



BioScience

American Institute of Biological Sciences
AUGUST 15, 1992
BCRAIGH3FOC060167 001 INDF7101
DR. F. C. CRAIGHEAD
BOX 156
MOOSE WY 83012
VOL. 21 NO. 16

SECOND NATIONAL BIOLOGICAL CONGRESS

Fontainebleau Hotel
Miami Beach, Florida

23-26 October 1971

MAN AND ENVIRONMENT II

BIOLOGISTS AS PLANNERS

Saturday morning, 23 October

Ecological Engineering

Chairman: Athelstan Spilhaus, Woodrow
Wilson International Center

Ecology and the Planning of Future Cities

Chairman: Keith Hay, American Petroleum
Institute

Problems of Developing the New World

Chairman: W. Frank Blair, University of Texas

Agriculture in an Urban Society

Chairman: To be Announced

Newer Knowledge of Autoimmune Diseases

Chairman: Robert A. Good, University of
Minnesota Medical School

BIOLOGISTS AS OBSERVERS

Sunday morning, 24 October

Radiation—Its Control and Future Dangers

Chairman: Alexander Hollaender, Oak
Ridge National Laboratory

Our Mobile Earth

Chairman: William E. Benson, National
Science Foundation

Perspectives on Primary Productivity of the Earth

Chairman: Robert Whittaker and Gene E. Likens,
Cornell University

World Trends in Epidemic Diseases

Chairman: Marshall Laird, Memorial University
of Newfoundland

World Trends in Our Environment

Chairman: Thomas Malone, University of
Connecticut

BIOLOGISTS AS PROBLEM SOLVERS

Monday morning, 25 October

Advances and Needs in Sewage Treatment

Chairman: Gilbert V. Levin,
Biospherics, Inc.

Strategy of Approaching the World Protein Food Problem

Chairman: Aaron M. Altschul, U.S. Department
of Agriculture

Weather Modification: Ecological Opportunities and Environmental Problems

Chairman: Lee M. Talbot, President's
Council on Environmental Quality

Past, Present and Future of the Everglades

Chairman: Nathaniel Reed, The National
Park Service

Population Problems: Search for Solutions

Chairman: Philip Corfman, NIH Center for
Population Research

Saturday evening, 23 October

THE ROLE OF BIOLOGISTS IN SHAPING NATIONAL POLICY

Sunday evening, 24 October

THE ATWATER MEMORIAL LECTURE

Jean Mayer, Harvard University

15 AUGUST 1971

VOL. 21 NO. 16

BioScience

American Institute of Biological Sciences

Letters Editorial Articles

<i>S. K. Majumder</i>	842
Thoughts on National Parks, <i>J. L. Culliney</i>	843
ABSTRACTS	844
Grizzly Bear-Man Relationships in Yellowstone National Park, <i>J. J. Craighead and F. C. Craighead, Jr.</i>	845
Preservation and Management of Grizzly Bears in Yellowstone National Park, <i>G. F. Cole</i>	858
Evolution of a Light Scattering Photometer, <i>D. T. Phillips</i>	865

Education

Features and News

Professional Accreditation: Objectives and Objections, <i>J. G. Creager</i>	868
The R/V <i>Alpha Helix</i> Antarctic Expedition, 1971, <i>E. A. Hemmingsen</i>	869
PANORAMA	871
BIOLOGY BRIEFS	873
PEOPLE AND PLACES	874
MEETING REPORT: Phytotoxins, <i>R. N. Goodman</i>	875

Books

REVIEWS	877
Natural Resource Conservation, An Ecological Approach (<i>R. H. Manville</i>), p. 877; Flies and Disease (<i>R. L. Beaudoin</i>), p. 877.	
Animal Physiology (<i>M. Gordon</i>), p. 878; Social Implications of Biological Education (<i>H. J. McKenna</i>), p. 878; Cell and Molecular Biology, An Appreciation (<i>J. H. Taylor</i>), p. 878.	
The Elements of Palaeontology (<i>V. A. Zullo</i>), p. 879; Genetics of the Evolutionary Process (<i>P. J. Bryant</i>), p. 879; Basic Ideas in Biology (<i>T. F. Andrews</i>), p. 879.	

Employment

Advertising Index

Cover Photo

Capparis canescens Banks ex DC. of the family Capparidaceae is a stunted tree often less than 3 meters high. It is restricted geographically to Eastern Australia and Torres Strait in warm dry habitats under seasonal climatic conditions (the genus is reported from the Indus to the Pacific). The showy flowers are usually quite rare in the Queensland populations because of attacking ants. Photo by Stan Morain, University of Kansas, Lawrence.

BioScience, the official publication of the American Institute of Biological Sciences, 3900 Wisconsin Ave., NW, Washington, D.C. 20016, is published twice monthly. Institutional subscription prices: \$18.00 a year domestic (including Canada and Pan America); \$20.00 a year all other foreign. Single copies: \$1.50. Individual subscriptions to *BioScience* are not available except through membership in the AIBS. © 1971. American Institute of Biological Sciences. Changes of address, undeliverable copies, orders for subscriptions, and other related items should be sent to *BioScience*, 3900 Wisconsin Ave., NW, Washington, D.C. 20016. Second class postage paid at Washington, D.C.

Letters

Timely Effort Needed

The avalanche of literature on *Ecology* and *Environment* in recent years has assumed overwhelming proportions. Authors who have contributed to this phenomenal outburst are, by no means, limited to the area of biology; they come from such diverse persuasions as sociology, economics, political science, theology and English literature. I applaud this diversity and would like to defend it vis-a-vis such expressions of alarm and cynicism as "Instant Ecology," "Eco-freaks," and "Prostitution of Hardcore Science."

There is nothing new about a country's educational system reacting to national or international events of far-reaching consequence. We recall vividly how the Russian Sputnik, about two decades ago, made us question the efficiency of our Science program in the secondary schools. Our aeronautic and computer sciences reached maturity when it was seriously felt that Russia was about to steal the show in Space exploration. The pendulum has swung back and forth from basic to applied research during the wars and the aftermath of rehabilitation. In all such cases of emergency, only a specific ob-

jective goal was set; it was short-term and expedient.

I believe that the current ecological crisis is quite another story. Without the fanfare of a war or an epidemic, it crept up on us. It has lingered and intensified by the "protective callousness of affluence" as the illustrious anthropologist, Margaret Mead, describes it. So pervasive is the nature of the ecological crisis that for academicians and nonacademicians, and for young and old, it requires no definition. We all know that it plagues our waking hours with questions about the quality of life and even our future survival.

In addition to the physical threats to survival, the industrial society also poses a different kind of human predicament; it points to man's concurrent inner crisis. Dr. Howard Thurman, one of America's great religious leaders, believes that "it is not possible to pollute and ravage Nature without deep agony and terror registering in the collective psyche of modern man."

According to the basic principle of "Information Theory," as I understand it, the greater the number of questions we have to ask to conceptualize a system, the greater is the indication of our initial ignorance about

such a system. Judging from the multitudes of questions that have been posed in recent times about *Ecology* and *Environment*, our collective ignorance is distinctly manifest. It is only by educational re-orientation and resilience, if you will, that we turn the tide and begin to minimize the wasting of our creative energy.

The educational program in question is necessarily interdisciplinary. The problem of man's place in the sun entails scientific as well as socioeconomic, political, philosophical and religious questions (McClary, 1970; White, 1967). I am convinced that the realization of the need for this synthesis of knowledge is one of the most significant phenomena in academic life today. With insistence, "timely" effort may very well testify to the "timeless" quality of rational human beings.

References

- A. McClary. 1970. *BioScience*, 20: 10
L. T. White, Jr. 1967. *Science*, 155: 1203.

SANAT K. MAJUMDER
Department of the Biological Sciences
Smith College, Northampton, Massachusetts

Erratum

In the article "Water Quality in Relation to Farm Use of Fertilizers" by Frank G. Viets, Jr., Vol. 21, No. 10, p. 460-467, there were the following omissions:

p. 462 last paragraph, middle column should have read "Dr. Barry Commoner, in the typescript of his talk to the AAAS at Dallas in 1968, used the Illinois State Water Survey data and additional data of the U. S. Geological Survey on the Missouri River." The words in italics were omitted from the sentence.

p. 466 References list, one incorrect name and one reference deleted - under the "D's" the correct reference should have been:

Davis, Sterling, F. T. Bingham, E. R. Shade, and L. B. Grass. 1969. Water relations and salt balance of a 1000-acre citrus watershed. In: *Proc. First Int. Citrus Symp.*, 3: 1771-1777.

Dawes, J. H., T. E. Larson, and R. H. Harmeson. 1969. Nitrate pollution of water, p. 94-102. In: *Frontiers in Conservation*. Proc. 25th Ann. Mtg., Soil Conserv. Soc. Amer.



The Negev: The Challenge of a Desert

Michael Evenari, Leslie Shanan and Naphtali Tadmor

In this lively, richly illustrated book, the authors describe the past and present challenges of the Negev desert to man, plants, and animals. This is more than just a scientific study. It is a book of life itself.

"It is no secret that the Israelis have made the desert bloom, and in this exhilarating book three Israeli scientists describe how they did it . . . by reviving the methods used by long-vanished civilizations."

John Barkham, *Saturday Review Syndicate*

" . . . a valuable and splendidly illustrated work . . . I commend it to all who are coping with the problem of desert and semi-desert agriculture, as well as to all ecologists."

\$15.00

Sir Julian Huxley

HARVARD

Harvard University Press, Cambridge, Mass. 02138

CIRCLE NO. 842 ON READERS' SERVICE CARD

15 AUGUST 1971
VOL. 21 NO. 16

American Institute of Biological Sciences

Editorial Board

Helmut K. Buechner, Edward S. Deevey, Donald S. Farner, Philip Grant, A. C. Leopold, Edward P. Radford, Howard A. Schneiderman, Philip Siekevitz, and Herbert Stern.

Editorial Staff

Publisher: John R. Olive

Editor: John A. Behnke

Head of Publications and
Associate Editor:

Robert S. Leisner

Managing Editor:

Margaret U. Chambers

Features and News Editor:

Walter G. Peter III

Associate News Editors:

Jo Ann V. Fowler

Business Staff

Advertising Production:

D. Anne Harberger

Institutional Subscriptions:

Frank Lo Verde

Membership: Joanna Buckle

Opinions expressed by authors are their own and do not necessarily reflect the opinions of the American Institute of Biological Sciences nor the institutions with which the authors are affiliated.



Circulation audited by Verified
Audit Circulation Corporation

Editorial and business address: American Institute of Biological Sciences, 3900 Wisconsin Ave., NW, Washington, D.C. 20016. Printed at Editors Press, Inc., 6041 33rd Ave., Hyattsville, Maryland 20782. National Advertising Representatives: Joseph Bourgholtzer, Inc., The JBI Building, Mahwah, New Jersey 07430. Advertising rates and information mailed on request.

August 15, 1971

BioScience

THOUGHTS ON NATIONAL PARKS

The recent papers in *BioScience* (Vol. 20, No. 21) on human-bear interactions impart a sense of urgency to conservationists' pleas to preserve, as intact as possible, the flavor of wilderness in our national parks. The proposal by Moment (1970) to eliminate grizzly bears from Glacier and Yellowstone Parks for the protection of campers is, at best, shortsighted. I believe that the simple challenges and, indeed, dangers of wilderness experiences will become priceless outlets for mental health in more and more individuals who already feel a loss of control over events that shape their lives in a dis-individualized society.

Grizzly bears have injured far fewer visitors in the national parks than have certain man-made hazards, for example, automobiles. Statistics from Yellowstone National Park reveal that from 1968 through 1970 automobile accidents injured 384 of the Park's 6.7 million visitors. These data reduce to an average annual injury rate of 1 visitor per 17,500. Furthermore, during this 3-year period, 10 people died in auto accidents in the Park.

Herrero (1970 a, b) states that grizzly bears have injured only 77 of a total of 150 million visitors during the nearly 100-year history of North American national parks where the grizzly is found. This reduces to an injury rate of about 1 person per 2 million, easily less by two orders of magnitude than the rate cited above due to automobiles in Yellowstone Park. In addition, Herrero can find records of only five persons ever having been killed by grizzlies in the parks.

To promote safety and retain the sense of wildness surrounding the varied beauties of our parks, it would be more appropriate to eliminate or curtail the growing private automobile traffic in the parks before getting rid of the grizzlies.

I therefore recommend Edward Abbey's (1968; 1970) provocative proposal to return the parks to the people and relegate cars to "national parking lots" outside the parks. This would not only enhance natural features and solitude but would also give an enormous number of motor-bound Americans a novel recreational experience. As Abbey points out, people walking, bicycling, or horseback-riding would find previously crowded parks suddenly seem much larger, less congested, more relaxing. Family-sized tents and other gear in excess of that easily carried by visitors themselves could be efficiently transported in Park Service trucks from a parking lot to a pre-selected campsite. While encouragement could be given to campers to "go light," the baggage transportation should be vastly simpler than present systems serving airline travelers. A limited amount of motorized public transportation could be provided for sightseeing by the elderly and the infirm, including the hopelessly addicted mechanical tenderfeet.

Yellowstone National Park is now taking steps to reduce the vehicular crush around several major impact areas, including the Old Faithful geyser. Soon visitors will follow bypass roads leading to large parking lots, and then walk to the geysers. Such changes cannot come too soon, for it seems obvious that parks have carrying capacities (in terms of vehicle density) which, when exceeded, will diminish a visitor's recreational experience, or the natural quality of unique park features or, most likely, both. A park can undoubtedly entertain infinitely more pedestrians, cyclists, etc., than motorists, and I urge the National Park Service to develop experimental programs, especially in presently crowded areas, to get people out of their cars and into the parks.

Finally, it seems ironic that we should be so well protected from minute personal hazards, such as grizzly bears or the danger of falling (guard rails are erected in high places everywhere), while protections of a higher order (from shoddy goods and services, from modern warfare, from eco-catastrophe, etc.) are slow to emerge. Being reasonably well-coordinated, my friends and I do not need guard rails. We feel we do need to know that bears are out there, even though, as Herrero suggests, we use whistles in the back country to warn them of our approach. We may get to see one at a distance, and after returning home, we resurrect the grizzlies, the high places, scorpions, rattlesnakes, and even the mosquitoes again and again, and the appreciation of these things does not lessen. It grows until the next time.

References

- Abbey, E. 1968. *Desert Solitaire, A Season in the Wilderness*. McGraw-Hill Book Co., New York.
_____. 1970. Applachian pictures. *Audubon*, 72 (5): 4-13.
Herrero, S. 1970a. Man and the grizzly bear (past, present, but future?). *BioScience*, 20 (21): 1148-1153.
_____. 1970b. Human injury inflicted by grizzly bears. *Science*, 170 (3958): 593-598.
Moment, G. B. 1970. Man-grizzly problems - past and present, implications for endangered species. *BioScience*, 20 (21): 1142-1144.

JOHN L. CULLINEY
Museum of Comparative Zoology
Harvard University

Editorial opinions of the author do not necessarily reflect the position of AIBS.

Articles

Grizzly Bear-Man Relationships in Yellowstone National Park

845

John J. Craighead and Frank C. Craighead, Jr.

For over 80 years, during tourist seasons, garbage dumps have concentrated grizzly bears in Yellowstone National Park. From 1968 through 1970, many dumps were closed and grizzlies dispersed throughout the Park—including campgrounds. The Park Service plans to close the last Yellowstone dump during 1971; this rapid phaseout could create the most dangerous grizzly situation that has existed during the history of the Park. (Accepted for publication 2/19/71)

Preservation and Management of Grizzly Bears in Yellowstone National Park

858

Glen F. Cole

Park records for the past 40 years showed artificial food altered the habits of some grizzlies. This increased the opportunity for bears to injure humans. The desirability of maintaining grizzlies under natural conditions was shown by the low incidence of injuries from bears in the "wild." (Accepted for publication 3/31/71)

Evolution of a Light Scattering Photometer

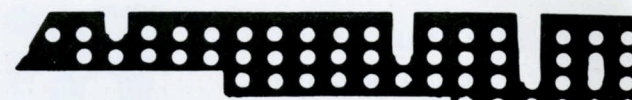
865

David T. Phillips

Development of a new light scattering photometer is traced from an idea for the identification of bacteria through early experiments and prototype instruments to a commercial product. The design was shaped by laboratory use. Precision of scattering measurements surpassed the optical microscope and led to discovery of new microbiological techniques. (Accepted for publication 6/18/71)

NAS Exchanges with USSR & EE Academies

The National Academy of Sciences invites applications from American scientists who wish to visit the USSR, Bulgaria, Czechoslovakia, Hungary, Poland, Romania, or Yugoslavia for varying periods during the 1972-1973 academic year. Under agreements with the respective academies of sciences, American scientists may make visits of a minimum of one month's duration for familiarization with current scientific research or longer visits of 3 to 12 months for research. Applicants must be U.S. citizens and have a doctoral degree or its equivalent in physical, biological, or behavioral sciences, mathematics, or engineering sciences by the time of the intended visit. All necessary expenses will be met by the NAS and the foreign academy, including reimbursement for salary lost up to \$1,500 a month during a visit of 3 months or more and for transportation of families for visits of 5 months or more. Deadline for applications: 22 November, 1971. (National Academy of Sciences, Office of the Foreign Secretary (USSR/EE), Washington, D.C. 20418).



