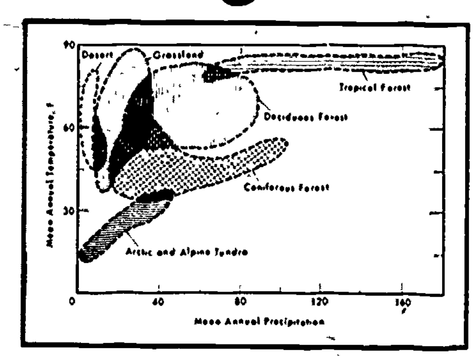
biological sciences

Ecologists get it all together



Scientists attempting to study complete life-and-environment systems are launching a revolutionary new era in the ecological sciences.

Ecology is the study of living things in relation to each other and to their total environment. It is the study of dynamic systems.

It is done traditionally by individual biologists who concentrate on pieces of an ecological system: a mammal, a bird, an insect population, a kind of plant, a glade or a stream. Although these ecologists must often combine, in their research, elements of such diverse scientific disciplines as biology, chemistry, meteorology, physics and geology, they are usually restricted to studying only a piece of any ecosystem in depth. Their hope is that enough scientists doing this with enough pieces of enough ecosystems over enough time will produce the fragments of a mosaic. The assumption is that these, ultimately, would evolve and be assembled into a comprehensible whole.

"Big Science"

Now ecology is undergoing a revolution.

It is becoming "big science."

It is growing to meet the demands of the "ecosystems analysis" or "biome studies" approach to ecological research, under the sponsorship of the National Science Foundation in support of the United States' contribution to the 57-nation International Biological Program.

It focuses on the study of ecological systems the combined talents of many researchers from many disciplines. Together they hope to develop an understanding, as no individual researcher could, of the complex and dynamic relationships among biological and physical phenomena that make an ecosystem function.

To some ecologists it seems to be the way their science always should have been done. "We're sold on it," says Dr. Jerry Brown of the Army's Cold Regions Research and Engineering Laboratory, head of the IBP team studying the Arctic tundra biome as an ecological system. "It's the first chance we've ever had to put a team together on a project, to design so large and complex an ecology study in advance. A group can get out results quickly; an individual could not."

According to Dr. Lee M. Talbot, an ecologist now with President Nixon's Council for Environmental Quality and Dr. George M. Van Dyne, director of Colorado State University's Natural Resource Ecology Laboratory and chief of the IBP grasslands biome study, the systems approach is the wave of the future in ecological science. "An ecosystem is a complex, dynamic thing," says Talbot. "The only way it can be studied is as a system of inter-related parts."

The Systems Approach

"There are two ways you can organize ecological research on total systems," says Van Dyne, "from the bottom up or from the top down. You don't build a car from the bottom up, out of 25,000 unrelated pieces. You design the whole system first, and then you design the subsystems. Then you can put the small pieces into place. But unless you start with a whole-system concept," he believes, "you will not end up with a system you can manage."

A biome is a basic ecological unit, characterized broadly by its soil and climate. Despite differences in the species that inhabit them, similar biomes are essentially the same ecologically from continent to continent. Even though, for instance, the animals and plants of African or Russian and North American grassland biomes may differ, they occupy parallel slots in their physical and biological environments. The study of a biome on one continent provides a significant level of insight into the ecology of similar biomes elsewhere.

The 400 or so scientists working in biome-based teams under the combined aegis of the NSF Ecosystem Analysis Program and the U.S. IBP have selected six terrestrial biomes for study from among the world's ecosystems. These are tropical, coniferous and deciduous forests, tundra, grasslands and desert. "There may be few biomes in the world or many," says Van Dyne, "depending on whether you are a lumper or a splitter." He identifies himself as a "lumper", and opts for the few.

Individually the biomes are representative of ecosystems the world over; together they can be taken as representative of the world as an integrated ecological system. Hopefully the systems-oriented study of them will provide scientists and resource managers with an invaluable tool. It should enable them ultimately to forecast the effects on the world's ecosystems of decisions and changes that up to now have been made blindly and, in some cases, disastrously.

For example, in the American grasslands, there is a bird called the lark bunting. It likes to build its nest near a scraggy plant called the saltbush. Should the land be overgrazed and the saltbush disappear, so could the lark bunting.

But the bunting is one of the ecosystem's principal controls of grasshoppers and other insects; if the bunting disappeared, the insects could proliferate out of control with disastrous effects not only on the natural ecosystem but on a vital resource as well.

How much grazing can the land take before ecological disaster strikes?

The computerized, mathematical models the ecologists will develop out of the results of the research, says Van Dyne, ought to enable managers to help answer such questions. He expects, for instance, to be able to feed into the computer models such simulated resource management decisions as the addition or subtraction of lands assigned to grazing purposes. "Then we could run 200 years of simulated consequences through the computer to see what the ultimate impact of the decision might be," he says.

Gaining Momentum

None of the other biomes are as far along as the grasslands. Funding for them has been building slowly within the National Science Foundation, which spent $4 million last year in support of all of the U.S. programs involved in the International Biological Program. Of that, the grasslands biome got almost half; the desert biome studies got $650,000 and a little money was made available to the deciduous forest biome study. This year the Foundation expects to be able to spend some $7.5 million on IBP programs, and the grasslands, desert, coniferous and deciduous forest biome programs are all benefitting. The NSF's overall budget request for the effort next year is $2.5 million higher, with the biome efforts expected to gain momentum proportionately. (Additional support "in kind" has been provided by such other Federal agencies as the Agricultural Research Service, the Forest Service, the Bureau of Sport Fisheries and Wildlife, the Bureau of Land Management, the Office of Naval Research, and the Atomic Energy Commission. NSF is the Government's "lead agency" for the programs.)

The tundra biome studies were not originally funded as such, but were able to begin on the basis of studies its teams were asked to make of the impact of resource development in the Alaskan Arctic. "We just did the research," biome director Jerry Brown points out. "We weren't producing any 'go-no-go' answers.... We had to design our research around the stresses connected with increased activity in the Arctic," he says. "Nevertheless, the concern following oil discoveries in the Alaskan Arctic did give us a chance to get a quick start."

The tundra biome started with $360,000 in non-IBP funds provided by NSF, and about $75,000 more from industry.

"We have been looking at short-term stresses," says Brown. "Now we plan to take a longer-range, in-depth look," with an additional $990,000 recently made available under IBP and the new NSF Arctic Research Program.

As of the current government money year, then, five of the six biome studies are under way. The early-starting grasslands have been allotted $4.4 million over four years; the deciduous forest biome studies have been given $1.96 million in the last three years; the desert biome has been given almost $2 million in the last two years; the coniferous forest biome study got its first $462,000 this year and the tundra study, with a $1.4 million running start, hopes now to maintain its momentum more formally under the aegis of IBP and NSF's Arctic Program.

Problem-Oriented Research

The biome incorporating the Eastern deciduous forest regions is among the more "civilization oriented" of the biome studies. It stresses the impact of man's activities in the eastern United States where two-thirds of the nation's people live on one-third of the land area, says Dr. Stanley I. Auerbach of Oak Ridge National Laboratory, director of the Eastern deciduous forest biome. Most important, he believes is the coupling of land and water in the landscape segment called a watershed.

"We see this coupling increasingly in the pollution of our lakes and streams, generally from materials produced or used on the land. You cannot really separate land and water," says Auerbach, "because they are parts of a complex interacting system; we're trying through the systems approach to focus on the processes which couple these parts. . . . "

"We're not going to end up as a pollution study," he declares.

"Nevertheless, to do something in total abstraction, without regard to the very real environmental problems now being encountered would be to work in a vacuum; we would be making the same mistakes that science has made for years."

Another Emphasis

The scientists involved in the Western-oriented coniferous forests biome study are also concerned with land-water interactions and with the impact of man, says Dr. Stanley P. Gessel, director of the College of Forest Resources at the University of Washington in Seattle and director of the coniferous forest study. But each of the biome teams establishes its own emphases.

"We do not intend to focus on the problems created by civilization," declares Gessel, "though we will take those problems into account in the manipulative phase of the research."

In the Desert

In the desert biome program, headed by Dr. David W. Goodall of Utah State University, researchers from 19 institutions have assembled a list of target studies that includes:

- Studies of water relations, growth of tops and roots, photosyntheses and mineral nutrition in important shrubs, perennial grasses and annuals.
- Investigations of food habits, bioenergetics, and population dynamics of rodents, hares and rabbits.
- Similar studies on the more important herbivorous birds.
- Investigations of the food habits, metabolism and population structure of ants, termites and grasshoppers.

- Studies on nitrogen cycling, including the role of algal soil crusts in nitrogen fixation—the process by which plants convert free atmospheric nitrogen into forms useful in biological processes.

A Missing Link

Only the tropical forests biome study has yet to be funded. But the planners of the biome studies feel that it represents a gap that ultimately will have to be filled. Not only do current—and widespread destructive slash-and-burn agricultural practices of many parts of the tropics threaten irreparable damage to the tropical ecosystem, several biome directors point out, but the world ecosystem cannot be thoroughly understood without this key component.

Efforts are being made by the new biome director, the University of Florida's Dr. H. T. Odum, to assemble existing knowledge of tropical ecosystems. But none of the scientists involved regard this as more than a stopgap.

"If we do not get the data from the humid tropical forests, we will be unable to make any models that encompass the vegetation of the world," says Dr. Helmut Lieth of the University of North Carolina, until recently director of the tropical forests biome effort. "The tropics always contain the extremes," he says, "and if you exclude the extremes you are never safe in ecology."

The Early Models

The early models to come out of the system will not be as finely detailed as the ecologists eventually would like, though they are expected to be useful as well as informative.

"We will be working at a fairly coarse level of resolution when we get to modeling across biomes," says the grasslands' Van Dyne. But he believes the effort will have to be made if the projects are to make any sense. "If we are going to try to see what the effect of a resource management decision is on a large watershed," he says, "we are going to have to have inputs across biomes."