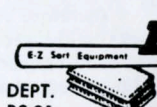
INFORMATION RETRIEVAL

FIND IT FAST

WITH E-Z SORT PUNCHED CARDS

- E-Z TO SORT
- WITHOUT COSTLY MACHINE EQUIPMENT.
- SIMPLE TO CODE
- RAPID RECOVERY OF DESIRED DATA
- CAN BE DECENTRALIZED
- FLEXIBLE — EXPANSIBLE

WRITE TODAY FOR COMPLETE INFORMATION ILLUSTRATING HOW E-Z SORT SYSTEMS CAN AID YOU TO QUICKLY RETRIEVE SELECTED DATA — USING marginally punched cards.



E-Z SORT SYSTEMS, LTD.
DEPT. BS-81 351 Bryant St. • San Francisco 94107
CIRCLE NO. 844A ON READERS' SERVICE CARD

Mogul-ED™

THE PRIMARY SOURCE OF SUPPLY ...FOR TEACHING: BIOLOGY

Mogul-ED... now a consolidated source which identifies a group of established companies with over 60 years of quality, economy, and service. Mogul-ED products include live animals, biological materials, and our famous DI/SEKTO preserved animals.

DI/SEKTO... THE ODORLESS, NON-TOXIC, PRESERVATIVE THAT MAKES STANDARD FORMALIN PRESERVATIVES OBSOLETE.



MAIL TODAY FOR 155-PAGE CATALOG

Mogul-ED LABORATORY PARK
CHAGRIN FALLS, OHIO 44022

Name _____
School _____
Street _____
City, State, Zip _____

CIRCLE NO. 844B ON READERS' SERVICE CARD

BioScience Vol. 21 No. 16

Grizzly Bear - Man Relationships in Yellowstone National Park

John J. Craighead and Frank C. Craighead, Jr.

The grizzly bear, *Ursus arctos horribilis*, is an intelligent, extremely efficient omnivore and a relatively inefficient carnivore. This large bear feeds on grasses, sedges, tubers, berries, nuts, carrion, meat caches, rodents, big game, livestock, garbage, and even modern packaged foods. The propensity to seek and utilize a wide range of edibles has brought the grizzly into frequent contact with man. This ecological relationship of the omnivorous grizzly associating with omnivorous man and the predatory bear competing with the predatory human has led and will continue to lead to confrontations, property damage, and occasional conflict and injury. The grizzly has a long history of seeking and taking the food it wants with little opposition. The erratic, aggressive, and frequently unpredictable behavior of both grizzly and man increases the probability of conflict. The opportunity for confrontation and for injury to humans is small, but it is greater in national parks than elsewhere.

To understand grizzly bear-man relationships in Yellowstone National Park, we must first recognize that the ecology of bear and man has always overlapped. Within recent geological time, wherever the species existed, the grizzly bear was at or near the top of the North American food pyramid.

The North American Indian and the grizzly bear coexisted in a spacious environment. Two questions we wish to explore are can the grizzly bear and modern man co-exist in the congested environments of our large national parks? Specifically, can man and grizzly live together in Yellowstone? Secondly, if they can co-exist, how should man achieve this? Both questions require more than theoretical or philosophical answers, ethological extrapolation, administrative decrees, or generalized guidelines.

The authors are with the Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana 59801.

We, our colleagues, and our graduate students sought to answer these questions 12 years ago when we began a long-term study of the grizzly bear within the 19,943 km² (7700 miles²) National Park and adjacent national forests (Craighead et al., 1960). Since 1959, we have captured, examined, and released over 550 grizzlies, immobilized and individually color-marked 256 and logged over 40,000 man-hours observing and recording their activities and behavior. In addition, 24 individual grizzlies have been fitted with radios and radio-monitored for approximately 30,000 hours in order to obtain data on movements, home ranges, food habits, social and denning behavior, and an understanding of bear-man relationships (Craighead and Craighead, 1965, 1969, 1970).

Some Biological Facts

Using data from 324 censuses totaling 11,340 hours and from an intensive trapping, re-trapping, and marking program, we have calculated a minimum of 175 grizzly bears in the Yellowstone area. One-third of the adult females (about 15) breed each year and produce an average of 33 cubs or a 19% annual increment. The females first breed successfully at 4 1/2 years though many may not produce cubs until they are 8 or 9 years old (Craighead et al., 1969). The annual increment slightly exceeds the mortality rate; thus, the population grew at an average annual rate of approximately six grizzlies per year from 1959 through 1966 (Craighead and Craighead, 1967). An increase in the death rate, especially of adult females, could jeopardize the population.

In the summer months, grizzlies gradually, but steadily, congregate at Trout Creek (Fig. 1) and at other major open-pit dumps in and outside of Yellowstone. Grizzlies are attracted to these dumps from all portions of the Park and from the adjoining national forests. Peak densities are reached in

August. Our observations indicate that there are few grizzlies in the Yellowstone backcountry during this time. Mullen and Booth (1969) also found fewer grizzlies on the Shoshone National Forest adjacent to Yellowstone during August than prior to and after this month. Our census and movement data (Craighead and Craighead, 1967) show that Yellowstone National Park serves as a summer refuge for many grizzly bears whose home ranges extend beyond the Park boundaries. We have computed that a 12,950 km² (5000 miles²) area including Yellowstone National Park and an adjacent 16.1-km (10-mile) corridor of national forest land supports an average of about one grizzly bear to every 75.1 km² (29 miles²). Some grizzlies spend their lives entirely within the Park; others do not. Those that move outside the Park boundaries are hunted. Forty-eight per cent of the grizzlies shot outside the Park from 1959 to 1968 were adult animals and 52% were subadults ranging from yearlings to 4-year olds, showing that outward movement from within the Park is not confined to young animals. These data suggest that movements of grizzlies out of the Park result from the species' natural mobility and should not be interpreted as evidence that grizzlies have exceeded the carrying capacity of their environment in Yellowstone National Park.

Studies have been made of the movements and home ranges of grizzlies inhabiting Yellowstone and adjacent portions of four national forests. Data from color-marked and radio-tagged bears show that most, perhaps all, of the grizzlies in this population feed at one or more of the earth-filled garbage dumps (Fig. 2) at sometime during the course of their lives; some visit the dumps frequently, others infrequently. Thus, it is doubtful if the term "wilder-ness grizzly" is useful if we mean an animal having no contact with "artificial" food sources. For example, 114

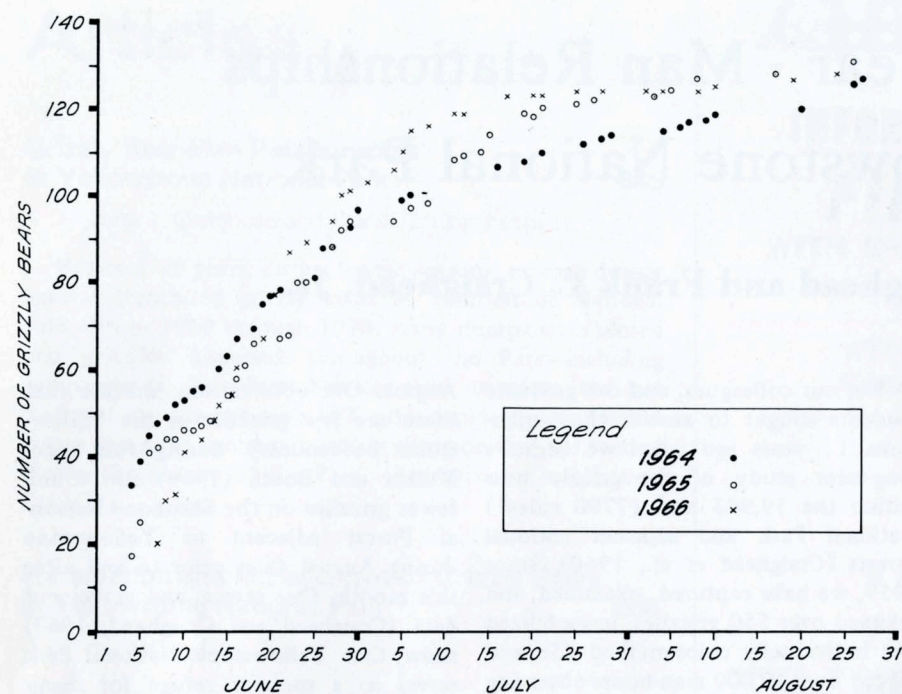


Fig. 1. Seasonal coalescence of grizzly bears at Trout Creek Dump. Each data point represents a 3 1/2 hour census.

marked grizzlies were identified at the Trout Creek Dump during the summers of 1966 through 1968. Table 1 lists the number of these marked animals identified at the dump and also in the backcountry. During a 3-year period, 37% of all the marked grizzlies that visited the Trout Creek Dump were also observed in the backcountry. Because of the pattern of human use in Yellowstone National Park, areas a kilometer or more from roads and developed areas conform to the definition of wilderness as it is stated in the National Wilderness Preservation Act. Approximately 95% of the 7806 km² (3400 miles²) in Yellowstone National Park can be considered backcountry. Most backcountry observations were made in spring and fall when the grizzlies were dispersed. As Table 1 shows, all age classes disperse throughout the Yellowstone backcountry.

Additional observations in the backcountry and at other garbage dumps during other years also show that, in the spring and fall months, the grizzlies that feed in summer at these garbage disposal areas also frequent the Yellowstone wilderness.

All Yellowstone grizzlies, regardless of their feeding habits or degree of association with man, inhabit wilderness portions of the Park and adjoining national forests from October through April. Thus, management of grizzly bears in Yellowstone Park affects not

only resident animals in the Park but also grizzlies inhabiting four national forests in three states.

Food disposal areas (Fig. 2) have attracted grizzlies for over 80 years. They have shaped and are integrally meshed with grizzly bear ecology in Yellowstone. Except for the nature of the food, they are ecological equivalents of the spawning salmon runs that attract and concentrate Alaskan brown bear (*Ursus arctos middendorffi*) during the summer months. Yellowstone garbage sites concentrate the grizzly bears during a 3-month period from June through August.

Key questions posed are: Have the garbage dumps basically altered the grizzly's relationship to man? Have they increased or decreased grizzly-man conflicts in Yellowstone? Should they be eliminated and, if so, how? To answer these questions we must understand bear-man relationships and the nature of bear-man conflicts.

Bear-Man Relationships

We can classify grizzly bears inhabiting the Yellowstone area into four types, based on their feeding behavior as related to humans. These are: (1) bears which forage at the garbage disposal areas during summer months; (2) those that either occasionally or habitually visit campgrounds or developed areas; (3) bears man-conditioned by food

handouts at lodges and construction camps; and (4) grizzlies which reside throughout most of the year in the backcountry and rarely visit a garbage dump, campground, or other developed areas. Overlapping of types occurs, yet the four categories are quite distinct. The majority of bears fall into the first category. Those in the second and third categories, though few, are the most troublesome. Practically no Yellowstone grizzlies qualify for the fourth category.

Behavior of grizzlies frequenting garbage dumps. We have obtained no evidence that the Yellowstone area has two distinct populations of grizzlies – “wild living” animals inhabiting the wilderness country and “garbage-addicted” grizzlies inhabiting the dumps and developed areas of the Park. On the contrary, thousands of man-hours spent observing grizzlies at open-pit dumps and hundreds spent observing these same color-marked animals and monitoring radio-instrumented bears in wilderness country divulged not two distinct populations but two distinct behavioral patterns. Many of the grizzlies that feed at the isolated, open-pit, garbage dumps exhibit less fear and greater tolerance of man at these areas than at other areas. The same animals that ignore human scent at the dumps are quickly alerted by it in the backcountry. From hundreds of encounters that we made with grizzlies when they were 0.8 kilometer (1/2 mile) or more from the dumps, we observed that, in most instances, they were alert and wary and would generally flee when they heard us or got a scent. Tolerance of man while feeding on artificial food at the dumps is definitely linked with specific sites. It is not a general toleration of humans or of human scent although in rare instances the on-site conditioning may alter behavior in other locations. Animals that feed at garbage dumps, presumably where the human scent is strong, ignore it there but not elsewhere. We have little evidence that garbage feeding changes their human avoidance behavior. Troublesome grizzlies normally develop their behavioral patterns toward humans under quite different circumstances.

The Yellowstone garbage dumps provide grizzlies with an abundance of palatable food, congregate them for an unnaturally long period of time, and alter some of their behavioral patterns. Feeding at these dumps does not normally develop grizzlies into garbage-

seeking animals, make them dependent on humans (Leopold, 1970), or create incorrigible animals. This does not imply that the garbage dumps are beneficial and should be kept open: it does mean that eating “unnatural” versus “natural” food does not, in itself, significantly alter the behavior of Yellowstone's grizzlies toward human beings.

Behavior of grizzlies frequenting campgrounds. Of 36 grizzly bears captured and initially marked in campgrounds, 64% re-entered a campground or developed area following their release; 28% re-entered two or more times. Among 221 grizzlies initially captured and marked at garbage disposal sites or in the backcountry, 36 (16%) were later captured in a campground or developed area. Only 9.5% re-entered two or more times (Table 2). Thus, many grizzlies initially captured and marked in campgrounds had already developed chronic campground feeding habits and they became problem animals more often than grizzlies captured and marked elsewhere. The data in Table 2 also suggest that capturing and marking grizzlies, which was essential to document the animals' behavior and movements, did not condition them to man or convert them into troublesome bears. Had this occurred, a much higher percentage of those captured and marked outside of campgrounds would have become “campground foragers.” Evidence indicates that most of the troublesome grizzlies were developing or had already developed into problem animals before they were captured and marked in campgrounds.

The large number of animals marked (over 60% of the population at one time), as well as the unmarked grizzlies, exhibited a normal range of bear behavior. However, only bear-man relationships involving marked grizzlies could be individually and quantitatively documented. Therefore, few objective or legitimate comparisons can be made between avoidance or confrontation behavior of marked versus unmarked animals. Since we have no evidence that capturing and marking grizzlies altered their behavior toward humans, information obtained from marked animals is considered representative of both marked and unmarked ones.

From observations of marked bears and from records of radio-tagged ones, we learned that grizzlies become accustomed to campground foraging

during spring and fall migratory movements when their travel routes intercept campgrounds. During this same period, grizzlies extend their home ranges searching for food. This pattern has been especially evident at the Lake and Canyon Village Campgrounds. Yearlings and 2-year-olds may wander into campgrounds following weaning, a time when they normally begin to disperse and establish home ranges of their own. For this wide-ranging, inquisitive animal, chance alone, no doubt, accounts for the discovery of, and addiction to, the food available in campgrounds. Those that learn to frequent campgrounds become conditioned to the near presence of humans. Those that enter infrequently remain shy and secretive. Habitual campground foragers normally develop behavioral patterns in response to the presence of man that are markedly different from those of grizzlies that feed at the isolated, open-pit dumps.

Any grizzly which frequents a campground is a potential hazard because humans may startle it at close range and be attacked. However, it is important to discriminate between habitual offenders and those that enter campgrounds for short periods of time, then move on and do not repeat the offense except infrequently over a period of years. It is difficult to define precisely the habitual offenders or incorrigible animals on a basis of frequency of visitation or frequency of recapture in campgrounds. However, until better criteria can be formulated, we have defined habitual offenders as those recaptured four or more times. Table 3 shows that among 72 grizzlies of both sexes, 69% were either never recaptured or were recaptured only once; 87% were not recaptured or were recaptured one to three times. Only 13% were recaptured four, five, or six times. These individuals constitute the habitual offenders.

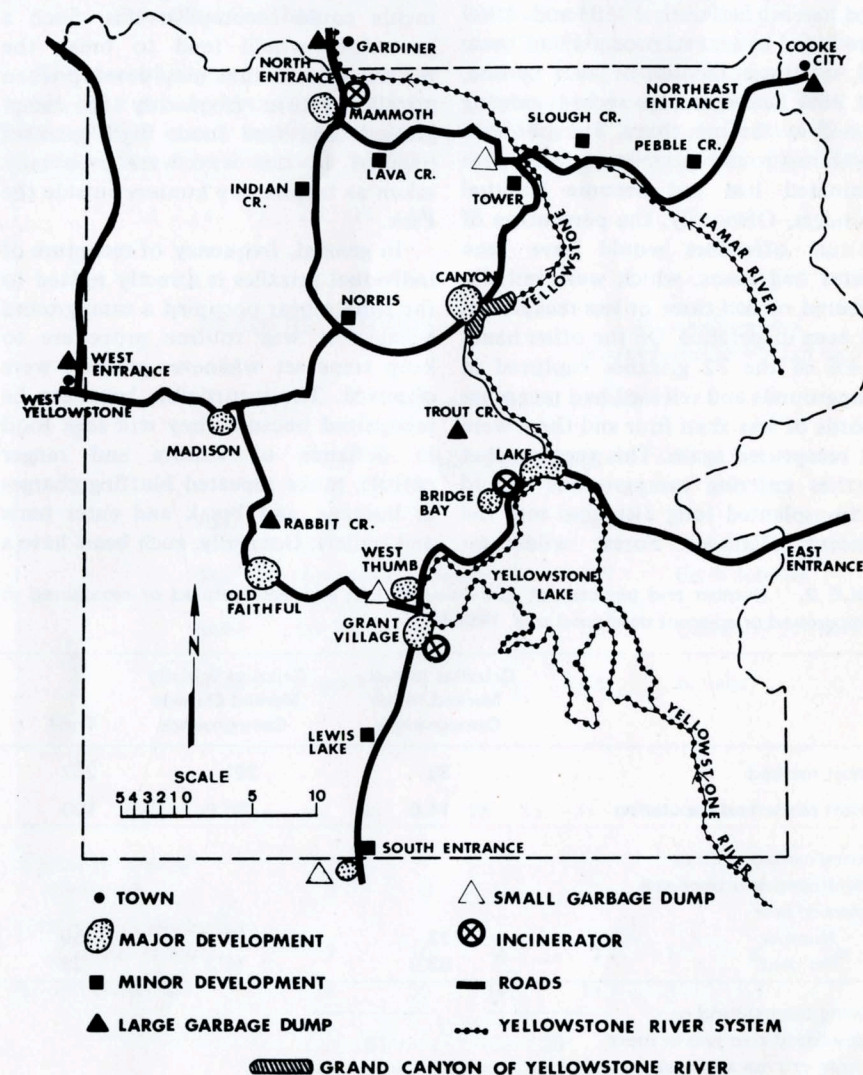


Fig. 2. Map of Yellowstone National Park showing developed areas, garbage dumps, and incinerators.