"Scientists used to think," summarizes Dr. Charles F. Cooper director of the National Science Foundation's Ecosystem Analysis Program, "that they needed to know everything about everything they were studying if they were to feel that they knew anything at all. But the hope in the biome studies is that we can work on what is important, refining our selection of targets as we go along.

"This selection could conceivably lead to the embarrassment in the end that the model missed the most important element—that the real regulating factor in an ecosystem was some virus in the soil or some such thing, and the whole process will collapse because nobody thought to look at that at all.

"But it is our expectation that 80 or 100 scientists working together, exchanging information as they go rather than holding it back for later publication, will really identify and concentrate on the most important elements of the system.

"That is the principal on which the whole biome effort is based."

And to the Environmental Council's Dr. Talbot, the effort is worth almost as much as the result.

"They are doing a whole new thing with ecological research," he said recently. "The science has never been done this way before."

DDT IN SMALL BIRDS

Migratory fowl could be a link between pesticides and hawks, falcons

Migratory birds–vireos, buntings, warblers, catbirds, olive-backed thrushes and others–appear to be a way-station on the route of persistent pesticides up through the environment.

They are the ones that take up pesticides like DDT in the insects and grain they eat off sprayed land. They concentrate it in the fatty parts of their bodies. It is further concentrated in the bodies of carnivorous birds further up the food chain.

Whether or not the migratory birds are being harmed by the pesticide burdens they carry is not yet known.

It is known, however, that ospreys, brown pelicans, peregrine falcons, bald eagles and other meat- and fish-eating birds are already in serious trouble as a result of the effects of pesticides on their life and reproductive processes. For one thing, the chemical concentration in their bodies appears to interfere with their ability to lay eggs with shells strong enough to insure that young will hatch.

An intermediate step

But except for an occasional look at starlings, grebes and robins, little attention has been paid so far to the terrestrial migratory birds in the ecological slots between the carnivores at the top and insects at the bottom of the food chain.

These birds, says Dr. David W. Johnston, associate professor of zoology at the University of Florida at Gainesville, are probably an intermediate step in the ecological concentration of pesticides. In addition, because they burn up their fat as they migrate, they can also be a clue to what happens to pesticides working their way through the body's biochemical systems.

The assortment of "before" and "after" migratory birds necessary to prove his theses has been virtually dropped into his lap. He has found a collection of preserved birds, killed either as they just started or just finished their biennial migrations, dating back almost a decade. He got them from television tower personnel in Tallahassee and Jacksonville. They for years have been picking the birds up where they fell dead after colliding with the television towers, and giving them to amateur taxidermists, museums, schools, and other collectors.

"They'd been collecting them for 15 years," says Johnston. "And we had some in the lab freezer. So when I thought about the pesticides, I saved some from the mounters and the skeleton makers."

Collecting the birds

Johnston, whose research is supported by the National Science Foundation, is beginning to check the bodies of fat birds downed as they started south in the autumn and lean ones at the end of their journey, being collected on Grand Cayman Island in the Caribbean where many of the birds winter over. Northbound journey's-end birds can be collected in the spring, at the base of the television towers; spring starters may be collected in Jamaica.

Johnston wants to see where in the birds' bodies the pesticide goes once the fat in which it is usually stored is consumed. "I intend to check several tissues," he says. "If they use up the fat, the pesticides may go to muscles or to the central nervous system. If it gets into the central nervous system, it can affect the fatty materials around the nerve cells and could be fatal."

Johnston also expects to compare the concentration of the chemicals in the bodies of migratory birds and of falcons further up the food chain; he will also compare southbound birds, who fattened in the pesticide-rich fields of North America, with their northbound cousins fattened "organically" in the Caribbean.

The Role of Life Inside of Rocks

Just as tiny microorganisms called phytoplankton are at the base of the oceans' life cycle, tiny rock-inhabiting organisms may be at the root of desert life cycles. Florida State University ecologist E. Imre Friedmann suggests that algae which are able to draw food and water from desert rocks could play an important "primary production" role in the desert ecosystem.

Friedmann, who recently showed these rock-dwelling organisms to be present in virtually all desert environments, is working under a National Science Foundation grant to find out just how basic a role they play in the desert life systems. "We don't know yet just what kind of organism might graze on the rock-inhabiting (lithophytic) algae," he says, "but they seem always to be associated with bacteria."

The bacteria, he suggests, could be the link between the algae inside the rock and the rest of the ecosystem outside. He has yet to show, however, what the critical link is that enables other desert life forms to "graze" on the ubiquitous lithophytes.

Lead kills ducks and geese, but how?

Tens of thousands of ducks and geese die every year of lead poisoning because spent buckshot contaminates the ponds in which they feed. But not all of them show evidence of having eaten the shot. In fact mallards, which are surface dabblers, show more lead poisoning than do other ducks which are bottom feeders. And Atlantic Flyway water fowl, which more frequently turn up with pellets in their gizzards, less frequently die of lead poisoning than do Mississippi or Central Flyway birds.

A University of Montana botanist, Associate Professor Mark J. Behan, has noticed these inconsistencies and begun to look for another source of the fatal lead poisoning than the eaten pellets themselves. Behan is working under a National Science Foundation grant to see if the contamination from the pellets can be traced up through the food chain, by way of the plants on which the ducks feed.

If the water plants absorb fatal amounts of lead from contact with buckshot—which covers the floors of some ponds to a density of two or three pellets per square foot—then the problem of protecting the birds from lead poisoning may be a different one.

Ploughing the pond bottoms or depositing enough sediment to keep plant roots from contact with the pellets, he suggests, may turn out to be a way to keep the lead out of the birds' food chain. Currently, the major effort is the search for alternates to lead in the manufacture of shot.

Behan is conducting both laboratory and field experiments to see how much lead plants can take up, and if that alone can explain the discrepancies he has seen. "You've got to be prepared to be wrong in a piece of research like this," Behan warns. "It might turn out not to be the plants that are responsible; it might be something like industrial pollution.

"But something has to account for the fact that pellets themselves aren't always the poisoner. It's time we checked out other possibilities, and the food chain is a good place to start."

Enzymes and Sperm Survival

The sperm is unique among body cells in a number of ways. Not the least of these is its ability to survive and move toward the egg it is to fertilize through what might appear to be an alien and even hostile environment. That it does survive and perform its function as a key link in the reproductive cycle appears to depend not only on the sperm itself but on a complicated chemical system involving substances in the fluid surrounding the cell as well.

The system seems capable of selecting some sperm to succeed in fertilizing an egg; others—the defective or the aging for instance—seem somehow to be made to fail.

The details of the chemical reactions that create this effect are still largely unknown. But research into the biochemical side of the reproductive process is beginning to turn up some hypotheses. Verifying them could be critical to understanding, correcting errors in or even controlling the reproductive process.

A key to the complicated processes by which sperm survive and function as they do, says Dr. Bruce M. Anderson, chairman of the Department of Biochemistry and Nutrition at Virginia Polytechnic Institute and State University, appears to be be in the enzymes involved. Enzymes are protein molecules whose job it is to make biochemical reactions occur rapidly. Many of them, each apparently with a special function, accompany sperm as parts of the seminal fluids. Some of these enzymes appear to aid the healthy sperm along; others seem able to contribute to the weeding out of failing cells. There are many enzymes, undoubtedly with many yet-unknown functions, which it is necessary to characterize before a thorough understanding of this vital link in the reproductive process can be understood.

Anderson, working with Dr. John R. Vercellotti under a National Science Foundation grant, is seeking to unravel those biochemical functions.

Bacteria, Acid and Mine Drainage

An ecological approach to the problem of acid mine drainage is being taken by a researcher at West Virginia University. The scientist, Dr. Wayne N. Millar, believes that balance among bacterial populations in mine wastes may be a factor in the production of sulfuric acid, which represents a major pollution problem in Appalachia and other mining regions.

"I won't say we can clean up the acid drainage problem this way," says Millar, "but nobody's ever looked at the problem from the ecological side before."

Dr. Millar, working under a National Science Foundation grant, is investigating the relationship between two kinds of bacteria: one whose biological processes are responsible for some 75 percent of the sulfuric acid in mine drainage, and another that appears to live on the organic waste products of the first. If the second bacterial population were controlled, Millar suggests, then the accumulation of biological wastes might act to control the population of the first, and thereby limit the production of acid.

ORIGIN TRACKED ON

Flies that migrated to the island of Hawaii within the last 700,000 years

Seven hundred thousand years ago the world was already old and incredibly rich in life forms.

Homo sapiens had emerged from some 60 million years of evolution, horses had taken on their modern form, the wolf and the dog were distinct species, and it had been 10 million years since the fox had branched off from the main trunk line of canines.

Most of the world's species as we know them had already evolved; the study of their evolution was to become a study of their adaptive processes and their fossil remains.

But at the southern end of the Hawaiian Archipelago, 30 miles across the Alenuihaha Channel from the young but life-rich island of Maui, a new ecology was being born on the still-erupting island of Hawaii.

Only recently thrust out of the sea, still heaving and boiling with the seismic and volcanic events that gave it birth, Hawaii was preparing ecological slots or niches for what was destined to become a rich array of new life forms. And candidates for these slots were arriving, bird- or wind- or water-borne seeds of living species which would subsequently evolve into new species in the isolation of their island home.

A wandering fruit fly

Among them, according to Dr. Hampton L. Carson, a population geneticist at the University of Hawaii, was a lonely female fruit fly of some ancestral population of the present-day species *Drosophila adiastola*. Her family was already well established in the more mature environment of Maui; her belly was rich in fertilized eggs.

She must have existed; "Nothing else explains what we see," says Dr. Carson. But why she left Maui and how she crossed the heaving channel to hatch those eggs in receptive, virgin soil are lost in the mists of time.