TABLE 1. Color-marked grizzlies observed at Trout Creek Dump and reobserved in wilderness areas^a of Yellowstone National Park from 1966 to 1968

Cubs	1-Year Olds	2-Year Olds	3-Year Olds	4-Year Olds	Adults		Total
					Males	Females	
229	218	183	158	141	30	39	
230	219	202	177	144	207	40	
236	220	216	185	147	217	101	
240	221	227	211	165		112	
241	233		228	183		128	
256				188		132	
				208		141	
						163	
						172	
						173	
						187	
						228	
6	5	4	5	7	3	12	42

^aWilderness and backcountry are used synonymously in the text. They are undeveloped, roadless areas retaining their primeval character without permanent improvements or human habitation. In these areas, the earth and its community of life are untrammelled by man, and man himself is a visitor.

Table 4 shows that 28 of the 72 bears captured in campgrounds or developed areas between 1959 and 1969 were killed or sent to zoos; 61% of these had recapture records of zero or one, and 86% had recapture records ranging from zero through three. Thus, 86% of the campground grizzlies which were eliminated had not become habitual offenders. Obviously, the percentage of habitual offenders would have been greater had bears, which were initially captured or had three or less recaptures, not been dispatched. On the other hand, 51.4% of the 72 grizzlies captured in campgrounds and released had recapture records of less than four and these were not recaptured again. This suggests that grizzlies entering campgrounds should be transplanted long distances into the adjacent National Forest wilderness

country following a first capture rather than dispatched. Cooperative agreements could accomplish this. Such a procedure would tend to break the reward pattern that may develop when grizzlies return frequently to campgrounds and find food. Eight grizzlies handled in this way were eventually taken as trophies by hunters outside the Park.

In general, frequency of recapture of individual grizzlies is directly related to the time a bear occupied a campground because it was routine procedure to keep traps set whenever grizzlies were observed. The incorrigible bears can be recognized because they will seek food in defiance of visitors and ranger patrols, make repeated bluffing charges at humans, and break and enter tents and trailers. Generally, such bears have a

TABLE 2. Number and per cent of 257 color-marked grizzlies captured or recaptured in a campground or adjacent developed area, 1959-69

	Grizzlies Initially Marked Inside Campgrounds	Grizzlies Initially Marked Outside Campgrounds	Total
Number marked	36	221	257
Per cent of marked population	14.0	86.0	100
Entering campground or developed area once as a marked bear			
Number	23	36	59
Per cent	63.9	16.3	23
Entering campground or developed area two or more times as a marked bear			
Number	10	21	31
Per cent	28.0	9.5	12

long history of campground tenancy. There is no question about the necessity of eliminating such animals. The problem is what to do with infrequent offenders. We believe great discrimination should be practiced in eliminating grizzlies after the first capture or with recapture records of one through three.

Behavior of grizzlies conditioned by food handouts. By radio-tracking grizzlies that had been regularly fed in the presence of humans or that had developed foraging habits bringing them into frequent and close association with man, we learned that such animals developed behavioral patterns that made them extremely dangerous. They learn to associate food-getting with humans and soon lose their fear of man and human scent. They become thoroughly conditioned to man. This conditioning is not associated with a particular feeding area, as is the case with grizzlies that feed at remote garbage dumps, but is a general conditioning to man wherever he is encountered. Such animals may co-exist with people for extended periods of time but, sooner or later, these man-conditioned animals are startled by humans at close range, defy interference at a food source, or completely disregard humans in their attempts to get food. This may occur in a campground, on a trail, or in the backcountry. The result may be a bear-man encounter ending in human injury or death.

For a grizzly to lose its shyness or fear of man requires cooperation and encouragement, and the initiative is usually with man. One male grizzly, No. 202, was radio-tracked for 2 consecutive years during the summer and autumn. Yearling No. 202 was instrumented and radio-monitored for 56 days in 1965. During that time, he established a 69.9 km² (97 miles²) home range that encompassed Canyon Village, but he did not visit the campgrounds and caused no trouble. However, the following spring when he emerged from winter sleep, he swam the river and traveled the north rim of the canyon which led him directly into the Canyon Village Campground with its food supply.

As a 2-year-old, he was radio-monitored for 118 days of 1966. Though frequenting the campground, he gave no serious trouble until fall when he began visiting two construction camps in the area. He received food handouts and soon became bold enough to attempt to enter trailers and to feed

fearlessly in the presence of humans. During 1966, this animal established a home range 323.7 km² (125 miles²), with Canyon Village Campground as his center of activity.

Emerging from winter sleep as a 3 ½-year-old animal, he returned to his old haunts in the campground. No. 202 was not an aggressive bear, had inflicted no injury, and had caused little or no property damage, but he had been conditioned by food handouts, had lost his normal respect for man, and, thus, became a potential menace to the safety of visitors. He was shot as a precautionary measure at the age of 3 ½.

Fortunately, grizzlies conditioned by food handouts at concessionaires or work camps have been rare in Yellowstone National Park. They have been more numerous in Glacier National Park. On the evening of 13 August 1967, at two widely separated locations in Glacier, grizzly attacks resulted in the deaths of two 19-year-old concessionaire employees and serious injury to an 18-year-old boy. Both attacks can be linked to food handouts and man-conditioned bears (Olsen, 1969; National Park Service, 1979; Leopold, 1970; and personal communications, Gerry Atwell, 1967; Frank Evans, 1967). Once man-conditioned by food handouts, the grizzly must be destroyed. The solution to such conditions is campground sanitation, frequent ranger patrols, and thorough enforcement of the National Park Service regulations pertaining to the feeding of bears.

Behavior of grizzlies in the backcountry. Grizzlies, living under wilderness conditions, utilize natural food but may be attracted to food made available by humans, and may become man-conditioned. For example, in 1961, a crew working on the control of blister rust experienced frequent confrontations and attacks from a 3-year-old, male grizzly in the Washburn Range, far from a developed area. At first the bear was shy and avoided the men. Over a period of several weeks, he gradually lost his shyness. He excavated buried lunch trash and then accepted lunch scraps thrown to him. Eventually, he approached boldly for food and made bluffing charges. On five occasions, he treed members of the crew and then rifled their packs and lunch pails. We later captured, color-marked, and numbered this animal. He became No. 80; his movements to and from camp-

TABLE 3. Recapture record of grizzlies captured in campgrounds — 1959-69

	Number of Times Recaptured in a Campground							Total
	None ^a	One	Two	Three	Four	Five	Six	
Males	13	16	4	4	2	1	1	41 (57%)
Females	13	8	2	3	1	3	1	31 (43%)
Total	26	24	6	7	3	4	2	72 (100%)
Per Cent	36	33	8	10	4	6	3	
	69		18		13			
	87				13			(100%)

^aNone = captured in a campground and never recaptured.

grounds are shown in Figure 3. This thoroughly man-conditioned grizzly was shot in June 1963 by Park rangers after molesting visitors camped in wilderness country near Lewis Lake. This documented account illustrates the role of food handouts in developing incorrigible bears. Generally, conditioning to man evolves in developed areas, but it is not necessarily limited to them.

Bear-Man Conflicts

The probability of being injured or killed by a grizzly bear in Yellowstone National Park is very small. From 1900 to 1970 there have been two fatalities from grizzlies (National Park Service, 1880-1970). Both occurred in the early 1900s. From 1931 to 1970, when more detailed records were kept, official National Park Service records show 63 injuries and no fatalities. During these 39 years, an average of a million people per year visited the Park. Thus, the injury rate from grizzlies has been one person per 600,000 visitors.

Although grizzly bear attacks on man are rare, they provide exciting news copy and generate apprehensive, public response. This, in turn, has initiated control action often with over-reaction-

ary measures that have been harmful to the co-existence of the grizzly and man. Following the 1967 fatal incidents in Glacier National Park, four female grizzlies were shot and a cub was wounded. Only one of these animals was conclusively linked with the attacks. The National Park Service Report, "Grizzly Bear Attacks at Granite Park and Trout Lake in Glacier National Park, August 13, 1967," suggested garbage-feeding as a conditioning factor, but did not mention the frequent feeding of grizzlies on garbage and food handouts in the presence of human viewers. This conditioned the bears at Granite Park to lose their normal respect for humans and may have man-conditioned the particular animal responsible for the tragedy.

Lightning storms, age, and physical ailments of the bears, and unknown reasons, were listed as possible causes of the Trout Lake fatality. Cosmetics, hair sprays, and menstrual odors were cited as the probable causes for this particular attack. Subsequently, signs were erected at trail heads, warning — "Women — Do not travel in the backcountry during menstruation." This presumed cause for the attack — to our knowledge unsubstantiated — was widely publicized

TABLE 4. History of the 28 grizzlies eliminated following initial capture or recapture in campgrounds — 1959-69

Times Recaptured in Campgrounds	None ^a	One	Two	Three	Four	Five	Total
Number of males eliminated	4	7	2	0	1	1	15
Number of females eliminated	3	3	2	3	0	2	13
Total grizzlies eliminated in control measures	7	10	4	3	1	3	28
Per cent eliminated	25	36	14	11	3	11	
	61		25		14		
	86				14		100%

^aNone = captured once in a campground and eliminated.

and probably deterred many women from making wilderness hikes.

Personal injury records. Personal injuries caused by grizzly bears have been recorded in Yellowstone National Park for the past 40 years (1931-70). We have found it difficult to evaluate these records because the injuries have varied in severity from bruises and minor wounds, requiring no professional medical attention, to those that required hospitalization. Also, there has been doubt whether some injuries were inflicted by grizzlies or by black bears. We have accepted with reservations the data which show 62 known and probable injuries from grizzlies, or 1.55 per year.

From 1959 through September 1970, we worked closely with Park rangers to keep more accurate records of personal injuries inflicted by grizzlies

(Table 5). Injuries during this period averaged two per year or approximately one injury for every 900,000 visitors. This is hardly a record that would support the removal of all grizzlies from Yellowstone (Moment, 1968) or a drastic control program within the Park. However, during 3 years of the Park Service's present program of bear management (1968-70), injuries averaged 3.33 per year. In comparison, injuries were only half as numerous from 1959 to 1967 — averaging 1.67 per year. We believe that the increase is due largely to the present management practices that have forced grizzly bears into campgrounds and developed areas of the Park (Fig. 5).

Control measures. Control of grizzlies within the Park is performed by the ranger staff. Troublesome animals are either killed or shipped to zoos. The

term "dispatch" includes both of these control measures. From 1931 to 1970, 140 grizzlies have been killed; this is a 40-year average of 3.50. The exact number shipped to zoos during this period is unknown.

Seventy-four grizzlies have been dispatched by the Yellowstone administration during our 12-year period of research. This averages 6.17 grizzlies per year (Table 5). During 9 years of this period (1959-67), prior to the enactment of the Park Service's present program of bear management, control averaged 4.1 per year. During 3 years of revised management (1968-70), control averaged 12.3 grizzlies per year. Twenty-two grizzlies were eliminated from the Yellowstone population in control measures in 1970. Information on the number of deaths occurring from other causes during 1970 is not yet available. However, there was an average of 11 such deaths per year from 1959 through 1966. These represent only those deaths where the causes of death were known. If we assume that 11 grizzly bears will die in addition to those eliminated by control, then the expected loss from the population during 1970 will total 33. This just equals the average annual increment (Craighead and Craighead, 1967), but statistics compiled during our study indicate that as many grizzlies die each year from unknown as from known causes. Consequently, the population loss for 1970 will greatly exceed the average annual increment. It is obvious that the Yellowstone grizzly population cannot long sustain such losses.

A comparison of the annual control figures and personal injuries with Park visitation from 1959 through 1970 (Table 5, Fig. 4) shows no correlation with the increase in visitor numbers. A correlation should be expected. We attribute the lack of one to the fact that the open-pit dumps served to concentrate and isolate the grizzly bear population during the tourist season. Also public use of these areas has been restricted, thereby reducing the probability of grizzly-visitor interactions. We believe that the increased number of bears killed or sent to zoos (Table 5) during 1968-70 was directly related to the abrupt phasing out of the Trout Creek Dump and the closure of the Rabbit Creek Dump, which forced grizzly bears into campgrounds. This destroyed the effective zoning of grizzly and man that prevailed from 1959

TABLE 5. Injuries from grizzly bears, and control measures in Yellowstone National Park, 1959-70

Year	Park Visitors ^a	Personal Injuries	Control Measures		Total
			Grizzlies Killed	Grizzlies Sent to Zoos	
1959	1,408,667	0	6	1	7
1960	1,443,288	0	4	0	4
1961	1,528,088	1	1	2	3
1962	1,925,227	2	4	0	4
1963	1,872,417	6	2	4	6
1964	1,929,316	1	2	1	3
1965	2,062,476	4	2	0	2
1966	1,130,313	1	3	0	3
1967	2,210,023	0	3	2	5
1968	2,229,657	1	5	0	5
1969	2,193,814	6	10	0	10
1970 ^b	2,200,000	3	14	8	22
Total	22,133,286	25	56	18	74

^aData obtained from Yellowstone Park records, 1959-69.

^bWe estimated visitor numbers for 1970.

through 1967. As we have shown, the average number of grizzlies dispatched during the last 3 years is three times the average for the preceding 9 years. Using 200 grizzlies as a maximum population estimate (based on 324 census of 3 1/2 hours each totaling 11,340 hours, Craighead and Craighead, 1967), we can calculate that the population reduction effected by control measures for 1970 alone (22 grizzlies through 15 September) will exceed 10% of the Yellowstone population.

Control methods must differentiate between the dangerous, but relatively few, man-conditioned animals in the population and those essentially wild animals that for generations have fed at the remote garbage dumps and, in the course of seasonal movements or rare periods of natural food scarcity, have entered developed areas. Grizzlies become man-conditioned by eating in the presence of humans.

Transplants. For many years, troublesome campground grizzlies in Yellowstone National Park have been transplanted to remote areas within the Park. To evaluate the effectiveness of transplant and release as a technique for disrupting the campground foraging habits of grizzlies, we marked captured animals and released them at suitable sites from 1959 through 1967. We then recorded their movements by recapturing them. Starting in 1968, this task has been performed by Park rangers. Table 6 shows that over an 11-year period, there were 145 releases of grizzlies within Yellowstone National Park at varying distances from the campgrounds

or developed areas where they were captured. Our data show that 68% of these animals returned to the same or another campground following release. Although the percentage returning decreased with the distance transported, the capture-transport-release technique within the Park is clearly only a partial solution for dealing with troublesome grizzlies. Information from campground bears radio-tracked for extended periods of time further supported this conclusion. We believe more distant releases on federal lands adjacent to the Park would prove more successful.

Campground management. A concerted effort has been made to remove food from campgrounds or make it unavailable to bears. The installation of numerous, bear-proof garbage cans has helped the sanitation problem. However, campgrounds are still attractive to bears and will probably remain so as long as visitors are careless with their food or deliberately distribute table scraps to entice birds, bears, and other animals.

Behavior of Grizzlies in Response to Revised Management Practices

In 1941, officials of Yellowstone National Park abruptly closed the Canyon Village and Old Faithful feeding stations where large numbers of grizzlies and black bears were viewed by the public. The following year, rangers found it necessary to kill 28 grizzlies and 54 black bears when these animals dispersed to campgrounds and the

hotels at Canyon Village, Lake, and Old Faithful in search of food. An emergency situation existed that year, even though only 191,830 visitors were recorded in the Park.

From 1968 through 1970, with visitor numbers exceeding 2 million per year, the Yellowstone administration proceeded to repeat this type of management by abruptly phasing out the Tower, West Thumb, Trout Creek, and Rabbit Creek open-pit garbage dumps.