An evolutionary drama

Nevertheless, in the intervening millenia that lonely, adventurous *Drosophila*, and perhaps a handful of other species "founders," appear to have become the principal characters in an evolutionary drama that is only now beginning to unfold. They helped create, on the island of Hawaii, an evolutionary laboratory that may be unique in the world: an isolated environment of known beginning, in which the origin of species can be traced to its source.

OF SPECIES HAWAII

evolved explosively into new species; their study holds keys to evolutionary theory

Because the island of Hawaii is a closed system, both in time and space, it may be possible there to detect the events that permit or force new species of animal to evolve. It may be possible there to write in many of the missing pages in the theory of species development and differentiation. There may be a chance to determine, for instance, whether or not survival-linked adaptations in a fierce competition for scarce ecological slots—the survival of the fittest—is the necessary key to Darwin's classical theory of evolution.

Those are some of the tasks Dr. Carson has set for himself. The 56-year-old geneticist recently left a berth at Washington University in St. Louis for a new one in Hawaii. There he intends to cap more than two decades of research into evolutionary genetics by zeroing in on the trail left by *Drosophila* as it drifted genetically, in the evolutionary brief space of a few hundred thousand years, to become hundreds of independent species occupying as many vacant slots in Hawaii's still-evolving ecology.

He believes—and he is attracting support for his views from other geneticists—that Hawaii holds evidence that modifies the notion of evolution as a gradual process. Evolution may not have to begin with minor changes as a species seeks to adapt to new environmental demands and end aeons later with the emergence of entirely new species.

Dr. Hampton L. Carson of the University of Hawaii, a National Science Foundation grantee, surveys the Haleakela Crater on the island of Maui where he traced the "founder" species of fruit flies responsible for the explosive, recent and ongoing evolution on the nearby island of Hawaii.

The fact that the evolutionary history of the island of Hawaii can be dated, says Carson, and of the evolutionary explosion there of *Drosophila* species found nowhere else in the world, suggest another or at least an alternate, route for the origin of species: evolutionary "drift," more by chance than by selection.

Wild evolution

In a brand new environment offering many opportunities and no competition, the offspring of single "founder" *Drosophila* appear to have evolved wildly, in all directions.

"The new species," he says, "would then find slots in the wide-open ecology that roughly suit them; then the processes of adaptation would take hold, as they settle down to perfect themselves as species." Speciation came first; adaptive evolution followed.

Carson's "genetic drift" theory may not apply to all evolution. The classical, aeon-long evolution of many species might still be explained by a slow process of minor adaptive changes.

But evolutionists have long sought an explanation for the occasional rapid spurts of evolutionary change through which some species—including man—have gone. Carson's Hawaiian *Drosophila*, all descended from one or a few "founders" over less than a million years, may fill that gap.

In his recent proposal to the National Science Foundation, which as part of its program in support of genetic biology is sponsoring his research, Dr. Carson proposes not only that the origin of some species can be traced to their source in the enclosed environment of Hawaii, but that new species are still evolving in the island's not-yet complete ecology and that the process can be observed.

Carson's colleagues, in Texas, Illinois, Missouri, and elsewhere, are enthusiastic about his work and its prospects for success.

"There's a golden opportunity in Hawaii," says Dr. Richard Lewontin, a population geneticist at the University of Chicago. "There are some key evolutionary questions that can be answered there. Now Hamp has a chance to look into them."

Drosophila

"Evolution on Hawaii has really been explosive," points out Dr. Herman W. Lewis, acting Director of the Science Foundation's Genetic Biology Program. "Things can be observed there which just may not be available anyplace else in the world."

Among these may be what Lewontin has called a kind of "missing link" stage in the evolution of new species. This, he explains, would be a stage at which species, close or even apparently identical chromosomally, develop marked shape or behavioral differences which effectively distinguish one species from another.

For example: Carson and others have found fruit flies on Hawaii that have developed patterns of territoriality more like those of birds or of mammals. One will perch on a leaf and fight off anything that invades its turf until a proper mate comes along. Another has evolved an elaborate mating ritual that begins with a male-female eyeball-to-eyeball confrontation and ends with the male arching his abdomen over both of their heads to make contact with the female. Insects unfamiliar with the ritual simply fail to reproduce.

"It's as if," says Lewontin, "a single species went crazy and did the evolutionary things all species do."

All in all, says Carson, the Hawaiian Islands house about 250 of the thousand or so known species of fruit flies, most of them found no place else in the world. Since 1963, he has been doing chromosomal analysis of Hawaiian *Drosophila*, and has collected extensive data on about 80 different species.

It is this information that has enabled him to propose the link between what he calls the "founder" fly, its present-day relatives on the island of Maui and its varied descendants on the island of Hawaii.

"We can find closely related species elsewhere," says Carson, "but we don't know if they evolved a million years ago or 10 million years ago. Here we know it all took place in the last 700,000 years or so, and is probably still taking place."

Having done much of the chromosomal analyses that tracked the origin of the species back to a founder event, even to the point of suggesting the precise chromosomal "finger print" of that ancient, migrant female, Carson now wants to carry his work forward.

He believes conditions are ripe on Hawaii for speciation still to be taking place. This is true both because of the relative newness of the species, and because of the continued availability of unfilled ecological "slots" on the island.

Through his latest NSF grant he hopes to confirm the links between the two Hawaiian species and their Mauian relative, and so to the common ancestor. At the same time he believes the descendent Hawaiian varieties now are ripe for speciation, a process about which there are many theories and much fossil evidence, but little documented fact.

Rat Experiments Show Instincts Modified

Some rats consistently kill small animals: others never do.

But once a rat has killed a smaller animal, he will kill over and over again, in the same stereotyped fashion characteristic of instinctive behavior.

But the instinct, says Dr. James S. Myer, an experimental psychologist at the Johns Hopkins University, is modified by experience.

The notion that an instinct is pure is probably wrong, says the psychologist, whose investigation of "Learning and the Stimulus Control of Instinctive Behavior" is supported by a National Science Foundation grant. "An instinct," he says, "is apparently nothing more than a behavioral tendency."

"The surprising thing is the low proportion of rats that will kill," he says. "It is something fewer than half." He is currently trying to see whether the controlling factors can be found in either the early social experience to which a rat is exposed, or in some other combination of social and sensory factors.

The overlooked sense of smell

It may be no accident that there is an odor to sweat, or that musk and civet—sex-linked scent agents of the musk deer and civet cat respectively—are used in perfumes. People's behavior could be more strongly influenced by smell than they think.

The sense of smell is less well developed in man and other primates than it is in the lower animals. Nevertheless, says Dr. Gisela Epple of the University of Pennsylvania and the Monell Chemical Senses Center in Philadelphia, "We have good evidence that chemical signals (pheromones) have a much more important function in the reproduction and social life of primates than is generally believed.... This may even apply to man...."

Dr. Epple has been studying the scent-related behavior of primates, particularly the South American marmoset monkey, under a National Science Foundation research grant. She is finding that much of those primates' behavior, including the social order within the group and mating patterns, appear to be regulated by chemical communications, principally odor.

Dr. Epple does not suggest that odor is of direct or primary importance in human behavior. If there is an effect, she says, it would certainly be subtle and complex. "Since humans have the smallest olfactory system of any primate," she says, "we may simply have become unaccustomed to seeing scent as a motivational force."

Nevertheless, there seems to be some evidence of olfactory influences on human behavior.

Children, she notes, are not only tolerant of but at some stage may be preoccupied with certain body odors; "Whether they change because they outgrow it or because of social conditioning we can't say." Some primitive peoples employ body odors in some of their social rituals. Psychiatric literature notes instances in which specific behavior or inhibition is triggered by smell. And one researcher, she notes has found that in a college setting the menstrual cycles of roommates or close friends appeared to have become synchronous; odor may have played a part in that phenomenon.

The implications of Dr. Epple's research for human behavior, though distant, are intriguing. They are far from a focus of the research, however. She anticipates several additional years' work in spelling out the chemical communications phenomenon just for the marmoset.

Magnetic Study of Body's Organs

Electrical currents created by the action of the body's organs have been diagnostic tools for years. The electroencephalogram (EEG) by which "brain waves" are read, and the electrocardiogram (ECG) for heart function, translate the organs' alternating currents into readable information by way of electrodes placed on the skin.

The heart, the brain and other organs also put out an array of direct current electricity, as the result of a different class of physiological processes. This should be an equally valuable diagnostic tool. Medical students have long been taught, for instance, that an ECG can indicate a DC "current of injury" produced by a heart undergoing myocardial infarction–damage caused by a blockage of the blood flow to the heart muscle. Such a current of injury has never been demonstrated directly, however, because internal direct currents can not be read as the alternating currents can; electrodes pick up extraneous DC from the skin and mask the signal. In an effort to study these injury currents, tests have been conducted directly on the exposed hearts of experimental animals during surgery, but they have produced conflicting results.

Because electric currents set up magnetic fields, however, Dr. David Cohen, a nuclear physicist who turned to biological research, is working with several medical specialists to develop techniquies for reading the DC magnetic field produced by the body's internal direct currents, thus bypassing the electrode problems entirely. Working with the National Science Foundation support at the Massachusetts Institute of Technology's Francis Bitter National Magnet Laboratory, he is seeking DC magnetic fields associated with the damaged hearts of experimental animals. If he finds them, they would become the first direct evidence of some kind of current of injury. If not, he says, "Then the classic theory of injury currents as taught in the medical schools would have to be revised." So far he is finding enough at least to raise questions.

Cohen is also seeking magnetic fields around the head produced by electric currents associated with such brain disorders as epilepsy and tumors. These, he says, should come not only from the AC fields generated by the currents that produce the EEG readings, but from the brain's hard-to-measure DC output as well. Such magnetic field readings could produce information on brain events not available from the standard EEG.

The Massachusetts-based NSF grantee hopes to be able to map the entire body's magnetic outputs, associating specific measurements with the functioning or malfunctioning of an array of bodily organs.

"We haven't forged a diagnostic tool yet," he says, "but we are showing that we can measure what we know must be there."

Besides the National Science Foundation, Dr. Cohen's work is also being supported by the National Institutes of Health, the American Heart Association and the American Cancer Society.

physics and astronomy

HE BLOWS

AN

ILL

WIND GOOD

PHYSICIST TURNS TO MUSIC

"An oboe," says the old Danny Kaye lyric, "it is clearly understood, is an ill wind that no one blows good."

But if the oboe is an ill wind, then so are the clarinet, the bassoon, the saxophone and some pipe organs. And nothing seems to be "clearly understood" about this family of reed-driven woodwinds that Prof. John Backus of the University of Southern California at Los Angeles calls "self-excited acoustical oscillators." Nothing, that is, beyond the fact that a large number of talented and dexterous people seem somehow able to draw music from them, despite the absence of scientific, acoustical principles in their design.

Backus is a nuclear physicist turned bassoon player—"I reformed," he says—who has become one of the nation's outstanding authorities on the complicated acoustical physics of the wind instruments. As a result of his research he has already developed what appears to be an improved clarinet reed; he hopes ultimately to improve the design of the instruments themselves.

Stringed Instruments

"It was in some ways easier for scientists to understand the physics of the stringed instruments," comments Dr. Rolf M. Sinclair, director of the National Science Foundation's Atomic, Molecular and Plasma Physics Program which is supporting Dr. Backus' research on the winds. "The four open strings of the violin set up a relatively simple array of basic vibration and resonance patterns on which the instrument builds and with which a physicist can work." As a result, sound scientific principles are being used successfully—though not commercially—to design violins, violas, cellos, double basses and even guitars.

But the wind instruments are something else. The complicated wave patterns that build up inside them, and the difficulty in determining what is "good" and "bad" in the sounds produced by those wave patterns, make understanding them a difficult process.

The NSF grantee—who once wrote papers on such subjects as "Plasma Phenomena in Magnetic Fields" and "The Design of Cyclotron Oscillators"—has concentrated, during more than a decade of research into wind instrument acoustics, on the clarinet. Its bore is a cylinder and it uses a single reed; it is in some ways the simplest of the woodwinds. He and his graduate students, however, are also looking at others of the orchestra's wind instruments—the brasses and the more complex conical-bored and double-reed woodwinds.

Studying the Woodwinds

Initially, he is trying to do for the winds what is being done for the strings: understand the physical processes that make them work so that better and easier-to-play instruments can be more readily and regularly produced.

"Part of the problem is with the musicians," says the physicist who, in mid-career, took a masters degree in music with a major in orchestral conducting, learned to play bassoon in an orchestra, and wrote for musicians the semi-technical book: "Acoustical Foundations of Music."

"Players," he declares, "have strong ideas about the tonal and other qualities of their instruments, but when you try to pin them down, they generally get vague." On the other hand: "Though laboratory equipment is more precise than the human ear in measuring the physical properties associated with tone, it lacks the ability to make aesthetic judgments." Backus says.

If the musicians could agree on the differences in the tone qualities of "good" and "bad" instruments, the scientist says, the electronic equipment in his acoustical laboratory should be able to detect what differentiates "good" from "bad." Presumably, then, a clarinet that optimizes the good and minimizes the bad could be designed and manufactured, possibly with the assistance of computers. So far that marriage of art and science has not been achieved, but progress is being made.

Both his laboratory equipment and the best player-listener combinations he has been able to assemble, for example, indicate that the material of which a wind instrument is made seems to make no difference in its quality: a plastic clarinet can be played so that it is indistinguishable from one made of the best African wood, and even a length of garden hose can give out creditable clarinet sounds. A cornet embedded in putty and played has a tone "no different from one not so horribly treated," he says. And his measurements have shown no marked differences between the wave patterns or spectra in the vibrating air columns inside "quality" and cheap instruments.

Material Doesn't Count

"An organ pipe," he declares, "can be made of heavy paper and will give off the same sound as the costliest tin pipe; the vibrations through the walls of the tube are that inconsequential."

But what makes the difference between an instrument that puts out a quality tone and one judged to be poor, or even what makes a clarinet sound like a clarinet, continues to be elusive. Subconscious clues, like the click of the keys, seem to be as important as anything else in enabling a listener to identify an instrument by sound, he says. And musicians' most unequivocal judgments are frequently not borne out by experiments.

The Southern California researcher's first major problem, before he could progress even as far as he has in analysis of his "self-excited acoustical oscillator in which a generator, the reed, is coupled to a resonant system, the air column . . ." was the clarinet reed itself.

Reinventing the Reed

When a clarinet is played, he explains, oscillations are produced in the air column by vibrations of the reed. These oscillations in turn react back upon the reed, causing it to supply energy to the air column and so maintain oscillations at one of the resonance frequencies of the system. These oscillations, carried through the air, are what is heard as sound.

In the 200 years the clarinet has been around, its reeds have been made of natural cane. While cane may be made to be acceptable for musical purposes by a player who knows how to manipulate it, in a laboratory where conditions must be reasonably reproducible, it is quite unsatisfactory.

It also makes an instrument difficult to play, as any clarinet, oboe, or bassoon beginner can testify. Principally because he needed experimental uniformity, Backus reinvented and has a partial patent on a clarinet reed made of a composite material. The National Science Foundation, as supporter of the research, holds a royalty-free license. (Details are not available pending full patent protection.)

"We have a material that has the same characteristics as natural cane," says Backus. Each reed can be made to perform like every other one, though to achieve this he had first to modify his reed-cutting machinery to take the material.

"What I was after," says the physicist-musician, "was a material I could use in the laboratory."

But he had an ulterior motive as well.

"I'm a bassoon player," he says. "In the back of my mind was the possibility that I—and other musicians—could get some benefit from my own research." This is possible because predictable reed is also a more playable reed; if every one vibrates like every other one, a troublesome variable has been eliminated from musicianship.

With the reed standardized, and the "multiple resonant air column" of the clarinet amenable to study, Backus feels that he has a firm handle on the physical properties of at least one woodwind.

"If (Backus') ultimate goal of high quality is realized," says one observer of his research, "the problems of the wind player—professional and amateur—will be reduced to mechanical skill and artistry. It is possible that the range of performance will become so narrow at the high levels that boredom will result."

Backus won't go that far.

The deficiencies of his instrument create a good share of the musician's problems, he says. Perfecting the instruments will simply free the musician to play better. But improving the instruments, he insists, is never going to make musicianship a mechanic art.

Einstein Theory Being Tested

Einstein's general theory of relativity is the one that ties the force of gravity to the shape of the universe. It also predicts such phenomena as a tiny drift in the orbit of the planet Mercury as it revolves around the sun, and the bending of light as it passes a star.

Scientists have been checking the theory for years, within the limits of their ability to measure the phenomena it predicts, and almost invariably they find that it works. Nevertheless, for a variety of complicated reasons, many of them are dissatisfied with it; it doesn't, for instance, take into account the electromagnetic forces that permeate the universe along with gravity, and which should have an effect.

In the last 15 years, the controversy has centered around an alternative theory, first put forth by Dr. Carl H. Brans of Loyola University and Dr. Robert Dicke of Princeton University. The Brans-Dicke theory seems to cover for many physicists the objections they have to Einstein's, with one exception: its failure to predict the drifting of Mercury's orbit (1/32,400 of a circle each 100 years) as accurately as does Einstein's.

This ought to wipe out the competition, except for Dicke's contention that Einstein's figure for Mercury's orbit is correct only if the sun is a sphere. His own, he says, works better if the sun is slightly flattened at the poles. He and a co-worker, Dr. H. Mark Goldenberg, measured the sun back in 1966 and found it to be slightly flat—about 50 miles smaller north-to-south than it is east-to-west.

This ought to make Dicke's theory fly, but his colleagues are not yet ready to discard Einstein. Dicke's reading might have been caused by a mistake in his instruments, they say, or by conditions in the atmosphere near where he was set up, or by events in the 11-year cycle of sunspots and other solar activity.

Now Dr. Goldenberg is trying to account for all those objections. With National Science Foundation support, he is building another instrument at the University of Massachusetts with which he is now affiliated. He will use it to make measurements of the sun's disk from a number of locations, starting within the next few months—five years after Dicke's measurements and at another point in the 11-year sunspot cycle.

"If the objections are correct," he says, "then we should get different readings now than we got in 1966. We have to find out if the data are reproducible."

Search for Ancient Solar Cycles

Scientists believe that on top of the known 11-year cycle of sunspot and other solar activity, there may be longer, supercycles of what might be supersolar events. So far evidence in support of this speculation is limited. But a University of Arizona scientist, Dr. C. Y. Fan, believes he can refine the measurement of the radioactivity in tree rings clearly enough to describe the cycles of solar activity for the last 10,000 years.

"If he can do it we may be able to relate past cycles to historic events they may have influenced. We may also be able to predict the next cycles," says Dr. Neil M. Brice, director of solar-terrestrial research programs for the National Science Foundation. NSF is supporting Fan's research.

Fan's proposal is based on the fact that cosmic rays coming into the atmosphere create radioactive carbon-14, which living things will take up along with regular, nonradioactive carbon.

By measuring the long-lasting radiocarbon in tree rings, he says, he can determine when the interplanetary magnetic field was strongest as a consequence of higher solar activity. The stronger interplanetary magnetic field would fend off the cosmic rays during those periods, he says. This would reduce the radiocarbon available to the trees at those times. The identification of the rings having low radiocarbon content, then, would effectively date past solar cycles and perhaps supercycles for as far back as tree rings are available.