In 1967, prior to this decision, we had made a report to the National Park Service, *Management of Bears in Yellowstone National Park*, (Craighead and Craighead, 1967). In that report, we recommended slow phasing out of the open-pit garbage dumps, cautioning that:

Because phasing out of refuse dumps will disperse the grizzlies by destroying an attractive, if not essential, food source, the transition from pits to incinerators must proceed gradually, enabling the grizzlies to develop new feeding habits as well as altered social behavior and movement patterns. If the transition is slow and follows a recommended procedure, it is possible that no severe changes in population level, distribution, or behavior will result. If, on the contrary, the phasing out operation is abrupt, and a carefully planned procedure is not followed, the result most certainly will be increased grizzly incidents in campgrounds, accelerated dispersal of bears to areas outside the Park, and greater concentrations of grizzlies at

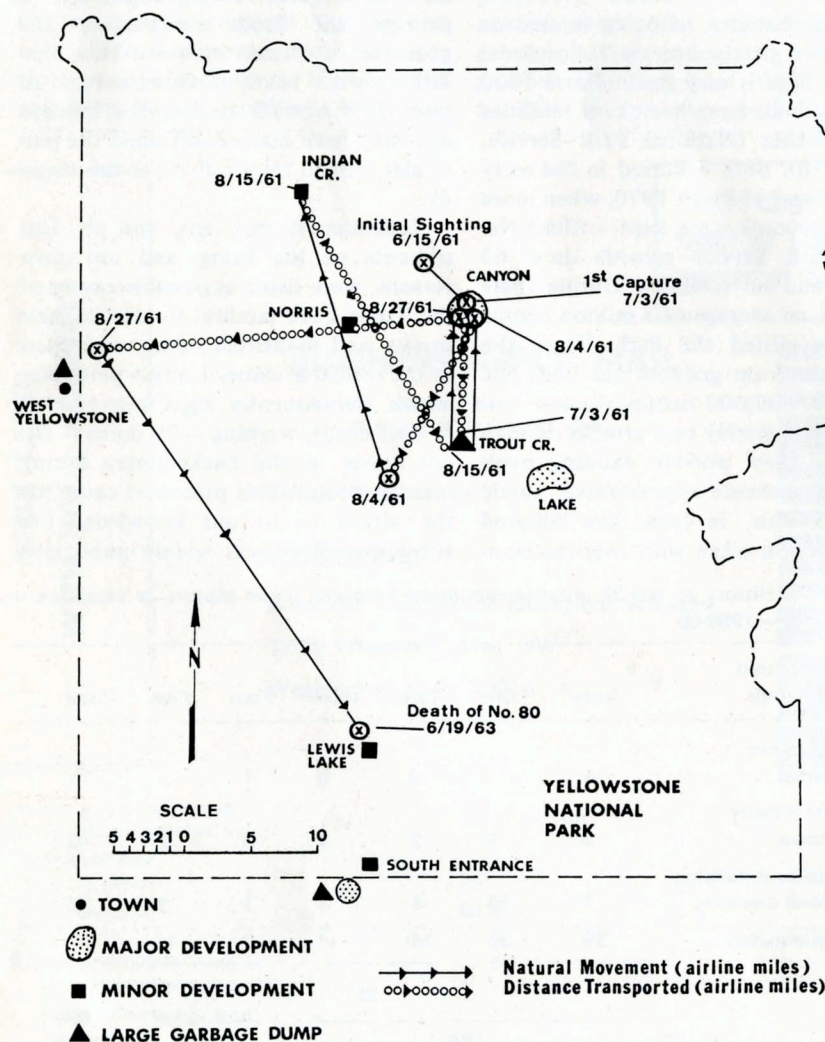


Fig. 3. Movements of Grizzly No. 80.

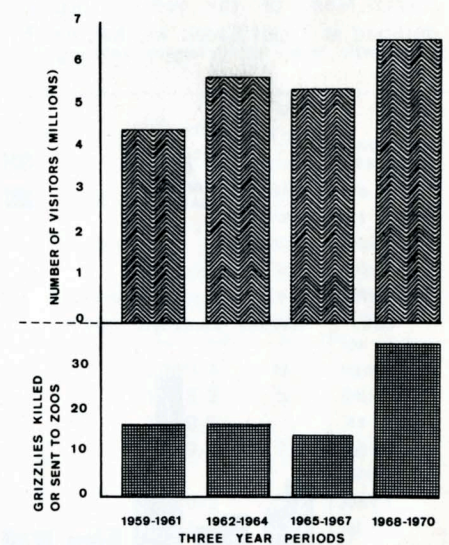


Fig. 4. Comparison of number of visitors and number of bears dispatched at Yellowstone National Park during 3-year periods, 1959-70.

TABLE 6. Record of the release of grizzlies after initial capture in a campground or developed area and subsequent recapture, 1959-69

	Distance Grizzlies Transported (airline km)				Totals
	0 - 10	11 - 20	21 - 30	31 - 40	
Number of releases after initial capture	75	46	20	4	145
Number of recaptures in any campground or developed area after release	53	32	12	1	98
Per cent of recaptures in any campground or developed area after release	70.7	69.6	60.0	25.0	67.6

the public dumps in Gardiner and West Yellowstone, where food will be available but where adequate protection will not. The net result could be tragic personal injury, costly damages and a drastic reduction in the number of grizzlies.

Phase-out of open-pit dumps. During the summers of 1959 through 1967, approximately 1000 cans of unsorted edibles and trash had been deposited daily at Trout Creek. The refuse was lightly covered with soil, usually on the day of deposit. The volume of food attracted and held grizzlies in the area during the summer months. During 1959-67, we documented the effect of this artificial feeding situation on the habits and behavior of grizzlies.

In 1968, the volume of garbage taken to Trout Creek was drastically reduced and we documented the effect of this on grizzly behavior. Edibles were partially separated from trash and dumped, but not buried. The sorted food consisted of approximately 50% nonedible trash. Most of the refuse formerly dumped at Trout Creek was handled by

the newly installed incinerator at Bridge Bay which had an operating capacity of 272.7 kg (6000 lb.) per hour. Our records, made when the refuse was dumped, showed that a maximum of eight cans per day were deposited from 3 June through 14 June; between 15 June and 15 July, the number gradually increased to 40 per day. During the remainder of the summer, the number was not increased significantly except when the Bridge Bay incinerator broke down.

The early summer cut-off of food, followed by a drastic reduction in edibles during the summer of 1968, dispersed the grizzlies throughout the Park. Our documentation of marked animals showed that many found their way into campgrounds, traveling between Trout Creek and the Canyon Village and Lake Campgrounds. Others moved back and forth between Trout Creek and the dumps at Rabbit Creek and West Yellowstone. This type of movement did not occur from 1959 through 1967 prior to the phase-out. Our censuses of population units in the vicinity of each

major dump showed that these units tended to be self-contained with very little exchange of animals (Craighead and Craighead, 1967).

Many unmarked grizzlies also entered campgrounds. Fifty-four per cent of the 37 grizzlies captured in campgrounds in 1968, 48% of 33 captured in 1969, and 41% of 49 captured in 1970 were unmarked. The movement of practically all the Trout Creek grizzlies, marked and unmarked, was greatly accelerated. A measure of this movement and disruption of long-established habits is reflected in the frequency of capture and the numbers of grizzlies captured in campgrounds each year during the period 1959-67 as compared to similar data for 1968 to 1970. The number of individual grizzlies captured in 1968 is approximately four times the average for the previous 9 years and double the previous high of 1961. Frequency of capture was the highest recorded in 10 years (Fig. 5).

In 1969 we continued on-site measurements of the volume of garbage dumped at Trout Creek. Between 130 and 170 cans were deposited daily from 15 June through August. Most of this was in plastic bags. Only about half the contents were edible. As in 1968, the garbage and trash were not buried, so the grizzlies that arrived at the dumps first were able to consume most of the food by evening; this left little to hold animals which arrived later. From 1959 through 1967, the general procedure was to dump trash with garbage and partially cover it with soil each day. This provided a long feeding period and allowed numerous animals to share the food. This procedure had, in the past, kept the grizzlies concentrated.

The dispersal of grizzlies that began in 1968 continued in 1969. The slight increase in the amount of garbage, designed to rectify the situation, was ineffective. The frequency of capture as well as the number of grizzlies captured in campgrounds and developed areas remained high (Fig. 5). In 1970, following the closure of the Rabbit Creek Dump, frequency of capture of grizzlies in campgrounds climbed still higher to a peak of 72; just twice the value of the 1961 peak. The number of individual grizzlies captured was 49, the greatest number ever recorded (Fig. 5). Thus, data on the number of individual grizzlies captured in campgrounds during the 3 years of revised management clearly show that the new management

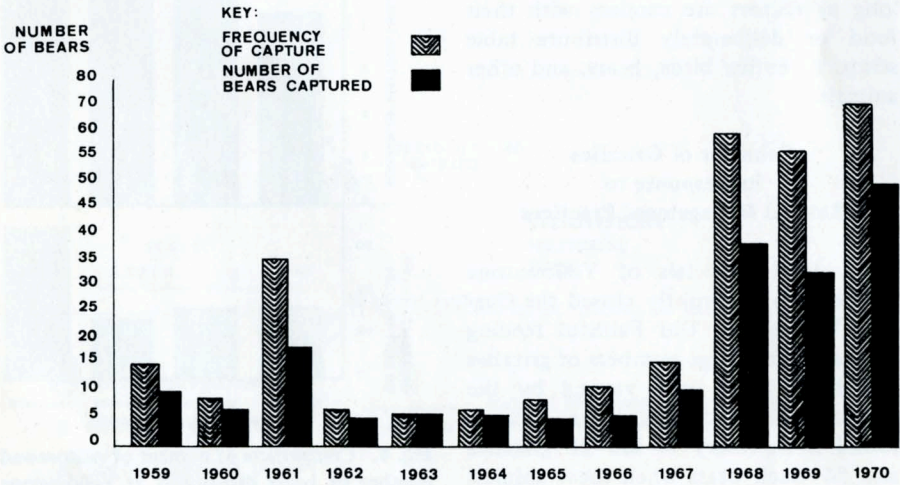


Fig. 5. Frequency of capture and number of grizzly bears captured in campgrounds.

practices have been creating problem bears that then must be dealt with by the Park administration. In Table 7, the frequency of capture and the number of individuals captured in campgrounds and developed areas during 1959 through 1967 was totaled and compared with similar data for 1968 through 1970. The rate of capture for 9 years (1959-67) was 117; for the past 3 years it was 190. The number of individual grizzlies captured for the same periods also increased.

Of the total number of grizzlies involved in campground foraging it is particularly revealing that 57 were captured during the 9 years prior to the rapid phase-out of the open-pit dumps, whereas 70 were captured during the first 3 years of phase-out (Table 7). Thus, from 1959 through 1967 an average of six grizzlies became campground foraging bears each year, but during the rapid cut-back in garbage (1968 through 1970), an average of 23 grizzlies became campground-oriented each year. Data in Table 7 also show that Grant Village, which was first opened to the public in 1967, presumably had no problem bears that year, as none were captured. The following years it was visited by grizzlies. Twenty-five were captured during the 3-year period of revised management. Similarly, no grizzlies were captured at Slough Creek, Tower Fall, Madison Junction, and Mammoth from 1959 to 1967, but grizzlies were captured at these campgrounds from 1968 to 1970.

We must conclude that the new bear management practices, programmed to quickly phase-out the open-pit dumps in Yellowstone without first adequately sanitizing the campgrounds, greatly increased the probability of bear-man conflicts as more grizzlies entered congested visitor areas. This program has rapidly "created" troublesome campground grizzlies. The administration's policy formulated to deal with this situation has been to kill or ship to zoos all two-time offenders entering campgrounds or developed areas within a successive 2-year period.

In 1969, the Natural Sciences Advisory Committee of the National Park Service met with Park administrators, biologists, and consultants to review grizzly bear management in Yellowstone National Park and to formulate a bear management policy and program (Natural Sciences Advisory Committee

Report, 1969). The Committee summarized the management goals as follows:

- 1) To maintain populations of grizzly and black bears at levels that are sustainable under natural conditions as part of the native fauna of the Park.

- 2) To plan the development and use of the Park so as to minimize conflicts and unpleasant or dangerous incidents with bears.

- 3) To encourage bears to lead their natural lives with minimum interference by humans.

TABLE 7. Frequency of capture and the number of grizzly bears captured in campgrounds

Campgrounds and Developed Areas ^a	1959-67		1968-70 ^b	
	Frequency of Capture	Individual Bears Captured	Frequency of Capture	Individual Bears Captured
Canyon Village	48	33	42	24
Lake	40	26	73	48
Old Faithful	9	9	23	17
West Thumb	17	11	7	6
Grant Village	-	-	30	25
Norris	1	1	2	2
Lewis Lake	0	0	1	1
Indian Creek	2	2	0	0
Slough Creek	0	0	3	3
Tower Fall	0	0	3	3
Mammoth	0	0	1	1
Madison Junction	0	0	5	3
Totals	117	82	190	133
Corrected totals ^c		75		124
Total individuals involved		57		70

^aCanyon Village includes Canyon Village and Otter Creek Campgrounds. Lake includes Lake, Fishing Bridge, Bridge Bay, and Pelican Creek Campgrounds. Grant Village opened in 1967 when the National Park Service began phasing out open-pit dumps.

^bUnmarked grizzly bears entering campgrounds during 1968 and 1969 could not be individually marked because of Park Service policy prohibiting marking of any animals in Yellowstone. Thus, in addition to marked animals, a minimum number of unmarked individuals, determined by criteria of sex, age, and time of capture, were recorded for the period.

^cIn 16 instances, bears were captured in two areas during a year. The corrected total of individual grizzlies captured per year corrects for this bias.

TABLE 8. Campground captures of five female grizzlies following the rapid phase-out of Trout Creek Dump, 1968-69

Bear No.	Year Marked	Date of First Capture in Camp-ground	Interval Between Marking & First Capture in Camp-ground	Age at First Capture in Camp-ground ^a	Number of Capture Areas	Frequency of Capture by Years	Number of Off-spring Produced Between Marking & First capture	Status of Female 1969
34	1960	1969	9	19 ½	1	1969-1	6	Alive
39	1960	1968	8	13 ½	2	1968-2 1969-5	5	Alive
40	1960	1969	9	11 ½	1	1969-1	7	Killed for control
109	1961	1969	8	8 ½	1	1969-2	0	Alive
128	1962	1969	7	18 ½ Min	1	1969-1	10 ^b	Alive

^aAge in years — all bears were aged by cementum layer technique. Ages designated minimum (Min) represent minimum cementum layer age. (Craighead et al., 1970.)

^bNo. 128 produced three more cubs in 1970.

The ultimate objective agreed upon by all participants was the sanitary disposal of trash and garbage in a manner that would deny this food source to bears.

The report continued:
But, in the meantime, there is a disagreement as to the sequence of steps leading to the elimination of garbage from availability to grizzlies. One view is to cut off all garbage quickly, forcing the bears to turn immediately to natural foods. The opposite contention is to phase out garbage feeding over a period of time, "weaning" the bears gradually. The issue hinges on which of these procedures will result in the least number of bears going into campgrounds.

In 1970, following the distribution of the Advisory Committee report, the Park continued its phase-out policy for garbage dumps by completely closing the pit at Rabbit Creek, which prior to this time attracted and held a population that fluctuated between 22 and 48 grizzlies. Our censuses showed an 8-year average of 32 grizzlies in the area during the summer months (Craighead and Craighead, 1967). Eight airline kilometers (5 miles) away a fenced sanitary land-fill dump was installed at Nez Perce Creek as a replacement for Rabbit Creek. With this accomplished, grizzlies with traditions of feeding at Rabbit Creek were completely and abruptly denied a long-established food source.

Movements of individual grizzlies in response to reduced food at the Trout Creek Dump during 1968-69. Five female grizzlies which frequented the Trout Creek Dump were color-marked between 1960 and 1962 (Table 8). They were captured in campgrounds or developed areas for the first time following the reduction of food at Trout Creek in 1968. The long interval between marking and first capture in a campground can be explained if these bears increased their daily movements and extended their home ranges in search of food. The home ranges of No. 39 and No. 40 had been established earlier by radiotracking (Craighead and Craighead, in Prep. a.).

No. 39 extended her home range in 1968 to include Lake Campground and the Bridge Bay-developed area. During 1968-69, she was captured five times at the Bridge Bay incinerator and twice in adjacent developed areas. In both years she was probably attracted there by odors from the incinerator.

We radiotracked No. 40 for 8 consecutive years (Craighead and Craighead, in Prep. b). While this female was radio-

monitored, she was never tracked into a campground or developed area. However, she entered the Lake-developed area in 1969 and was shot.

Since grizzlies of all ages made initial campground entries in 1968 and 1969, we do not think that the advanced age of three of the five grizzlies listed in Table 8 was a factor altering their behavior and movements. They were in excellent condition when last captured; all had reproductive records. No. 128 had produced ten cubs prior to her capture in 1969. She bore three more in 1970 at a minimum age of 19 1/2 - a total of 13 cubs during the 9 years she was marked. From 1960 to 1970, the five females bore a total of 28 offspring (Table 8). It is evident that management practices which "force" produc-

tive females into developed areas where they are subject to control could rapidly alter the population level.