Telescope to catch Supernovas

Supernovas, the catacylsmic outbursts of dying stars, occur in the observable sky about once a week. But that is only one every 50 years or so on average in each of thousands of observable galaxies: there is no way to predict where in the sky one will pop up.

This makes the detection of one in its first few explosive hours almost impossible, says Dr. Stirling A. Colgate, astronomer-president of the New Mexico Institute of Mining and Technology. So Colgate and Dr. Elliott P. Moore, with National Science Foundation support, are building an automated telescope on an old Nike Ajax radar mount, near the Institute on South Baldy Peak.

Instead of repeatedly photographing the sky and comparing plates hours or days later to detect supernova after the fact, their 'scope is being designed automatically to check 8,000 galaxies a night. The readings will be stored in a computer, and as soon as one night's reading for a galaxy shows a brightness over its normal level, the astronomers will be alerted to the catch. "We want to be able to see them within their first four hours," says Colgate. He believes that time to be critical in terms of understanding both the origin of cosmic rays and the origin of supernovas.

Supercold Approach to Cleaner Air

Paper mill stack emissions can smell like rotten cabbage. The human nose can smell them if the pollutants are present in concentrations as low as one part per billion of air. But existing antipollution equipment, says Dr. Russell J. Donnelly, a physicist at the University of Oregon, can't bring pollutant concentrations down much below one part per hundred million.

That's the problem Donnelly and his supercold-research laboratory turned their attention to when a mill was built recently at Halsey, Oreg. Pulp mills need a technique to get rid of the smell and, "The local Weyerhauser Paper Co. manager gave me a $25,000 grant," says Donnelly, who decided to use a concentration technique common in analytical chemistry laboratories. He came up with a trap in which inexpensive, byproduct liquid nitrogen, at temperatures of 77 degrees above absolute zero, captures pollutants down below the smell level and then pipes them off.

"It worked," says Donnelly, though it turned out to be a bit too expensive for plant use. Suitability will improve, he thinks, as needs go up and costs come down. He is currently, with National Science Foundation support, refining the technique which holds promise as remote instrumentation for the automatic monitoring of air pollutants as well.

oceanography

Wastes Won't Rot on the Seabed

The research submarine Alvin sank in a mile of water off Woods Hole, Massachusetts, in October of 1968. When it was recovered almost a year later, it was discovered that an oceanographer's lunch —two thermos jugs of soup, two apples and some bologna sandwiches—were virtually as unspoiled as they had been the day they went down.

The sandwiches were a little soggy and the apples had a pickled appearance from 11 months' exposure to sea water. But they showed no signs of obvious decay, and the soup was "perfectly palatable," according to Dr. Holger Jonnasch of the Woods Hole Oceanographic Institution, who examined it on recovery. Back on the surface, however, normal bacterial process took over, and the food all spoiled in a short time despite refrigeration and submersion in sterile sea water.

On the Ocean Floor

Two things apparently had happened on the ocean floor: The bacteria that accompanied the submariner's lunch on its plunge to pressures 150 times those encountered on the surface were apparently prevented by the pressure from multiplying and attacking the food. And the bacteria normally found at such submarine depths, though they obviously do multiply and function there, apparently do not function as their surface cousins do; at least they did not attack the food.

But what unique, internal biochemistry differentiates deep-ocean from surface bacteria—what permits one but not the other to live and multiply at pressures that can run as high as 1,000 atmospheres —was a mystery then and it is a mystery now.

But it is a mystery that will have to be solved, both because there is a need to understand the ecology of the ocean and because the ocean depths are constantly proposed as a dump for wastes and sewage that bacteria should decompose if given enough time.

"If we're thinking of dumping garbage and sewage in the deep-ocean," says Dirk Frankenberg, director of the National Science Foundation's Biological Oceanography program, "we had better have some second thoughts. It's not going to rot away; it's just going to lie there and accumulate. The 'Alvin lunch' has taught us at least that much. Now we have to find out why."

In an effort to learn more about sea-floor bacteria and biochemistry under pressure, the NSF Oceanography program is supporting the work of two scientists—Drs. Joseph Landau and Henry Ehrlich of Rensselaer Polytechnic Institute at Troy, New York. They are combining separate approaches to the problem into a concerted research effort.

Landau for years has been experimenting with surface bacteria like the common intestinal organism E. coli, and has discovered that high pressures like those at oceanic depths somehow turn off several key biochemical systems. Under pressure, E. coli will stop making proteins and some genetic materials, for example.

Ehrlich, at the same time, has been examining the deep-sea bacteria that do function under pressure and seem to contribute biochemically to the accumulation of the manganese nodules that dot the ocean floor. He has collected several cultures of those bacteria and has examined the operation of some of their chemical machinery.

Now, under NSF sponsorship, the two biologists are putting their heads and their research together: Landau is contributing experience with the effects of pressure on the biochemistry of terrestrial bacteria and Ehrlich is contributing deep-sea bacteria and insights to their chemical functioning despite depth and pressure.

Each is making use of the other's background; together they hope finally to learn what biochemical variations make deep-sea bacteria different from surface varieties.

Life thrives on the seabed

Ecological theory says a stable environment should lead to the presence of many kinds of life.

The ocean floor is a highly stable environment. It is constantly dark, constantly cold and constantly low in available food.

Such an environment, stable or not, has been thought to be relatively inhospitable to life; the ocean floor has even been called a biological desert.

But Dr. Howard L. Sanders, a Woods Hole (Mass.) Oceanographic Institution scientist, working with National Science Foundation support, has been writing even the deep-ocean floor into ecological theory. He has been finding that even though the density of life may be low, the diversity of species on the deep-ocean floor "is about the same as that in the physically stable, shallow, tropical marine environment," where life abounds.

Earlier efforts to sample life forms from the seabed 1,500 to 15,000 feet beneath the surface met with relatively little success; the limited number of samples brought up in dredges led inevitably to the conclusion that there were few kinds of life to find.

But through the use of improved collecting equipment of their own design, Dr. Sanders and his colleagues have been able to find tens of thousands of organisms where their predecessors found few or none at all. In 19 samples, for instance, they retrieved 3,257 specimens of a single bivalve species, only one specimen of which had ever been seen before. Of another almost unknown species, they retrieved 255 specimens in 10 samples.

Thousands of Species

Dr. Sanders has found that deep sea-floor species, of which there appear to be thousands, vary far more with depth than they do with geography, and that the 34-to-36 degree sea-floor temperatures are often far more critical to their survival than are pressures. This is despite the fact that they live under pressures 400 to 500 times those encountered at the surface.

"In many cases we are unable to retrieve specimens alive during the summer," says a colleague, Dr. J. F. Grassle of Woods Hole. "The greater warmth of the surface waters seems to make that much difference."

Dr. Sanders and his colleagues have found a rich diversity of life virtually wherever they looked. So far they have made sweeps from New England to Bermuda, from Senegal to Brazil, along the southwest African coast, around the Canary Islands, and in the Southwest Atlantic Ocean off the Argentine coast. At least two more surveys are still to be made: off Iceland and Northeast South America.

Dr. Sanders' hope is that ultimately enough will be known of the entire Atlantic Basin so that it can be considered as an ecological unit. He also hopes to learn more about the reproduction of sea-floor organisms, and why some species seem to be fairly well localized while others are represented in samples from over wide areas.

She Sheds Light on the Scattering Layer

Dr. Elizabeth Kampa prepares a red swimming crab, "an occasional member" of the deep scattering layer, for examination in her laboratory. She says layer-dwellers' daily rise and fall is a response to light.

During World War II submarines were able to hide from sub-killers' sonar under a "deep scattering layer" made up of billions of tiny marine organisms. The layers, broad, thick sheets of living animals, rise and fall over distances of thousands of feet during a 24-hour period, and a submarine commander who knew how to find his way beneath them was safe from sonar which could not penetrate them.

Since then sonar has been designed to overcome the "scattering layer" problem. Scientists, however, are still trying to understand the regular rise and fall of those billions of tiny "mesopelagic" or mid-depth creatures which range in size from microscopic to visible and represent the base of the oceans' food chain.

The phenomenon has been explained by hypothetical "biological clock" and other mechanisms. But, though the plankton, tiny crustaceans and other organisms in the layer have been studied for 100 years or more, the reason for their dramatic vertical migrations has never been nailed down.

What is coming to be accepted as the answer, however, is the contention, backed by evidence accumulated over more than a decade by Dr. Elizabeth M. Kampa of the Scripps Institution of Oceanography and others, that even a half mile beneath the sea the denizens of the scattering layer are responding to daylight, moonlight and, perhaps, even starlight.

Light in the Deep

The mid-depths of the ocean are not uniformly dark, Dr. Kampa has found. Nor are its denizens all blind; the specialized eyes of the scattering-layer organisms, sensitive to particular intensities of narrow wavelength bands of light, facilitate the regular migrations of these animals through vast vertical distances in response to those wavelengths and intensities.

The sc ttering layer organisms, says Dr. Dirk Frankenberg, director of the National Science Foundation's biological oceanography program which is supporting Dr. Kampa's research, can respond to changes in light 100 times less intense than the human eye can detect. Dr. Kampa has found that even on a cloudy day, appearing from the surface to be just like a preceding cloudy day, subtle differences in light energy reaching the depths can cause changes of hundreds of feet in the depth of the light-seeking organisms. Animals only a quarter-inch long, she reports will swim upwards at a rate 230 feet per hour faster during a cloudy dusk than during a clear one.

Direction of Evolution

She is using delicate light sensors to measure radiation at the depths inhabited by the layer organisms, and she is exploring the unique structures of their eyes.

She is finding, for instance, that the eyes of animals in the layer are more like those of other layer-dwellers, even though they are of different families, than they are like those of more closely related animals having different life styles.

She is also finding that blind, bottom-dwelling, relatives of some light-sensitive "migrants" have eyes which are almost, but not quite as complete as the migrant's. Whether those incomplete, blind eyes are precursors or successors of the functioning eyes of scattering layer organisms is still unknown. Dr. Kampa hopes ultimately to be able to determine the direction in which those species are evolving: whether the direction of evolution in the scattering layer is from the blind to the seeing or from the seeing to the blind.

meteorology

Rebuilding a Tornado to See What Makes it Tick

Hurricanes can be studied from airplanes flown through them and from instruments located in their paths. But even if a meteorologist or engineer could predict the narrow path of a tornado, any instruments he might place in its path would be swept away by the force of the storm. As a consequence, relatively little research has been done and little is known about the forces that swirl inside those funnel-shaped land storms.

So the National Science Foundation is supporting a combined effort by teams of Texas engineers and meteorologists to work backwards: to reconstruct from the damage it caused the tornado that ripped through Lubbock, Texas, on May 11, 1970, killing 26 persons and destroying property worth some $130 million.

The engineers, led by Kishor C. Mehta and Albert J. Sanger of the Department of Civil Engineering of Texas Tech University, have been examining and documenting in detail the structural damage done by the storm.

The meteorologists, behind Joseph L. Goldman of the Institute for Storm Research at the University of St. Thomas in Houston, Texas, are attempting to use the engineers' and other available data to construct a model of the storm.

The engineers, says Dr. Michael P. Gaus, director of the NSF engineering mechanics program which is supporting the effort, are determining the forces necessary to have done the damage they see. The meteorologists will translate that information into wind direction and speed, and hopefully a structural model of the storm that ripped Lubbock.

RADAR SHOWS STORM IN 3-D

The Doppler effect is a shift in the frequency of waves coming from a moving body. It makes an approaching train whistle sound shrill and a receding whistle drop in tone, as if the sound waves were compres ed by the train's approach and stretched out by its departure. Similar effects are present in other kinds of emitted or reflected waves: light or radar, for example.

By designing radars capable of measuring the Doppler effect, meteorologists for more than a decade have been able to use them to measure the speed of approaching or receding storm systems as well as of some of the winds within them.

But radar "sees" only in a straight line and even Doppler radar can measure motion only toward and away from it. To get around this limitation and permit his computers to display a three-dimensional picture of the complex air motions within a storm, Dr. Roger M. Lhermitte, a radar meteorologist now at the University of Miami, has devised a way to give radar a kind of binocular vision. With National Scence Foundaton support he is developing a dual Doppler radar, which he first reported experimenting with two years ago.

By placing a pair of Doppler-equipped surplus tracking radars some 20 to 30 miles apart and focusing them on the same part of a storm, he is able to measure and compute movement in all three dimensions.

Dr. Lhermitte is now building a preliminary system which will enable him to focus on developed local storms over the Florida Keys. As the system is improved, he hopes to be able to examine more modest systems, watching them develop in full 3-D and, perhaps, learning to pick the ones destined to become storms.

paleontology

"Living Fossils"

Tracing life back 3.2 billion years to explore paleontology's "Volkswagen syndrome"

The earth was born some 4.5 billion years ago.

Whether at that time it already carried the seeds of life, or just the chemicals from which that life would some day spring, is not known.

And it may never be known just when, in the next billion years, life made its appearance on earth.

Scientists are dependent on fossils trapped in sedimentary rock formations for their record of the earth's earliest life forms. No sedimentary rocks were formed in those first thousand million years, when the continents and oceans were emerging, the atmosphere was evolving and the earth's core was separating out of its mantle. At least none have ever been found, so no fossil record of those early aeons is known to exist.

But by creation plus 1.4 billion years or so there was life on the earth. Microfossils going back at least that far have been found and dated, in what are called the Fig Tree sedimentary rock deposits of the early Precambrian period in South Africa. Any attempt to trace the early evolution of life on earth must begin at least then: some 3.1 billion years ago.

Most ancient life

That is the task being set for himself by Dr. J. William Schopf of the University of California at Los Angeles. Schopf earlier was one of the discoverers of the 3.1 billion year old South African fossils which are now generally accepted as relicts of the oldest life forms known on earth.

Now with graduate student John

Oehler and National Science Foundation support, Schopf has embarked on a major, long term investigation of the evolution of those earliest known life forms and the link they may represent between past and present. He believes, for instance, that some Precambrian forms of algae might have survived 3.1 billion years of evolution essentially unchanged. He thinks there are ways to tell whether or not modern blue-green algae, of the kind that now clog dying lakes and ponds, are a kind of living fossil, descended in a straight, unbroken line from Precambrian ancestors.

A "Volkswagen syndrome"

They look like they might be he notes. External similarities could mean that blue-green algae are the same kinds of organisms that existed at the dawn of time. Or the organisms could have changed considerably in fine detail and biochemical functions, despite the absence of gross, obvious changes. They could represent, he says, "a 'Volkswagen syndrome': little or no evolution of external form concealing marked changes of internal machinery." Nobody, he notes, has ever been able to take the finely detailed look at the ancient and poorly preserved Precambrian microfossils this kind of research requires.

Schopf is going to have to start slow, by working backward from more recent, more clearly identifiable fossils of the upper Precambrian and Cambrian periods—600 million to 1 billion years ago, developing techniques as he goes.

He is also going to have to make his own fossils out of silica and modern algae, to see if he can reproduce and thereby understand the changes fossilization makes in an organism.

Schopf expects to find that the relatively recent, billion-year old, phototosynthetic algae, from his baseline source, the Bitter Springs formation in central Australia, are very much like modern blue-green algae. He proposes to nail that down by comparing clearly preserved Bitter Springs fossils with modern algal fossils he will make in his laboratory. This will help him prove out his techniques and set some "benchmarks" for later examination of the older fossils.

"The older fossils like the Fig Tree ones," Schopf explains, "are pretty poorly preserved. But once we have made our own fossils and compared them to good ones from Bitter Springs, we will know what to expect and we'll be able to interpret the structures we see."

The fossil-making process "is like embedding a leaf in Jello," he explains, except that the organisms are embedded in silica under high pressures and at temperatures of several hundred degrees.

Source of oxygen

If it works, and Schopf is able eventually to link the early Precambrian organisms to later life forms, he expects also to know more about when plants were first capable of photosynthesis. That particular point in evolution, he points out, is critical; on it depends the first production of large amounts of free atmospheric oxygen on which so much subsequent life depended. The origin of photosynthesis in the early Precambrian, says Schopf, would have helped to create the atmosphere in which the more complex, multicellular organisms could evolve in the Paleozic era starting some one-half billion years ago.

Two-Billion-Year-Old Algae

Fossil evidence that blue-green algae much like those that exist today existed as much as two billion years ago has been found on a knoll near Eveleth, Minnesota. Blue-green algae are among the world's most primitive organisms; they are not much more advanced than the most primitive bacteria. Yet the Eveleth samples appear to be very similar to the blue-green algae that help clog today's eutrophying ponds. They are among the world's earliest identifiable life forms, and the Minnesota fossils, says Dr. Preston Cloud, a biogeologist at the University of California at Santa Barbara, are the oldest demonstrable examples yet found.

The Minnesota fossils appear to be "slightly older—probably not more than a few million or tens of millions of years," than now-famous Gunflint microfossils from the north shore of Lake Superior, the oldest that could up to now be confidently identified, says Dr. Cloud.

"But the real significance is not the age," says Dr. Cloud, whose research is supported by the National Science Foundation and the National Aeronautics and Space Administration. "They are not all that much older than the Gunflint fossils."

In contrast to the Gunflint microfossils, however, the fact that they are readily separable from the rock deposits in which they occur permits a comparison with living organisms with a precision and detail not heretofore possible.

If, thanks to fine detail like that seen in these fossils from the Pokegama strata in Minnesota, evolutionary changes can be detected in blue-green algae, he suggests, then perhaps they can be used to identify the relative ages of strata in which they are found.

Older microfossils have been reported, says Dr. Cloud, going back some 3.2 billion years or more. But he feels that those are still open to scientific question; the Pokegama and Gunflint fossils, he says, are the oldest ones that can be called relicts of early life with 100 percent certainty.

anthropology

Over the Land Bridge

Inhabitants of the Aleutian Islands occupy the remnant of the Ice-Age land mass that once linked Asia and North America.

The notion that ancient Asian man, some 10,000 to 25,000 years ago, walked across a narrow neck of land bridging what is now the Bering Strait and began the population of the Western Hemisphere has become a kind of popular folk tale.

On its surface it is close enough to accepted scientific fact to have the ring of truth. And the picture of stone-age man taking advantage of a geologic accident to reach for another horizon is romantic enough to be attractive.

Such an account carries the germ of truth, but it is more romantic than accurate.

Geological and archaeological evidence points to the fact that the Bering Land Bridge really did exist during the great glacial ages that sheeted much of the Northern Hemisphere with ice. Once, at least, during the last great ice age, some 10,000 to 25,000 years ago, the Land Bridge linked Asia and North America head to head like great, continental Siamese twins; people apparently did migrate across it from west to east.

But the Bering Land Bridge was no narrow neck of land. Nor did its stone-age inhabitants know that they were migrating.

Continent Linking Continents

The "Bridge," according to the best available geological evidence, was virtually a continent linking continents. It stretched south for more than 1,000 miles from its Arctic Ocean coastline to the north. Its southern shore swept south and east from Siberia's Anadyr Peninsula. It enfolded what are now the Pribilof

Islands and made what are now St. Matthew and St. Lawrence Islands in the Bering Sea hilly projections in a probably swampy and cold if not ice-locked plain. At its southeastern-most point it included the Alaskan Peninsula and what is now Umnak Island in the eastern Aleutians. Umnak then was the end-of-land for northwestern North America.

Map of Alaskan Peninusla and eastern Aleutian Islands, showing outlines of the continent of Beringia at a time when the Ice Ages caused sea levels to drop by hundreds of feet. Present water depth is shown in meters.