Scarcity of the staple natural foods during 1968 and 1969 did not cause the movement, since the availability of these during the period was not importantly different from other years. Our data on the utilization of natural foods by grizzlies and on the relative abundance of these foods throughout a 12-year period cannot be presented here, but these fully support this conclusion. We, therefore, conclude that the five females recorded in Table 8, as well as 11 other marked grizzlies of both sexes, were captured for the first time in campgrounds in 1968 and 1969 primarily because of the acute food shortage at Trout Creek. Thirty-five

TABLE 9. Dispersal of 34 color-marked grizzlies and two recognizable cubs from Trout Creek following management changes at Trout Creek Dump during 1968 and 1969

Marked Bear No.	Campgrounds and Developed Areas Visited by Marked Grizzlies							
	Lake	Canyon Village	Grant Village	Norris	Cooke City Dump	Tower Dump	West Yellowstone Dump	Rabbit Creek Dump
7								X
10+(2) ^a						XXX		
30	X							
34					X			
39	X							
40	X							
88								X
109	X							
112		X						
128	X							
130			X					X
141	X	X						
144		X						
147								X
166							X	X
183	X							
188		X						
189								X
190							X	
194								X
201								X
207	X	X						
208	X	X						
210	X							
211	X			X				
213							X	X
217	X							
218								X
228		X						
236	X	X						
240	X							
241	X							
242					X			
256	X							
Totals	16	8	1	1	2	3	3	10

^aThe cubs of bear No. 10 dispersed with their mother and could be recognized.

unmarked individuals were also captured in campgrounds or developed areas for the first time.

Figure 6 and Table 9 show the movements from Trout Creek of 34 marked grizzlies and two recognizable cubs. Records of these movements were obtained by capturing the animals or by observing their individualized color markings. Sixteen individuals visited the Lake-developed area, eight entered Canyon Village, and ten moved to the Rabbit Creek Dump. Two moved to Cooke City; three, to Tower; three, to West Yellowstone; one, to Norris; and one, to Grant Village. Eight of the marked bears visited two campgrounds or developed areas (Table 9), thus accounting for the total of 44 bears shown in Figure 6.

Dispersal of individual grizzlies following the closure of Rabbit Creek Dump in 1970. Grizzlies inhabiting Rabbit Creek dispersed widely following the closure of that open-pit dump in 1970. Figure 7 shows the movements of 12 color-marked and two recognizable grizzlies to new feeding areas. All of these grizzlies were observed and recorded at Rabbit Creek for between 3 and 11 years prior to the closure (Table 10). Therefore, all could be considered resident members of this population unit.

Seven grizzlies moved 29 airline kilometers (18 miles) to the West Yellowstone Dump, which lies outside of the Park. Two joined the grizzlies at Trout Creek, 30.6 airline kilometers (19 miles) away; these also visited the West Yellowstone Dump. Grizzlies No. 2 and No. 8 moved 22.5 airline kilometers (14 miles) to the Grant Village Campground and developed area. Three grizzlies, including No. 2, moved to the Old Faithful area only 8 airline kilometers (5 miles) distant. Comparison of the 1970 census data taken at Trout Creek and West Yellowstone with other years suggests that many of the unmarked grizzlies from Rabbit Creek also moved to these other open-pit dumps.

In 1970 five grizzlies from Rabbit Creek were captured in campgrounds or developed areas and four were dispatched. None of these had previous campground records. The long intervals between marking and first capture in a campground or developed area (Table 11) show that the policy of rapidly closing the long-established open-pit dumps was still creating problem bears in Yellowstone. The official solution was still to dispatch the animal. There is

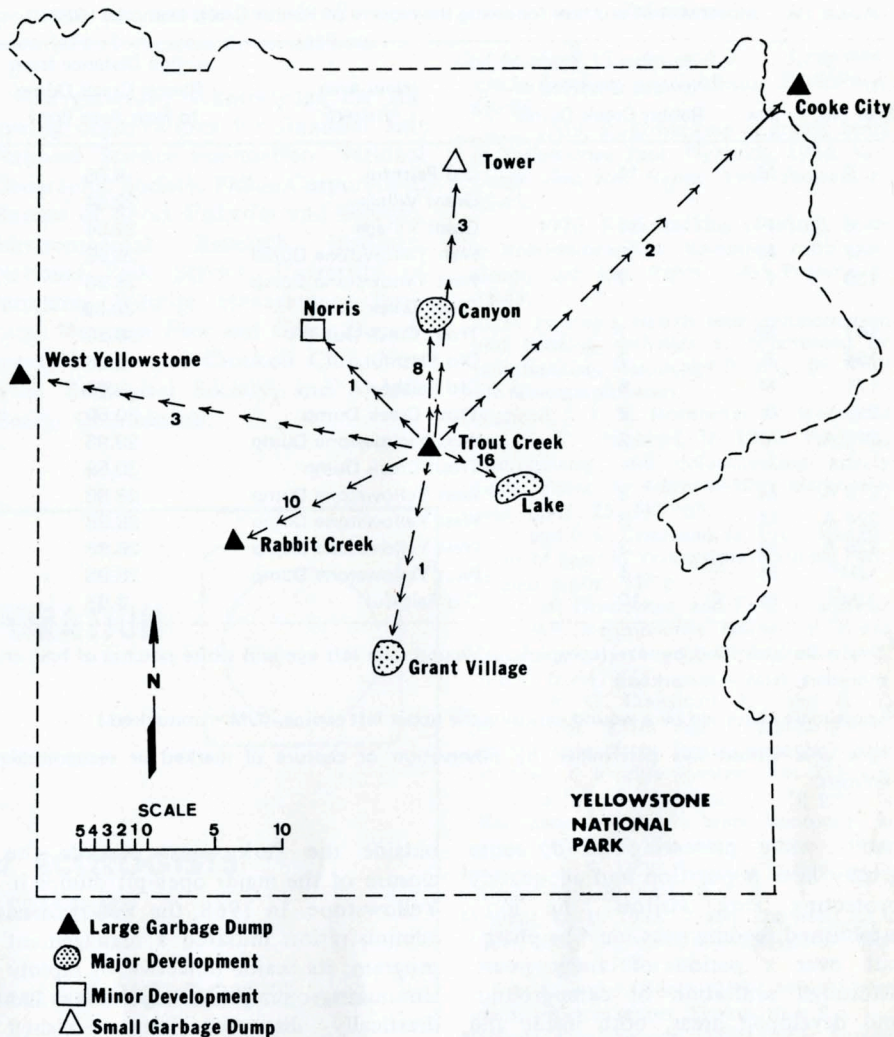


Fig. 6. Dispersal of 34 marked and two recognizable grizzlies following management changes at Trout Creek Dump during 1968 and 1969.

circumstantial evidence that No. 8 severely mauled a Park visitor in Grant Village on 3 September 1970. This color-marked animal had not been captured or observed in a campground during an 11-year period prior to this time.

The Park Service plans to completely close the Trout Creek Dump during the spring and summer of 1971. At the same time, the West Yellowstone Dump will be moved and fenced. This will disperse approximately 180 grizzlies in one season. This action, in all probability, will create more acute bear problems in campgrounds and developed areas in and near the Park than have existed in 100 years of Park history.

Discussion

Grizzly bears and man have co-existed in Yellowstone since the estab-

lishment of the Park in 1872. They have shared this environment during the past decade with about a 900,000-to-1 chance of confrontations leading to personal injury. The open-pit garbage dumps that came into existence with the establishment of Yellowstone Park have become traditional feeding areas for grizzlies. A long-term study showed that these dumps have altered the bear's behavior patterns at these sites, but they have not made grizzlies dependent on man or created the incorrigible animals that are a threat to the visiting public. On the contrary, the isolated dumps, with restricted public access, have effectively concentrated grizzly bears during the height of the visitor season. They have been extremely effective in reducing the probability of grizzly-man encounters and injury.

In order to induce the Yellowstone grizzlies to adopt more natural feeding

TABLE 10. Movement of grizzlies following the closure of Rabbit Creek Dump in 1970

Bear No.	Sex	Number of Years Previous Observed at Rabbit Creek Dump	New Area Visited ^C	Airline Distance from Rabbit Creek Dump to New Area (km)
2	M	11	Old Faithful	8.05
			Grant Village	22.54
8	F	11	Grant Village	22.54
57	M	10	West Yellowstone Dump	28.98
139	F	7	West Yellowstone Dump	28.98
			Trout Creek Dump	30.59
147	M	7	Trout Creek Dump	30.59
164	F	7	Old Faithful	8.05
171	M	6	Old Faithful	8.05
213	M	5	Trout Creek Dump	30.59
217 A	M	3	West Yellowstone Dump	28.98
			Trout Creek Dump	30.59
219 A	M	3	West Yellowstone Dump	28.98
224 A	M	3	West Yellowstone Dump	28.98
226 A	M	3	West Yellowstone Dump	28.98
UM ^a	M	4	West Yellowstone Dump	28.98
UM ^b	M	10	Old Faithful	8.05

^aThis male identified by size, conspicuous wound over left eye and white patches of hair on shoulders. (UM = unmarked.)
^bLarge male identified by a wound exposing the upper left canine. (UM = unmarked.)
^cNew area visited was determined by observation or capture of marked or recognizable animals.

habits while preserving an optimum grizzly bear population and adequately protecting Park visitors, the long-established feeding sites must be phased out over a period of many years. Thorough sanitation of campgrounds and developed areas, both inside and

outside the Park, must precede the closure of the major open-pit dumps in Yellowstone. In 1968, the Yellowstone administration initiated a management program; its major objective of rapidly eliminating open-pit garbage dumps has drastically disrupted long-established

TABLE 11. Campground captures of five grizzlies following the closure of Rabbit Creek Dump, 1970

Bear No.	Sex	Year Marked	Interval in Years Between Marking and First Capture in Campground	Age at first Capture in Campground	Capture Areas	Frequency of Capture	Status in 1970
2	M	1959	11	15 ½ - 16 ½	Old Faithful Grant Village	2	Killed for control
8	F	1959	11	19 ½ ± 2	West Thumb Grant Village	2	Killed for control
164	F	1963	7	12 ½	Old Faithful	1	Alive - Yellowstone
171	F	1964	6	9 ½	Old Faithful	3	Zoo for control
UM ^a	M	1960	10	22 ½ - 25 ½	Old Faithful	1	Killed for control

^aLarge male unmarked but identifiable during a 10-year period by a wound exposing the upper left canine.
^bExact age unknown.

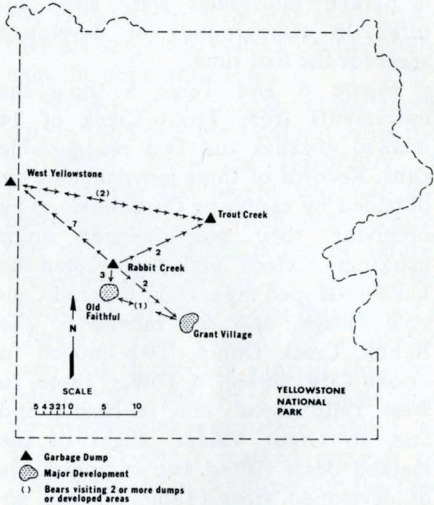


Fig. 7. Movement of 14 marked or recognizable grizzlies following closure of Rabbit Creek Dump, 1970.

grizzly bear patterns of feeding and movement. This has forced grizzlies into areas of high visitor use and vastly increased the probability of bear-man conflicts. Rapid elimination of "artificial" food at the dumps is not forcing the Yellowstone grizzlies to quickly adjust to an all-natural food diet, but is instead moving them into unsanitized areas inside and outside of the Park.

Since practically all of the grizzlies in the Yellowstone area have fed at open-pit garbage dumps during some time in their lives, a "wild population" cannot be made by denying this food and then dispatching all grizzlies that find it elsewhere in campgrounds and developed areas of the Park. The present rapid phase-out policy, combined with the elimination of two-time offenders, could reduce the grizzly bear population of the Yellowstone Park-National Forest Ecosystem to a dangerously low level in a relatively short period of time. We believe that grizzly bears and man can co-exist in this vast ecosystem if management is tailored to the facts of bear behavior, if all campgrounds and developed areas are sanitized, if open-pit dumps are slowly phased out, if the visiting public is willing to accept a small risk, and if all agencies having a vested responsibility in solving the problem work cooperatively toward common objectives.

Acknowledgments

This paper would not be possible except for the team assistance of many people and the financial support of numerous organizations.

We extend special thanks and credit to Jay Sumner, Harry Reynolds, Jim Claar, Maurice Hornocker, and Robert Ruff, who first as students, then as research associates, worked closely with us in the field and in the laboratory. Bart W. O'Gara critically reviewed the manuscript. Special thanks are also due Mr. Lemuel Garrison, former Superintendent of Yellowstone National Park, and C. R. Gutermuth, Vice-president, Wildlife Management Institute. Their understanding and encouragement of our research made it possible for us to initiate this grizzly bear study and to

maintain the continuity of effort so essential to long-term investigations.

We gratefully acknowledge the following organizations for financial aid: National Science Foundation, National Geographic Society, Philco Corporation, Bureau of Sport Fisheries and Wildlife, Environmental Research Institute, National Park Service, University of Montana, Wildlife Management Institute, Montana Fish and Game Department, Boone and Crockett Club, New York Zoological Society, and Atomic Energy Commission.

References

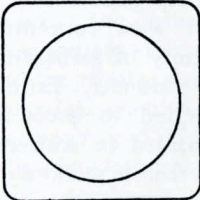
Craighead, F. C., Jr. and J. J. Craighead, 1965. Tracking grizzly bears. *BioScience*, 15: 88.
———, 1969. Radiotracking of grizzly bears in Yellowstone Park, Wyoming, 1964. *Nat. Geogr. Soc. Res. Repts.*, 1964 Projects, p. 35-43.
———, 1970. Radiotracking of grizzly bears in Yellowstone Park, Wyoming, 1965. *Nat. Geogr. Soc. Res. Repts.*, 1965 Projects, p. 35-43.
———, In prep. a. Grizzly bear prehibernation and denning activities as determined by radiotracking. Manuscript in prep. for Wildlife Monograph Series.
Craighead, J. J., M. Hornocker, W. Woodgerd and F. C. Craighead, Jr. 1960. Trapping, immobilizing and color-marking grizzly bears. *Trans. N. Amer. Wildlife Natur. Resour. Conf.*, 25: 347-363.
——— and F. C. Craighead, Jr. 1967. Management of bears in Yellowstone National Park. Mimeo. report, 118 p.
———, M. Hornocker, and F. C. Craighead, Jr. 1969. Reproductive biology of young female grizzly bears. *J. Reprod. Fert., Suppl.*, 6: 447-475.
———, F. C. Craighead, Jr., and H. E. McCutchen. 1970. Age determination of grizzly bears from fourth premolar tooth sections. *J. Wildlife Manage.*, 34: 353-363.
——— and F. C. Craighead, Jr. In prep. b. Management of grizzly bears. Manuscript in prep. for Wildlife Monograph Series.
Leopold, A. S. 1970. Weaning grizzly bears. *Natur. Hist.*, 79: 94-101.
Moment, G. B. 1968. Bears: The need for a new sanity in wildlife conservation. *BioScience*, 18: 1105-1108.
Mullen, L. and J. Booth. 1969. Grizzly bear study progress report. Typewritten, 5 p.
National Park Service. 1880-1970. Annual reports of the superintendents of Yellowstone National Park. Historical Museum; Mammoth, Yellowstone National Park, Wyoming.
———, 1967. Grizzly bear attacks at Granite Park and Trout Lake in Glacier National Park, August 13, 1967. Mimeo. report, 22 p.
National Sciences Advisory Committee of the National Park Service. 1969. A bear management policy and program for Yellowstone National Park. Mimeo. report, 8 p.
Olsen, J. 1969. *Night of the Grizzlies*. G. P. Putnam's Sons, New York. 254 p.

Storage and Retrieval of Biological Information

The course of lectures given in the Autumn of 1970 on this topic, at the Linnean Society in conjunction with the Committee on Biological Information, will be reprinted in the September issue of the *Biological Journal* of the Society. Lists of libraries, abstracts and indexes, data and information retrieval services in pure and applied biology, and culture collections, etc., will be included. As there will be a limited number of extra copies printed, at 2 pounds, 50 pence, requests should be sent promptly to: Editorial Secretary, Linnean Society of London, Burlington House, Piccadilly, London W1V 0LQ, England.

EARTH SATELLITE CORPORATION

(EarthSat)



BIOLOGISTS and ECOLOGISTS
REMOTE SENSING

EarthSat requires the services of BIOLOGISTS and ECOLOGISTS to staff expanding programs in Coastal Zone Mapping and Wetlands Ecology.

Applicants lacking remote sensing experience will be considered for internal training programs. Applicants should document their remote sensing experience and submit a detailed resume to include related experience, publications, and salary requirements. Only successful applicants will be notified.

APPLY IN WRITING TO

Dr. Frank J. Wobber
Earth Satellite Corporation
1771 N Street, N.W.
Washington, D.C. 20036

Preservation and Management of Grizzly Bears in Yellowstone National Park

Glen F. Cole

The grizzly bear (*Ursus arctos*) is part of the native fauna of Yellowstone National Park. The preservation of a representative grizzly population is integral to the park's basic purpose. This is to preserve natural environments and native biota as an integrated whole (i.e., ecosystem) for their scenic, educational, cultural, and scientific values.

This paper presents general information on bear numbers, increases in park visitors, the extent of human developments (campgrounds, etc.), and garbage disposal facilities within Yellowstone Park. Data are also presented on grizzly relationships to developments, garbage disposal sites, humans, and the results of management. Conclusions are made on conditions which favored the preservation of a grizzly population, the desirability of eliminating artificial food sources, the effects of repeated transplants of bears, and management actions which could reduce the opportunities for injuries to humans and the need to control bears.

Methods

Figures on grizzly numbers were compiled from park records. These were mainly in annual wildlife reports. Figures between 1930 and 1959 had been based upon yearly counts of up to 150 bears and/or estimates by park personnel. Those since 1959 had been based upon annual counts of 154-202

The author is supervisory research biologist, Office of Natural Science Studies, National Park Service, U.S. Department of the Interior, stationed at Yellowstone National Park, Wyoming 82190.

This paper, except for the addendum, was presented at the Second International Conference on Bear Research and Management, November 1970, University of Calgary, Alberta, Canada.

individually marked or unmarked bears, as reported by Hornocker (1962), Craighead and Craighead (1967), plus estimates. Counts were primarily of bears that were concentrated at or in the vicinity of garbage disposal sites during the summer. Estimates generally attempted to account for bears which remained in scattered distributions in the remote sections of the park.

Information on visitor numbers, developments, garbage disposal facilities, bear injuries to humans, and management activities was obtained from current park records or reviews of past correspondence and administrative reports. Interpretations were aided by the author's association with bear control and visitor protection activities, by interviews with park rangers who had carried out such activities since the 1930s, and by coincident observations of grizzlies while carrying out research on wild ungulates in both the remote backcountry and more accessible sections of Yellowstone Park since 1962. Grizzlies had been individually marked from 1959 to 1967 as reported by Craighead et al. (1960;1969).

Results

Grizzly numbers — Population estimates for 10 years in the 1930s ranged from 160 to 310 and averaged about 240 grizzlies; 6 years in the 1940s, 200-320 and averaged 235; 4 years in the 1950s, 150-180 with a 170 average; 9 years in the 1960s, 200-250 with a 220 average. The reasons for the lower estimates in the 1950s were not apparent. The accuracy of population estimates between 1930 and 1959 could not be assessed. Those since 1959 could be conservative because the portion of the population which remained in the more remote areas of the park was underestimated.

A population of 200 grizzlies within Yellowstone's approximately 8800 km² (3400 miles²) would represent an average density of one bear per 44 km² (17 miles²); 300 grizzlies, one bear per 28.5 km² (11 miles²). Densities of one grizzly per 23 km² (9 miles²) have been reported for Glacier National Park by Martinka (1969), one per 39 km² (15 miles²) for Mount McKinley National Park by Dean (1958) and for a northwestern Montana area by Jonkel (1967). The density figures from these other Rocky Mountain regions indicate that the general estimates of about 200-300 grizzlies for Yellowstone Park since the 1930s were reasonable.

Randall's (1961) accounts of hunting and trapping grizzlies outside Yellowstone Park boundaries suggest that bears which inhabited or ranged into these areas were either eliminated or greatly reduced in number during the early 1900s. Hunting ceased in Yellowstone Park after 1886. The park grizzly population has probably since occurred at "carrying capacity" levels. Accounts and records of bears moving outside the park, that may reflect regular or periodic emigrations, are presented by Skinner (1925), McCracken (1955), Craighead et al. (1964), Craighead and Craighead (1967). The carrying capacity of the park environment for grizzlies since the early 1900s could be lower than previously because of a reduced biomass of wild ungulates (possibly one of a limiting food source complex) and/or lowered habitat security levels (Errington, 1946). The latter would occur where grizzly home ranges included areas outside park boundaries that became heavily hunted.

Park visitors — Numbers of yearly visitors to Yellowstone increased from about 1000 to 260,000 between the establishment of the park in 1872 and 1929. The average number of visitors

per year was about 0.3 million during the 1930s, 0.5 million during the 1940s, 1.3 million during the 1950s, and almost 2 million during the 1960s.

From the late 1880s through the 1920s, most visitors traveled to the park by train and stayed at inns or hotels. After 1930, most visitors came by car and increasing numbers camped outdoors. Eleven campgrounds with a total of 1119 campsites were present in 1940; 14 campgrounds with 2253 sites in 1969. During 1969, about 16% of 2.1 million visitors stayed an average of 2.6 nights in park campgrounds.

Developments — Approximately 95% of Yellowstone Park's 910,575 hectares (2.25 million acres) are wild lands. The remaining land is in roads or developments, such as campgrounds, hotel, inn, and cabin sites, and miscellaneous other visitor or administrative facilities. Units which were a campground-other facility complex, as well as those which were only campgrounds, are collectively called "developed areas" or "developments." The locations of six major (with 200 or more campsites) and nine minor developments are shown on Figure 1. None were fenced to exclude bears.

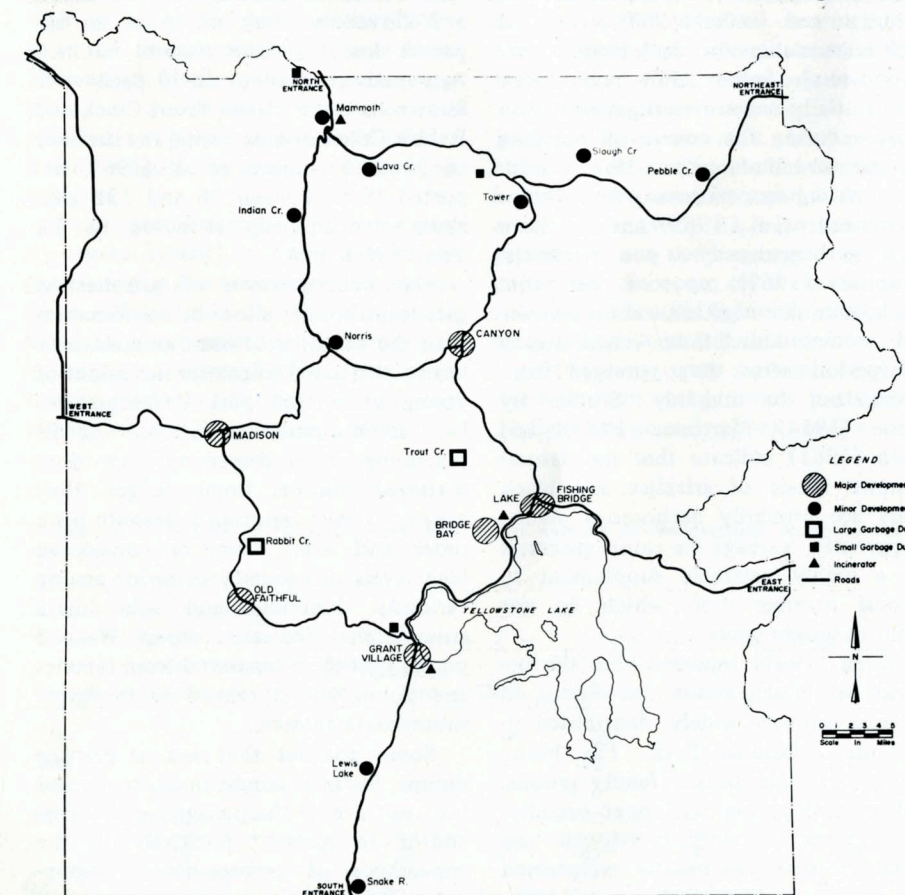


Fig. 1. Location of park-developed areas and garbage disposal sites.

Garbage disposal — Approximately 6.35 million kilograms (7 thousand tons) of garbage were collected and disposed of within the park each year between 1 June and 15 September 1968 and 1969. The location of dump and incinerator sites are shown on Figure 1. Only the Mammoth area incinerator was completely enclosed within a bearproof fence. The two other incinerators near the Grant Village and Bridge Bay developments left sufficient unburned food to attract bears during periods of mechanical difficulty or when the volume of garbage was greater than their burning capacity. Garbage dumps were unfenced pits.

Grizzly relationships to developments — The number of campsites in different developed areas, the distances to the nearest garbage sources at dumps and incinerators, and the relative use of areas by grizzly bears (as reflected by control actions) are shown in Table 1. Habitual use was considered to involve repeated intrusions into developed areas by individual bear between June and September, as well as seasonal intrusions between May and mid-July or September and October. Seasonal intrusions occurred from animals traveling through

a developed area to some place else, from breeding season movements and associations of males with females, and from food-seeking by particular bears before garbage became available at disposal sites (usually in June) or after sites ceased to be used in the fall.

Five of the six major developed areas were 12.9 km (8 miles) or less from garbage dumps. Table 1 shows these areas were habitually used by grizzly bears. Two incinerators that were within 0.4 to 3.2 km (¼ to 2 miles) of three of these developments probably contributed to habitual use. Intrusions into the major Madison development and nine other areas with approximately 100 or less campsites were comparatively rare or not known to occur.

Relatively high numbers of grizzly control actions (numbers of bears transplanted or destroyed) have occurred in 1935, 1937, 1942, 1949, 1959, and during at least 4 years since 1963. Conditions that may have contributed to the relatively high numbers of control actions during 1968 and 1969 were yearly carryovers of animals that repeatedly returned from transplant sites (discussed later), the presence of garbage in nonbearproof cans within some campgrounds, and an experimental "phasing out" of artificial food sources that involved dumping separated "edible" garbage for bears at the Trout Creek site. The latter may have contributed to some bears intruding into certain park developments by intensifying the behavioral interactions among the variously dominant and subordinate animals that fed at this dump.

About two-thirds of the grizzlies that were removed from the Canyon, Lake Outlet, and Bridge Bay developments in 1968 and 1969 were marked animals (discussed later). Data were not available, but it is suspected that most of these bears had been marked at or near the Trout Creek dump, or had a history of occurring at this dump area either prior to or in conjunction with their use of developed areas. During 1968 and 1969, only unmarked bears were observed or captured in the Grant Village development which was 29 km (18 miles) from the Trout Creek dump. Some of these unmarked animals were believed to have come from the small dump that was about 6.4 km (4 miles) from Grant Village. This dump was closed in 1968. The lower number of control actions in the Grant Village

development in 1969 apparently resulted from partially successful transplants of grizzlies which first intruded into this area in 1968.

Other factors also influenced grizzly bear use. Bearproof garbage cans were not present in all portions of the Canyon and Lake Outlet campgrounds until the fall of 1968 nor in the Grant Village and Bridge Bay campgrounds until the spring of 1969. Such "bear-proofing" reduced the amount of artificial food for bears within these campgrounds. During the summer of 1969, the only available food within park campgrounds was from visitors failing to put their edible camp supplies in the trunks of cars or a similarly secure place. Despite distributed and posted warnings that this would attract bears, enough camp food was available in larger campgrounds to attract some grizzlies.

The locations of the Canyon, Lake Outlet, and Grant Village developments at the edge of physiographic barriers (rugged canyon or Yellowstone Lake) probably placed these areas in the path of grizzly travel routes. The locations of the first two on or adjacent to large unforested areas with fertile alluvial soils (with relatively high densities of rodents and bulbous plants) also placed these in what appeared to be superior spring and, in some years, fall habitat for the bears. The suggested overall relationships were that habitual grizzly use was influenced by the physiographic locations of developments, the distances developments were from garbage dumps or incinerators, and the quantity of garbage or edible camp supplies within larger campgrounds.

Grizzly relationships to garbage disposal sites — Hornocker (1962) reported from his studies in Yellowstone Park that grizzlies traveled long distances to concentration sites that centered around garbage dumps. Individual bear traveled from areas within as well as outside the park. The numbers using a dump progressively increased from June to a peak around 1 August. Dispersals of bears from concentration sites occurred rapidly after about mid-August and while dumps were still operating. Hornocker concluded that garbage food sources affected bear distributions and movements, but were not a major factor in determining population numbers.

Craighead et al. (1969) considered the movements of grizzlies to use artificial food at refuse dumps during the summer "a special type of migration."

TABLE 1. Relationships between campground size, distances to garbage disposal sites with available food, and grizzly bear use during 1968 and 1969

Development	No. Campsites		Kilometers to Nearest		Control Actions ^b		Habitual Use by Grizzlies
	1940	1969	Dump	Incinerator	1968	1969	
Old Faithful Canyon	300	Closed	6.4		1(1) ^c	c	Yes
Lake Outlet	250	340	12.9		14	16(4)	Yes
Grant Village	300	428	11.3	3.2	16(3)	25(5)	Yes
Bridge Bay		433	6.4 ^a	0.8	20(1)	5(1)	Yes
Madison		230	11.3	0.4	8	9	Yes
Norris	35	292	14.5				No
Lewis Lake	20	116	20.9			1	No
Mammoth		100	17.7			1	No
Indian Creek	100	19	8.0 ^a				No
Tower Fall		78	16.1				No
Four other units	30	53	6.4				No
	84	92	12.9-32.2				No
Totals	1119	2253			89(5)	57(10)	

^aClosed or garbage not available after 1967.

^bNumber of times bears removed by capturing for transplanting or destroyed with latter in parentheses.

^cRepeated attempts to capture other grizzlies unsuccessful.

Distances between the summer and autumn ranges of individual bears were reported to be 16-120.7 km (10-75 miles) or more. The migrations of some grizzlies from distant areas to a garbage disposal site probably resulted from previous garbage-feeding experience as a young animal. Jonkel (1967) postulated such relationships for black bears (*Ursus americanus*). Some adult males may have initially encountered garbage food sources during the course of breeding season movements or mid-May to mid-July mating associations with females (Craighead et al., 1969) and not have been "garbage-raised" as young animals.

Jonkel (1967) reported that most black bears that used natural food either lost or maintained their weight during the period after they emerged from hibernation to mid-July. Studies by Murie (1954), Martinka (1969), and Tischer (1961) indicate that the natural summer foods of grizzlies and black bears are primarily herbaceous plants. Apparently, garbage or camp groceries are a highly palatable supplement to natural summer diets which do not result in weight gains.

Murie (1961) reported that the behavior of grizzlies was one factor in keeping animals widely distributed in McKinley National Park. The home ranges of single adults, family groups, and weaned young overlapped broadly, but spacing (between individuals and social groups) was usually maintained by what could be considered avoidance behavior. The agonistic behavior of

female grizzlies was pronounced in the defense of young. Dispersals of weaned young from family associations were gradual or occurred abruptly as a result of the agonistic behavior of maternal females. Murie considered the close association of 30 grizzlies he observed on a Yellowstone Park dump as an apparent loss of "wild natural habits." Aggregations of about 20-30 bears were known to occur at the Trout Creek and Rabbit Creek dumps during the summer of 1969. Craighead et al. (1969) reported that between 98 and 132 grizzlies were annually attracted to the Trout Creek area.

The concentration of grizzlies at garbage disposal sites, in combination with the behavior of adult animals, may have contributed to greater intrusions of young bears into park developments, i.e., as compared to young animals remaining on or dispersing from more scattered summer home ranges. Hornocker (1962) reported a definite peck order and what could be considered high levels of agonistic behavior among variously dominant and subordinate animals that fed at a dump. Weaned young that were separated from females and young adults ranked as the most subordinate animals.

Some grizzlies that fed at garbage dumps became conditioned to accept (i.e., not avoid) the presence of humans and/or to respond positively to the appearance of garbage-hauling equipment. Young bears, females with young, and some adults may have made such

TABLE 2. Visitor numbers, injury records, and number of bears killed for control in Yellowstone National Park, 1930-69

Period	Average No. Visitors (millions)	No. Known and Probable Injuries ^a		Injury Rates per Visitor	No. Grizzlies Killed for Control
		Visitor	Employee		
1930s	3.2	4(1)	2	1:800,000	23
1940s	5.5	9	3(1)	1:610,000	42
1950s	13.6	5(4)	1	1:2,720,000	25
1960s	19.5	38(12)	1	1:510,000	37
Totals	41.8	56(17)	7(1)	1:746,000	127

^aNumber circumstantially probable in parentheses.

behavior adjustments to obtain food before it was appropriated by other dominant but more wary (of humans) animals. The indicated overall relationships were that garbage food sources altered the natural summer distributions of a substantial portion of the park grizzly population and placed concentrations of interacting bears within comparatively short distances of certain park developments.

Grizzly-human relationships — Two grizzly-caused fatalities have occurred within Yellowstone Park over the past 97 years. One in 1907 involved a visitor who chased a cub up a tree, prodded it with an umbrella, and was fatally injured by the responding female bear. The other fatality occurred in 1916 when a government employee attempted to chase a large grizzly from a freight wagon containing edible camp supplies.

Sixty-three known and probable grizzly-caused injuries to humans have occurred within the park over the 40 years since 1930 (Table 2). The data show that less than proportionate increases in injury rates occurred with increases in visitor numbers during all but the 1950s. As will be discussed later, the

decrease in injury rates during the 1950s resulted mainly from differences in bear control procedures.