The Land Bridge was a creature of the Ice Ages. It was a result of the fact that thousands of cubic miles of water were locked in glaciers thousands of feet thick blanketing much of Europe, Asia and North America and reducing sea levels the world over by more than 300 feet. It disappeared beneath the ocean's surface with the end of the last glacial epoch, some 9,000 to 10,000 years ago, when sea levels were increased by the melting ice.

The people who moved across the Land Bridge out of northeast Asia had thousands of years in which to do it. They were more likely occupants of a continent now being called Beringia, drifting eastward across it generation after generation, than migrants over a causeway.

"From the point of view of those living on the Bridge, it was permanent occupation," says Dr. William S. Laughlin, professor of biobehavioral sciences and of anthropology at the University of Connecticut at Storrs, "and from the point of view of one (himself) who has investigated 8,000 or more years of (Aleutian) habitations, it continues to be permanent occupation."

Laughlin has devoted the last 33 years–virtually his entire professional life–to the study of the inhabitants of the eastern Aleutian Islands, their culture, their origins and their relationships to the Eskimos and American Indians who apparently crossed the Bridge at the same time. Those eastern islands, he says, are remnants of the Land Bridge, and the present Aleut inhabitants of those islands are direct descendants of the Mongoloid people who made the millenia-long trek.

Two Routes

On the basis of his own research and that of others he concludes–though, "Nothing is proven," he cautions–that at least two routes were followed by early Asian nomads drifting eastward across the Bridge:

The root stock that became the Indian tribes of North and South America might have been inland Asians who followed the big game on which they depended, skirting the ice east and south into the heart of the new continent. In support of this, Laughlin cites 15,000-year-old human remains found at Choukoutien, 26 miles southwest of Peking, China. These remains, Laughlin notes, have been said by Harvard University anthropologist W. W. Howell to look like "unmigrated American Indians."

Those more Mongoloid migrants who became the Aleuts and Eskimos, on the other hand, would have hugged the Bridge's southern coast, holding to the life-style and the marine hunting and gathering habits of their coastal Asian forebears. They might have originated in the Soviet Maritime Territories or on the Kamchatka Peninsula of eastern Siberia; stone tools Laughlin has found in the Aleutians, as well as physical characteristics, "clearly" link the Aleuts, and by extension the Eskimos, more closely to ancient coastal Asiatics or Siberians than to Alaskan Indians, he says. Additionally, the Japanese archaeologist, Masakazu Yoshizaki has studied early Aleut tools. He has found, Laughlin reports, that they could fit easily among Hokkaido findings from the general period 9,000 to 12,000 years ago, though Laughlin himself is unconvinced of this link.

As Laughlin reconstructs the history of the Aleuts and Eskimos, on the basis of his own research, that of his University of Connecticut colleagues, geologist R. F. Black and archaeologist J. S. Aigner, and others, they began their migration probably more than 15,000 years ago, somewhere along the North Pacific or Bering Sea coasts of eastern Asia.

They drifted north along the Asian coast, then east and south along the southern Beringian shore over the next several thousand years; in all probability they remained isolated from the big-game-hunting inland peoples living on the Bridge at the same time.

The Oldest Site

By some 8,000 years ago, ancestors of the present Aleut population had reached the Bridge's southernmost end–the Alaskan Peninsula–and turned west along its ice-free northern shore. By then they had already established a large permanent village as well as a lookout for whales and a toolmaking site on a high rocky outcrop that was then near the very end of the Alaskan Peninsula and is now tiny Anangula Island. Anangula is only a mile across a shallow, once-dry channel from Umnak Island in the eastern Aleutians.

Other related Mongoloid groups settled elsewhere on the Alaskan coast. Some eventually reached Greenland; a few drifted inland. These now comprise separate, though still-related, Eskimo populations, according to genetic linguistic, anthropological and archaeological evidence.

Because of the opportunities they present for detailed study over time, however, Laughlin has concentrated on the Aleuts. And though only a tiny fraction of even the known sites of Aleut habitation have been explored, the findings have been rich.

"We have found more than 20,000 tools at Anangula," Laughlin reports, "the largest number found at any site in the entire polar region." The Anangula site has been reliably dated at more than 8,000 years: "The oldest dated archaeological site found thus far on the coast of Alaska."

As Laughlin and his colleagues reconstruct it, the Aleuts were already established at Anangula, as well as on or somewhere near the ancient site of the present Umnak Island village of Chaluka (Nikolski), and eastward along what are now the eastern Aleutians, when the ice receded and the Bridge was flooded by the rising sea some 9,000 to 10,000 years ago. The region had been, was then and still is what Laughlin calls "one of the richest ecological systems in the world." Its abundance of marine life along the shore and its location overlooking the migrating channels for whales and other marine mammals dictated their way of life.

A Thriving Culture

It enabled the ancient Aleuts to thrive as their Eskimo cousins living inland or along less hospitable coasts never could. The Aleuts had, Laughlin concludes from ancient remains and other evidence, the lowest infant mortality and greatest longevity of any ancient people in the north. Their gathering as well as hunting-based economy, a factor of the richness of their environment, enabled them to use and value their old and disabled as few primitive cultures could.

There were some 16,000 of them when the Russian explorer, Vitus Bering, discovered them in 1741. Massacre and disease, both apparently introduced by the Russian trading parties that followed Bering, decimated them. "The Russians not only introduced long noses into the Aleut gene pool," Laughlin comments, "they apparently introduced some old world plagues as well." One Russian skeleton found among 13 victims of a 1764 massacre, Laughlin says, shows signs of ravages of syphillis.

Today there are fewer than 1,200 Aleuts.

University of Connecticut graduate students Ruth Sternbach (left) and Al Harper unearth 200-year-old skeletons of massacred Russian trading party on Umnak in the eastern Aleutian Islands.

But 8,000 years ago the Aleuts were a thriving society of maritime hunters, as their stone tool technology, their habitations and residues of animal remains attest.

They apparently had free access back and forth along the peninsula, over an ice-free coastal route Black would like to define. They must also have had many village sites up and down the Bering Sea coast. Those Laughlin and Aigner would like to be able to find.

But when the ice withdrew, sea levels rose and wiped out the land bridge to Asia. The Alaskan shore line receded gradually, reaching its present position some 5,000 years ago. Any evidence of habitation older than the Anangula site and, apparently, any in the valley between Anangula and Chaluka, was probably reclaimed by the sea.

Isolated and Distinctive

In the process, what had once been Alaska's end-of-land became islands—the eastern Aleutians—and the Aleuts on those islands, ancestors of the modern Aleuts, were isolated. Even with the later admixture of Western customs and genes, they remained distinctive.

That is what attracted Laughlin to the Aleuts in the first place. He has found in those islands, he believes, a unique, continuous record of habitation, adaptation and evolution by a single group of people dating from the present all the way back to Anangula, if not beyond.

"Nowhere in the world," he declares, "except perhaps in the Nile Valley, can we find a people whose history can be so thoroughly assembled for a period of so many thousands of years."

The 55 Aleuts who still inhabit the Chaluka (Nikolski) village site are living where their ancestors have lived in unbroken succession for at least 4,000 years. Only this spring, Laughlin reports, the 4,000-year age of a stratum at the base of the Chaluka village mound was confirmed by radiocarbon dating of artifacts found by Dr. Aigner. And between the present residents, their customs and folklore, and the artifacts and skeletons that carry the story back in time, Aleut history can be assembled step by step over those 4,000 years.

There is still a time gap to be bridged between the oldest Chaluka dates and the 8,000-year ages of the Anangula artifacts. But the stone tools and other features at the two sites are so like each other that Laughlin has no doubt that he will find additional evidence linking the two through time.

Filling in that 4,000 year gap as well as other details of the origins and genetic and cultural history of this isolated people is one goal of the next, and perhaps final phase of the research on which Laughlin and a large group of colleagues are now embarked.

A Broader Purpose

A broader purpose of the research, however, and one that has attracted International Biological Program sponsorship and U.S. National Science Foundation support, is the promise it holds for general insights into human evolution and adapatation.

Under the aegis of IBP and NSF, Laughlin is now heading a 19-man interdisciplinary scientific team in a combined geological, archaeological and biological research effort. Beginning with a reconstruction of the geological history of the Bering Land Bridge and its southern terminus, Laughlin and his colleagues hope to reveal:

1–The influence of the physical and biological environment on the migrations and evolution of ancient men.

2–The economic adaptation of man to his environment and its impact on his cultural development.

3–Evolutionary changes and genetic influences on the development of human populations.

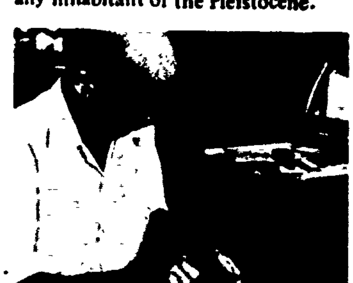
This kind of interdisciplinary study, Laughlin and National Science Foundation officials agree, could uncover some of the influences that led to the development of modern man. And the eastern Aleutians may well be the only place in the world where that can still be done.

It may take another 5 or 10 years to complete the work, Laughlin says. But he regards the current, interdisciplinary study of the living and ancient Aleuts in relation to their past and present environments as potentially, at least, the definitive, culminating phase of his life's work.

FLINTKNAPPING FOR FUN AND SCIENCE

A master Stone Age craftsman

POCATELLO, Idaho–Don Crabtree resembles nothing so little as he does a stone-age man. Yet he is as good a maker of stone-age tools as any inhabitant of the Pleistocene.



This slight, balding and mustached former hotel-keeper and soils conservationist has become so skilled in the making of flint and obsidian tools and weapons that he, himself, has become a valued scientific resource.