Table 2 also shows that consistent relationships did not exist between increases in visitors and the numbers of grizzlies killed for control. Some direct relationships between higher injury rates to humans and bear kills were indicated, but this was additionally influenced by control procedures.

About 75% of the 63 grizzly-caused injuries to humans were minor to the extent that they required only first aid, sutures, or lesser treatment on an outpatient basis (Table 3). The other 16 injuries (25%) entailed overnight or longer periods of hospitalization for treatment of shock and/or injuries.

Grizzly-caused injuries occurred predominantly in park campgrounds and to visitors (Table 3). Of the 60 known and probable injuries in such areas since 1930, 43 occurred while persons were in sleeping bags or bedrolls either in the open or in tents; four resulted from walking confrontations in areas where bears had been fed for tourist viewing; seven were walking confrontations in campgrounds (six during daylight and one at night); three result-

ed from attempts to chase bears away from camp food; one, from an attempt to pet a bear in a culvert trap; and two, from unknown circumstances.

Only three persons are known to have been injured while hiking in park backcountry areas between 1930 and 1969. Two of the injuries occurred in 1966; one, in 1960. All were caused by female bears with young. Martinka (pers. comm., 1969) reported that eight and possibly nine of the ten injuries that occurred while persons were hiking (one photography attempt) in Glacier National Park over the past 20 years resulted from natural defensive actions of female bears with young. The two fatalities and three other injuries to humans within Glacier Park during this period were caused by animals that habitually frequented developed areas to obtain garbage or camp food.

The suggested relationships in Yellowstone Park were that human influences in the form of artificial food were basically responsible for most (95%) of the grizzly-caused injuries over the past 40 years. The three injuries that occurred in the "wild" resulted from the natural defensive behavior of females with young.

Management — Park objectives to preserve a grizzly population under natural conditions and provide for the safety of visitors appear to have been formalized during the 1930s. Management to accomplish these objectives has involved removing bears which come into developed areas and regulating human activities or influences to decrease the opportunities for bear-caused property damage or injury to humans. Grizzlies were removed from developed areas by capturing them with culvert live traps or immobilization drugs (after 1962) and by shooting.

The removal or control of bears by shooting during years between 1930 and 1962 appeared to be variously responsive and preventive in relation to the incidence of injuries (Fig. 2). Removals during years without injuries or prior to the occurrence of injuries were considered preventive. Removals by shooting between 1963 and 1965 were apparently deferred despite high injuries. Those since 1966 reflect a progressively increasing response to a somewhat sustained occurrence of injuries.

Changes in removal procedures after 1962 were influenced by increased concern for the grizzly as a rare species. Bears that had become trap-shy from

TABLE 3. Records on grizzly-caused injuries to humans in Yellowstone National Park, 1930-69

Periods	No. of Injuries ^a		Conditions			Treatment		Persons	
	Developed Areas	Back-country Areas	Sleeping in		Other	Out-patient	Hospitalized	Visitor	Employee
			Bag ^b	Tent					
1930s	6(1)	0	1	1	4	3	3	4	2
1940s	12(1)	0	3	5	4	12	0	9	3
1950s	6(4)	0	4	1	1	4	2	5	1
1960s	36(12)	3	7	21	11	28	11	38	1
	60(18)	3	15	28	20	47	16	56	7

^aNumber attributed to grizzly by circumstantial evidence shown in parentheses.

^bSleeping bag or bedroll on ground.

previous experiences with culvert live traps and would have been destroyed in previous years were repeatedly captured and transplanted by the use of immobilizing drugs. Additional deferments from destroying particular bears were made because marked animals were important to research studies and critical public reactions to "destroying too many bears." These deferments resulted in individual bears, mating animals, and finally, family units habitually frequenting certain developed areas.

Figure 2 shows an average of three grizzlies was destroyed and about one injury occurred each year over the 1930 through 1962 period of both responsive and preventive control. An average of 2.5 grizzlies was destroyed and 0.6 injuries occurred each year during the 1950s. Preventive control was most continuous during this period. From 1963 through 1969, an average of four grizzlies was killed and 4.5 injuries occurred per year in park-developed areas. These values are not without influence from increases in visitor numbers, but they indicate that the attempts to substitute repeated transplanting within the park for the destruction of bears that habitually frequented developed areas contributed to increased injuries to humans and, ultimately, the number of bears destroyed.

The relatively high control kill of 28 grizzlies in 1942 may have been partially due to the 1941 closure of the bear-feeding and viewing site within 4.8 km (3 miles) of Canyon. Other coinciding circumstances were an apparent deficiency in natural food which increased intrusions of both black and grizzly bears into park-developed areas, and a greatly reduced ranger force for trapping and transplanting bears as a result of World War II.

Unmarked grizzly bears that were captured in or near park developments were transplanted a total of 47 times during 1968 and 1969. Twenty individually marked grizzlies and one recognizable grizzly were transplanted a total of 54 times during the same period. Eleven of these identifiable bears returned from transplant-release sites to the same development a total of 32 times, or to another development a total of four times. The distances these transplanted grizzlies returned are shown in Table 4. Five of the 10 marked bears that did not return were transplanted 12.9 km (8 miles) from capture sites. The other five were trans-

planted 29.0-41.8 km (18-26 miles) from capture sites.

The shorter return distances of 11.3-12.9 km (7-8 miles), shown in Table 4, were between the Canyon, Lake Outlet, and Bridge Bay developments and the Trout Creek dump. Apparently, neither the use of this dump nor more distant release sites prevented certain bears from returning to these developed areas. Most marked bears were adults, but four independent returns by two yearlings to the same area

Three sites where bears had been purposefully fed garbage to facilitate tourist viewing were closed between 1930 and 1941. Two were in the immediate vicinity of the Old Faithful and Canyon developments; one was within 4.8 km (3 miles) of Canyon. Four open-pit garbage dumps were also closed between 1950 and 1969. These were closed to disperse concentrations of bears that either contributed to intrusions into developed areas or caused injuries. Injuries resulted mainly when

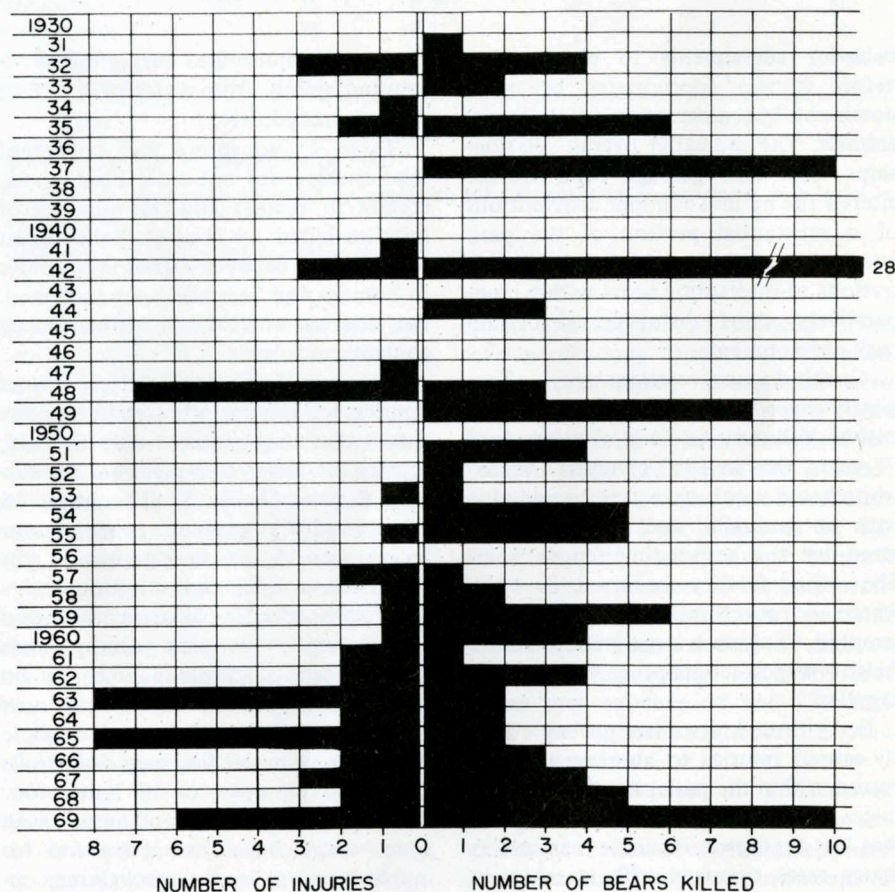


Fig. 2. Grizzly-caused injuries in developed areas in relation to grizzlies killed for control, 1930, Yellowstone National Park.

from transplant distances of 24-42 km (15-26 miles) indicate this age class has homing capabilities. The greatest airline distance a bear could be transplanted by vehicle from any centrally located park development without placing animals near other developments was about 58 km (26 miles). This distance may not be great enough to overcome the homing capabilities of most adult grizzlies. Transplants of adult animals into areas where population units already occurred at equilibrium densities could have adverse population consequences (Davis, 1949).

persons attempted to view or photograph grizzlies at close range.

Other controls on human influences or activities have involved installing bearproof garbage cans in campgrounds, limiting access to existing dumps or incinerator sites to authorized personnel, regulating the use of certain campgrounds to avoid May and June or fall intrusions by bears, and distributing and posting informational literature on how to travel and camp in bear country. A monitoring system maintains daily records of grizzly sightings, incidents of property damage or personal injuries,

TABLE 4. Number of times and distances in kilometers that marked grizzly returned from transplant sites in 1968 and 1969

Bear No.	No. Times Returned	Distances Returned: (airline km)						
		12.9,	12.9,	11.3,	45.1,	43.5,	12.9	
1	6	12.9,	12.9,	11.3,	45.1,	43.5,	12.9	
2	6	11.3,	25.8,	25.8,	32.2,	32.2,	27.4	
3 ^a	4	12.9,	32.2,	41.9,	24.1			
4 ^a	3	12.9,	32.2,	24.1				
5	4	12.9,	12.9,	41.9,	32.2			
6	4	12.9,	41.9,	24.1,	41.9			
7	3	12.9,	12.9,	12.9				
8	2	40.2,	41.9					
9	2	11.3,	11.3					
10	1	25.8						
11	1	11.3						

^aIn campground as cub and as yearling with first two returns in association with adult female.

and bear control actions. Records on the location of female grizzlies with young or particularly high densities of bears are used to advise appropriate precautions to hikers and restrict foot travel or camping in certain areas.

Conclusions

A representative grizzly population has been preserved within Yellowstone Park. This was primarily because the park was sufficiently large and ecologically intact to sustain a population and the existence of large blocks of wild land without conflicting human uses or developments. Except for limited mortality from control operations that averaged about three animals annually, and occasional scientific collections or shipments of animals to zoos, the resident grizzly population was essentially naturally regulated. Emigrations or movements of animals from the park population contributed to sport hunting and intrusions into settled areas outside park boundaries. The latter was mainly in response to available artificial food.

Management actions to remove all artificial food which alters grizzly bear habits and directly or indirectly causes some animals to intrude into developed areas could restore conditions more appropriate to the park's basic purpose and the objective of preserving a grizzly population under natural conditions. These actions, in conjunction with consistent preventive removals of bears from developed areas, could be expected to reduce the opportunity for injuries to visitors and, ultimately, the need to control bears. Repeated transplants of grizzlies which habitually frequent developed areas maintain these animals in the population, but eventually increases injuries and places bear control on a "sustained yield" basis.

The abnormally high incidence of injuries from such bears tends to make the park's attempts to preserve a wild grizzly population controversial.

Fencing existing incinerators and relocated land-fill dumps or hauling garbage outside the park would abruptly terminate garbage-influenced aggregations of bears in the vicinity (within 12.9 km [8 miles]) of park-developed areas. This would also preclude young bears from acquiring garbage-influenced habits. Abrupt exclusions of bears from garbage food sources could result in an initially greater number of intrusions into park-developed areas than a gradual withdrawal of such food. Gradual withdrawal could result in a greater total number of intrusions over time because young animals would continue to learn to use artificial food sources and concentrations of interacting bears would continue to occur on decreasing amounts of garbage.

Consistent preventive removals of grizzly bears from park-developed areas could reduce the opportunities for injuries to visitors, with either abrupt or gradual exclusions of the animals from garbage food sources. Distant transplants to re-establish grizzly populations in suitable remote wilderness areas in the Rocky Mountain region would serve as an alternative to destroying animals that could not be transplanted sufficient distances within the park to overcome their homing capabilities. Animals destroyed for control purposes within the park can be salvaged as scientific specimens and donated to educational institutions.

The total number of grizzlies that would need to be removed from the park by distant transplanting or shooting could be greater with gradual reductions in artificial food. It is unlikely,

however, that these or any subsequent removals that were confined to bears which came into developed areas would be of sufficient magnitude to have lasting consequences on the park's grizzly population (i.e., prevent the re-establishment of environmental and behavioral-influenced densities). The opportunities for injuries to visitors and the need to control bears within developed areas could be additionally reduced by imposing and publicizing fines for feeding the animals in campgrounds (as a result of not storing food), and either converting campgrounds within superior grizzly habitat to day-use picnic areas or enclosing them within bearproof fences.

Addendum

Following reviews of data and recommendations from a Scientific Advisory Committee,¹ park administrators directed that a program be implemented which would reduce injuries to visitors and restore a natural grizzly population. An outline of this program, the general design for evaluation studies, and a report on first-year results have been presented by Cole.² Mainly, the program lists steps for removing all artificial foods that attract bears into park-developed areas, procedures for controlling bears and protecting visitors, and an open-ended schedule for closing two large garbage dumps that were used by grizzlies. Evaluation studies involve testing hypotheses that relate to injury rates, bear control actions, and indexes of "naturalness" in the grizzly population.

The following is a brief summary of 1970 results. One of the two large open-pit dumps in the park was closed. Some portion of 30 control actions that involved 18 different grizzlies could be attributed to closing this dump and the presence of garbage cans without bearproof lids in one hotel and cabin complex. The remaining 40 control actions that involved 32 different bears were mainly due to intensified efforts to

¹"A bear management policy and program for Yellowstone National Park." Report to the Director by the Natural Sciences Advisory Committee of the National Park Service, 1969, 7 p., typewritten.

²Cole, G. F. 1970. Grizzly bear management in Yellowstone Park, 1970. Paper presented at the Second International Conference on Bear Research and Management, November, University of Calgary, Alberta, Canada (in press).

promptly remove grizzlies from campgrounds.

Thirty-nine different bears were transplanted within the park a total of 50 times. Sixty per cent of these transplants were successful in preventing subsequent returns to developed areas. Six bears that returned from transplants and one injured animal were intentionally destroyed. Eight bears were donated to zoos. Five other bears were unintentionally removed from the population because of drug malfunctions, or the animals charged personnel who were attempting immobilizations. Attempts to donate grizzlies to states to re-establish populations in suitable historical habitats were unsuccessful. Destroyed animals were processed as scientific specimens for educational institutions.

Two persons were injured in a campground by one grizzly bear in 1970. This is lower than the average incidence of injuries for the previous 10 years (Fig. 2), but valid tests for differences will require data from a series of years. One additional injury occurred in a backcountry area when a hiker approached too close to a female grizzly with a cub. This was the fourth such incident over a 41-year period.

The scheduled closure of the last open-pit dump for 1971 or "the earliest possible later date" could result in some bears visiting developed areas that do not already do so. Fewer such "new" visits may be expected to the extent that (1) successive generations of young bears do not become habitually linked to food supplied by humans, and (2) the interactions between the variously dominant and subordinate animals that use this dump are not intensified or prolonged by gradually reducing the amount of garbage that is hauled to the dump.

Contingencies listed in the park's program if bear-visits to developed areas "exceed control capabilities or lead to excessive numbers of animals being destroyed" are: continue to use the dump beyond the scheduled closure; manipulate campground opening or closing dates; restrict camping to trailer or pickup units; temporarily close campgrounds, if necessary.

Removals of incorrigible bears are expected not to exceed 10% of the population during 1971 and to decline to negligible levels in subsequent years. Only a temporary minor depression of grizzly population numbers seems pos-

sible, because the annual production of cubs exceeds any envisioned removals of bears, and an increase in the survival rate for young animals appears imminent. Martinka's (1969) comparisons of data from his studies with those from Yellowstone Park and other areas indicate that a high first-year mortality of young grizzlies (35 to 40%) occurs in population segments that concentrate at garbage dumps. Comparative mortality rates from the cub to yearling class in two naturally distributed bear populations were about 5 and 7%.

Acknowledgments

I wish to thank Dr. Adolph Murie, Moose, Wyoming; Dr. A. Starker Leopold, University of California; and Mr. Clifford J. Martinka, National Park Service, for reviewing the manuscript. Yellowstone Park Rangers Dale H. Nuss, Gary N. Brown, and Gerald E. Mernin provided information and reviews of manuscript sections on bear control and visitor protection activities that greatly aided interpretations of management results. Administrative reports and file records had been maintained by the Ranger Division of Yellowstone National Park. The paper is a contribution from the National Park Service's Office of Natural Science Studies, Project YELL-N-38.