After 40 years of flintknapping–flint chipping or flaking to make tools–this 59-year-old research associate at the Idaho State University Museum here is able to make fist-axes, spear points and scrapers real enough to fool the experts. His artifacts are good enough to teach professional anthropologists and archaeologists many things about the stone tools they find among ancient dwellings and which they use to reconstruct the life of stone-age man.

The Unwritten History

"We are trying to record the history of man from the aboriginal artifacts and implements he used for his livelihood," Crabtree explains. "We want to extend the unwritten history of man in order to better understand the everchanging environment."

"If this Crabtree had lived 40,000 years ago," says Francois Bordes, director of the Laboratory of Prehistory at the University of Bordeaux, France, "he could have taught ancient man a thing or two about toolmaking." As it is, he is teaching modern men about the culture and behavior of ancient toolmakers through analysis and reconstruction of ancient toolmaking technology.

Crabtree can use an antler mallet or chisel (billet and tine to the experts) to chip or flake a piece of obsidian or other stone in precisely the fashion the ancient artisans might have.

"When an artifact is replicated," says Crabtree, "it must be in every technological aspect a duplication, not an imitation . . ." of an actual object. And he has developed, through experimentation, a variety of pressure and percussion techniques, using a variety of materials, in order to create the effect he seeks: a tool virtually indistinguishable from one made by stone-age craftsmen.

How He Began

Crabtree has been pursuing stone-age craftsmanship since, when he was a boy, a neighbor gave him some stone arrowheads for running errands. Unable to learn anything of their manufacture from the Indians of the nearby Salmon River country of Idaho, he began to seek the answers himself.

By the time he was 12, he was using a deer antler billet and hammerstone for flaking stone by percussion, a deer antler tine for finishing tools by pressure flaking, and his father was offering him $100, which he turned down, to concentrate more on his farm chores.

Crabtree realized even then, however, that he was imitating, not duplicating, the artifacts. Since then, experimenting with both the techniques and materials suggested by archaeological finds, with which he is as familiar as the professionals, Crabtree though he never finished more than one college year has contributed considerably to the knowledge of prehistoric toolmaking.

While hunting suitable material for early experiments, for example, he realized that the waste materials found at Indian campsites were glassier and different in color than the raw rock he was trying to work. He noted similar qualities in implements he studied at the Ohio State Museum in the 1930's, and it occurred to him that the Indians had treated their flint before working it.

He also noted that volcanic obsidian, heated during its formation, is readily workable in its native state while more coarsely fibered similar but nonvolcanic minerals are extremely difficult to flake. Untreated material is tough, relatively inelastic and will not withstand the necessary pressure for flaking; after heating, the same material has great elasticity and will respond better to pressure, he explains.

He tried heat-treating specimens of native flint, and found that changes in lustre took place. He pursued the idea, using first an old-fashioned coal range, then a ceramic kiln, to produce the effects he had seen.

He has since developed the widely accepted theory that prehistoric toolmakers broke chunks of native material into smaller pieces, placed them in earth ovens beneath campfires and after a few days removed them and shaped them into implements. He has experimented with this method and found that it works.

"His European colleagues no longer laugh at Crabtree for 'cooking his flints,'" says Bordes.

Revealing The Technology

What makes Crabtree's work so important, says Dr. Earl H. Swanson, director of the Idaho State University Museum, is that, "He does not simply set out to make a copy of the final form of an attractive or especially interesting object, but examines the array of flakes and cores associated with such specimens at archaeological sites. He then sets out to produce a sequence of manufacturing steps (and) a duplicate of the archaeological specimen."

Since ill health forced Crabtree's retirement from his job as a soils conservationist for the Department of Agriculture, he has worked with Swanson on projects funded by the National Science Foundation and sponsored by ISU.

A major problem has been how to analyze, record and communicate his skills so that his knowledge of stone toolmaking may not be lost. Because he has found it impossible to express in writing the complex motions and techniques followed in shaping primitive tools, films and workshops for promising young archaeologists are being employed. NSF grants have made possible the completion of five educational films; the last four are now ready for distribution. The first has been available for some time.

Films and Workshops

Called "The Shadow of Man," the first film shows primitive toolmaking, from excavation to flintknapping, at prehistoric obsidian quarries in eastern Oregon.

The four others, designed for undergraduate college classroom use, show principles of flaking by use of force, focus on the production of a precise "cone of force", detail pressure flaking, explore heat treatment and examine the blade-making process used widely during some 40,000 years of human prehistory.

In addition, for the past two summers Crabtree has worked with graduate students from universities around the world at the flintknapping workshops in Idaho, made possible by NSF grants and ISU. A third workshop is being held this summer. The NSF is also helping Crabtree reduce as much of his work to writing as is possible. This will include an illustrated dictionary of stoneworking terms and a bibliography.

social sciences

Where Attitudes Have Their Roots

Words like "clean," "freedom," "forgiving," "equality," "salvation" and "honest" are loaded words, but not everybody loads them the same way. The relative importance people place on them and on other values-related words appears to hold a key to the whole host of attitudes and social and economic characteristics.

"A 'values print' is just as characteristic of a person's philosophical, psychological and religious orientation as a fingerprint is of his identity," says Dr. Milton Rokeach, a Michigan State University social psychologist.

Dr. Rokeach, currently on loan to the University of Western Ontario in Canada, believes that values, the things that people want ultimately to achieve and the ways in which they must behave to achieve them, are far more important in understanding and characterizing a group than are "attitudes" — short-range concentrations of values around single incidents or sets of circumstances. He also contends that it is a shortcoming of existing public opinion research that it concentrates on attitudes, rather than digging deeper toward the underlying values.

"This neglect," he says, "is not so much a matter of choice as it is a matter of necessity. Given the present state of development of the social sciences, it is not yet . . . feasible to assess routinely the values underlying public opinion."

It is toward the closing of that "technology gap" in the social sciences that he and other social scientists have been working for the last three years.

The Second Leg

With the National Science Foundation support, the Michigan scientist is currently embarked on the second leg of a long-term study of the values of segments of the U.S. population, and how they are changing over time.

So far he has developed and tested a pair of 18-item lists of "terminal" (ultimate achievement) and "instrumental" (modes of conduct) values which enable him to identify people on the basis of their value systems. On the basis of these scales, he expects to be able to assess changes in people's values over time.

The lists include such "instrumental" values as ambitious, capable, clean, honest, independent, intellectual, obedient and self-controlled, and such "terminal" values as an exciting life, family security, happiness, mature love, national security, social recognition and wisdom.

He can, he believes, differentiate among political philosophies, levels of affluence and religious denominations, to name a few, on the basis of the relative importance people place on value-laden words.

He has found, for instance, that racial differences in value systems appear to be far less significant than are economic differences. An exception is a greater concern among blacks with "equality." Otherwise the values of the poor black are likely to be very close to those of the poor white, Dr. Rokeach says.

Freedom vs. Equality

"The differences in political orientation that get people mad at each other in the United States are mainly a function of a single value: equality," Dr. Rokeach declares. "That's what the political fights appear to be all about. No matter how complex the issues may be, they all seem to come down to that," he says. Groups which value "freedom" highly, he says, for instance, may also rank "equality" low, and vice versa.

Only two values, "salvation" and "forgiving" appear to stand out as the most distinctively Christian, while differences among Protestant groups seem to hinge on differences among denominations in the value placed on "salvation." Values like "loving" and "helpful," on the other hand, do not turn out to be distinctively Christian; most other religious and non-religious groups value these just as highly in the United States.

Dr. Rokeach's values scales are finding application in efforts to understand, by assessing the order in which a group ranks its values, the things that appear to divide California junior college students from their teachers, the police from the policed, hippies from non-hippies and the young from the middle aged. He is also finding that values can be changed, and that the changes are long-lasting

The effort on which Dr. Rokeach is currently embarked, and which he thinks could represent a major contribution his work can make, is to repeat the national survey he made in 1968, to see how American values might have changed over time

"This can be where the values scale will really prove to be important," says Dr. John C. Scott, director of the National Science Foundation's Sociology and Social Psychology Program, through which Dr. Rokeach's work is being supported.

"A World of Beauty"

Scott and Rokeach both believe, for instance, that the general low ranking virtually all groups gave in 1968 to "a world of beauty" as a terminal value, will have changed radically when the results of this year's second go-round are in.

"It might take three to five survey cycles, one every three years or so, before a national values trend can be described with any confidence," says Dr. Rokeach. But he contends that it is important to conduct them in order to determine what the emerging national positions are on such subjects as freedom and equality, civil rights, ecology and national security.

With that in mind, he is designing his scales of values to become part of a broader effort in which social scientists, with National Science Foundation and other Federal agency support, are attempting to develop a scale of social indicators. These would be devised to do for social phenomena what the array of business and economic indicators is designed to do in economic fields: provide the factual information on where the country is and the directions in which it is moving, so policy decisions can be more intelligently made.

An Economist's View of Crime

Criminals, says Dr. Gary S. Becker, are "risk takers."

The term is one usually applied by economists to investors in legitimate but highly speculative enterprises. But Becker is an economist who, with National Science Foundation support, is using the tools of economic analysis to look at the more than $20 billion a year "crime industry" in the U.S.

The NSF grantee is trying to measure risks, incentives, direct and indirect costs and other determinants of the level and impact of criminal activity, and plug them into the standard analytical equations economists use to study economic phenomena.

All of the questions relating to society's response to crime, he says, "require analysis of behavioral responses and policy choices resulting from the scarcity of resources, and hence fit into the traditional framework of economics."

As is the case with any risk-taker, for example, says Becker who is associated with the University of Chicago and the National Bureau of Economic Research in New York, if the criminal's risks get high enough the speculative activity is bound to come down. And since the assurance of punishment is a greater deterrent to crime than is the severity of punishment, he says, a measured, businesslike expansion in that direction might represent a better investment of society's resources than more prisons or tougher laws.

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