References

- Craighead, J. J., M. G. Hornocker, W. Woodgerd, and F. C. Craighead, Jr. 1960. Trapping, immobilizing and color-marking grizzly bears. *Trans. N. Amer. Wildlife Natur. Resour. Conf.*, 25: 347.
- Craighead, J. J., F. C. Craighead, Jr., R. L. Ruff. 1964. An ecological study of grizzly bear. *Environ. Res. Inst. and Mont. Coop. Wildl. Res. Unit, Sixth Ann. Rep.* 18 p. (mimeo.)
- Craighead, J. J. and F. C. Craighead, Jr. 1967. Management of Bears in Yellowstone National Park. *Environ. Res. Inst. and Mont. Coop. Wildl. Res. Unit Rep.*, 113 p. (multi.)
- Craighead, J. J., M. G. Hornocker and F. C. Craighead, Jr. 1969. Reproductive biology of young female grizzly bears. *J. Reprod. Fert. Suppl.*, 6: 447-475.
- Davis, D. E. 1949. The role of intraspecific competition in game management. *Trans. N. Amer. Wildlife Natur. Resour. Conf.*, 14: 225-331.
- Dean, F. C. 1958. Investigations on grizzly bear in interior and arctic Alaska. *Alas. Coop. Wildl. Res. Unit. Quart. Rep.* 9(4): 61-71.
- Errington, P. L. 1946. Predation and vertebrate populations. *Quart. Rev. Biol.*, 21: 144-177, 221-245.
- Hornocker, M. G. 1962. Population characteristics and social and reproductive behavior of the grizzly bear in Yellowstone National Park. M.S. Thesis, Montana State University, Missoula. 94 p.

- Jonkel, C. J. 1967. Black bear population studies. Job Compl. Rep. W-98-R, Mont. Fish and Game Dept. 147 p.
- McCracken, H. 1955. *The Beast That Walks Like Man*. Hanover House, New York. 319 p.
- Martinka, C. J. 1969. Grizzly ecology studies, Glacier National Park. Nat. Park Serv. Prog. Rep. 43 p. (mimeo.)
- Murie, A. 1961. *A Naturalist in Alaska*. The Devin-Adair Co., New York, 302 p.
- Murie, O. J. 1954. Progress report on the Yellowstone bear study. 16 p. (typewritten).
- Randall, L. W. 1961. *Footprints Along the Yellowstone*. The Naylor Co., San Antonio. 186 p.
- Skinner, M. P. 1925. *Bears in Yellowstone*. A. C. McClurg and Co., Chicago. 155 p.
- Tisch, E. L. 1961. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. M.S. Thesis, Montana State University, Missoula. 108 p.

DEVELOPMENTS IN INDUSTRIAL MICROBIOLOGY

Volume 12

E. Don Murray, Editor

The Proceedings of the 27th general meeting of the Society for Industrial Microbiology includes symposiums on Enzymes as Additives in Detergents, Fermentation of Hydrocarbons, Microbiological Aspects of Seawater Pollution, Some Aspects of Cosmetic Microbiology, and Contributed Papers. 419 pp.

\$16.00 domestic \$16.50 foreign

including handling

All orders must be prepaid

AMERICAN INSTITUTE OF
BIOLOGICAL SCIENCES

Attn: Frank LoVerde

3900 Wisconsin Ave., N.W.

Washington, D.C. 20016

Evolution of a Light Scattering Photometer

David T. Phillips

Genesis of the Instrument

Bacteria are too small to be clearly resolved by an optical microscope. Though they are sharply recorded by an electron microscope, sample preparation is slow and difficult and the procedure both kills and distorts the cells. After many years experience in the analysis of nuclear and radar scattering, Dr. Philip J. Wyatt felt that light scattering measurements should provide much more quantitative information about bacterial structure than an optical microscope. A typical light scattering measurement is shown in Figure 1. To test his ideas, Dr. Wyatt computed the scattering from idealized models of living bacteria suspended in water (Wyatt, 1968). His calculations showed that the light scattering patterns of cells should be extremely sensitive to the size, shape, and structure of the cells. It was clear to him that light scattering measurements should allow quantitative studies of bacterial growth and response to stimuli, and perhaps even uniquely identify the organism.

The First Experiments

On 1 April 1968, the firm Science Spectrum was formed by Dr. Wyatt to pursue the identification of bacteria by the light scattering method. Working with the help of a recently graduated chemist, he leased a Brice-Phoenix light scattering photometer (Brice et al., 1950) and learned the microbiology necessary to begin to test his ideas. Using the newly acquired photometer wasn't easy (especially for a theoretical physicist). The angle between the light beam and the detector had to be set manually, then the intensity of scattered light was read on a galvanometer and was plotted by hand. The difficulties and tedium inherent in this process drove him to try various modifications. Thus the evolution of a totally new class

The author is with Science Spectrum, Inc., 1216 State Street, Santa Barbara, Calif. 93104.

of instrument began. A motor was connected to drive the detector automatically. An X-Y recorder was added to record the detector's signal as a function of the scattering angle by using a potentiometer attached with a friction drive to provide a signal proportional to angle. To improve collimation, spectral purity, and brightness of the light source, the mercury lamp supplied with the instrument was replaced by a small He-Ne laser.

The first results were hard to reproduce. The background light scattering from water alone was sometimes very high, and the bacterial curves varied greatly from run to run. After weeks of struggle with various liquid filters and experimentation with various sources of water, particle free water was obtained. The acquisition of an incubator allowed reproducible bacterial growth and at last the data began to make some sense. Early in 1969, a part-time experimental physicist was employed to improve the apparatus. The original vacuum tube detector power supply was replaced with a better regulated solid state unit to increase stability. A switch selectable smoothing filter was attached to the electrical signal output. The instrument underwent rapid mutation and only successful modifications survived actual use.

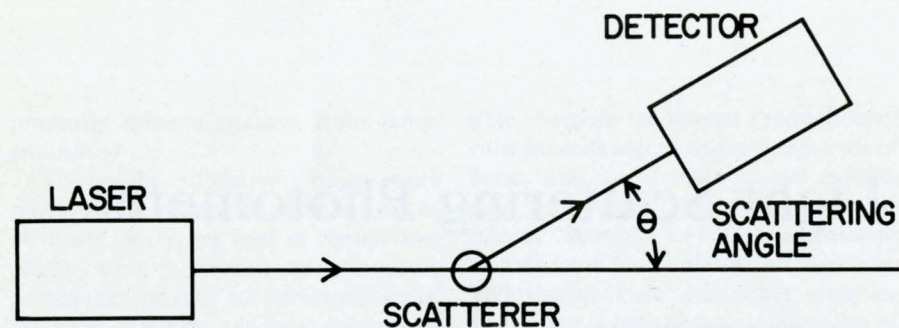
Theory Confirmed

Using this laboratory breadboard instrument (Fig. 2) was still no easy matter; nevertheless, experiments were run and data was obtained. This resulted in the first precise optical determinations of average cell wall thickness, radius, size distribution, and refractive index of cell wall and cytoplasm for cells of a viable bacterial culture (Wyatt, 1970). In addition, experiments to test the feasibility of bacterial identification were initiated (Wyatt, 1969). These studies confirmed the theory that the light scattering method could study effects that are not observable in an optical microscope.

A Working Model

In September 1969, a microbiologist was added to the staff. His inexperience with light scattering apparatus emphasized the need for a reliable, easy to use instrument instead of the maze of wire, tape, switches, and dials that had enveloped the original photometer. As he introduced precise microbiological methods to the Science Spectrum laboratory, he pleaded for a dependable light scattering photometer.

In March 1970, technicians and engineers went to work to provide this instrument. Since the optical alignment of an externally mounted laser was often disturbed, the first step in the redesign was to construct a prototype, with the laser and its power supply mounted inside the box (see Fig. 3). The scanning mechanism was improved by replacing the friction drive that had been added to the original instrument with an antibacklash gear drive. The detector drive D.C. motor was replaced with a stepper motor, in order to provide high torque and constant velocity even at low speeds. To provide fast rotation for preliminary survey and very slow rotation to allow for signal averaging, the motor scan rate could be varied over a 64:1 range. Signal averaging smoothed out noise components of the scattered light signal which arose from contaminants in the liquid-suspended bacterial sample. A preselected "normal" electrical filter was coupled to the scan speed selector switch to provide the greatest possible signal averaging without signal distortion at each scan speed. Theoretical computations predicted interesting effects beyond the existing angular scan range. To take advantage of this, the detector mount was improved to allow scans within 2° of the laser beam by locating the bulky detector below the laser beam and deflecting the light down into it with a small mirror. A precisely regulated solid state power supply for the detector was designed and incorporated.



LIGHT SCATTERING MEASUREMENT

Fig. 1. Scattered light intensity is recorded as a function of scattering angle to produce the scattering pattern. The scattering pattern is sensitive to differences in particle diameter of less than one-tenth of the wavelength of light.

New Discoveries

The "design prototype" scattering photometer was sufficiently easy to use so that the operator could concentrate on his experiment rather than struggle to keep the equipment running. Using this instrument, studies were made on changes in bacterial structure induced by chemical and heat treatment (Berkman and Wyatt, 1970). Conventional fixatives induce structural changes for up to 24 hours. The most significant discovery formed the basis for a process patent. This was that antibiotics were found to produce clearly observable effects on sensitive bacteria within minutes after their application, while leaving resistant strains unaffected (Berkman et al., 1970). This application promises to be of great utility in clinical medicine. Conventional antibiotic sensitivity tests require an additional working day to distinguish between sensitive and resistant strains. This time delay often forces physicians to begin treatment without adequate information.

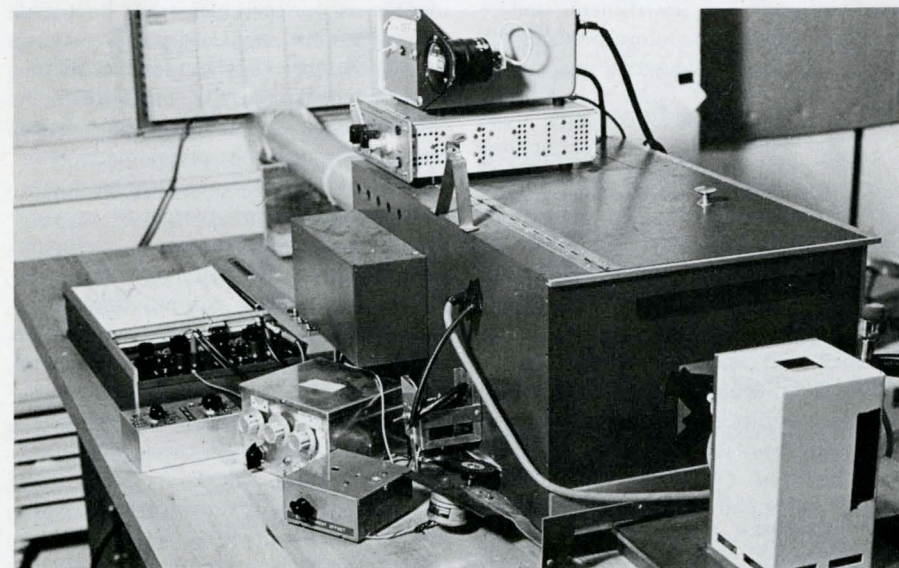


Fig. 2. Early experiments were done with this laboratory breadboard instrument.

By this time it was clear that many laboratories should want to use such a modern light scattering photometer, and plans were made to produce a commercial instrument.

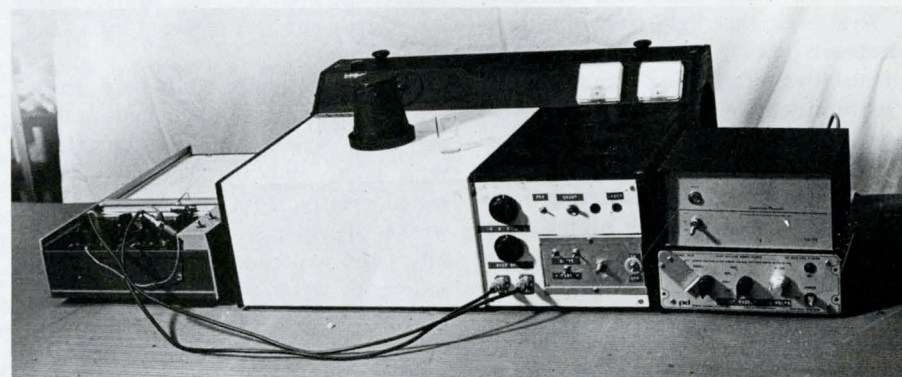


Fig. 3. A wooden working model provided a test of design ideas.

Production Prototype

As experience with the light scattering technique accumulated, the design specifications for the *Differential I* light scattering photometer were refined. The instrument should be simple to operate,

provide convenient, accurate data output, and yet retain sufficient flexibility so that it could be readily adapted to meet a wide range of new experimental requirements. In May 1970, the construction of a series of production prototypes was begun (Fig. 4). The entire scattering chamber was designed as a plug-in module so that thermostatic controls, flow monitoring systems, reaction chambers, etc., could be built into easily interchangeable modules.

Controls were organized on a single panel, grouped by function, and located for convenient operation. Pushbutton switches were employed which provided rapid decisive response when activated. A visual digital angle readout was placed on the panel. A variety of switch selectable angular scan speeds and scan limits were provided, offering manual, single

scan, and repetitive scan modes. All control logic was done with standard TTL (Transistor-Transistor-Logic) computer-compatible integrated circuits. A precision sine (θ) potentiometer was installed to correct the signal for the change with angle of the scattering volume viewed by the detector, a correction essential to record scattering details near 0 and 180°. A five-decade logarithmic amplifier was added to permit recording signal variations over a wide dynamic range.

Continued experimental usage revealed various "bugs," which were to be eliminated as the design was refined. Certain mysterious distortions of the data were eliminated by using low noise cables to connect the moving photomultiplier with the amplifier. Sad experience dictated that the photomultiplier high voltage be carefully interlocked with the light-tight lid to avoid damage to the detector. Provision was made for time studies at a fixed angle with a wide range of recording speeds, speeds appropriate for experiments

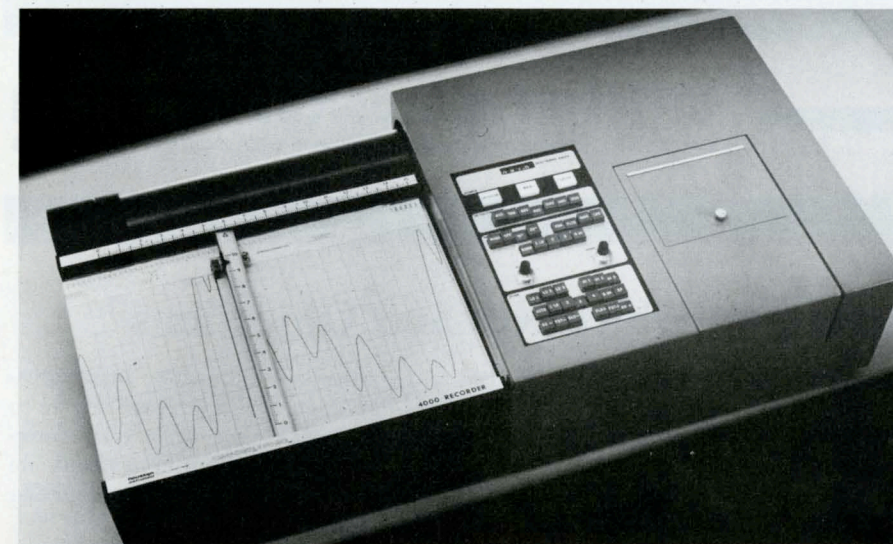


Fig. 4. The commercial *Differential I* light scattering photometer is the product of evolutionary development in which only successful modifications survived actual use.

ranging from bacterial growth studies to chemical reactions taking only a few seconds. The endless debate as to which type of recording system is best was resolved by providing output signals for almost any chart recording device: analog X-Y, stepper X-Y, or stepper chart recorder.

A TRW pulsed Argon-ion laser was completely redesigned to meet the needs of the instrument. An intracavity prism was added to provide single color operation at six wavelengths from 458 to 514 nm in the blue and green, and output power was increased by power supply modifications. A laser mount designed to provide generous space for the substitution of any small laser; a straight light path into the instrument was provided so that any externally mounted special purpose laser the experimenter might need could be used. Conversely, the laser supplied with the instrument can be easily removed for other applications.

Wide Applications

Experience has demonstrated the utility of this flexible design, for, in addition to the study of bacteria, it may be used for a wide variety of light scattering measurements (Kratohvil, 1966; Kerker, 1969). Manufacturers of spices, paint pigments, colloidal chemicals, petroleum catalysts, sintered metals and ceramics, or other small particles find light scattering an accurate and economical means of measuring particle size. The molecular weights of large molecules can be determined using Zimm plots (Kerker, 1969, Sec. 8.2)

readily obtained with the instrument. Studies of binary solutions and critical point fluctuations are additional applications. The instrument permits turbidimetric titrations of high precision and offers a significant improvement in the optical detection of antibody-antigen agglutination. Traditional turbidimetric measurements have been troubled by the effects of changing particle size distribution. By measuring the scattering as a function of angle, instead of at a single angle, turbidimetric measurements such as of sulfate in urine, haze in beer, or the clotting capacity of blood plasma can be made far more quantitative.

Developments

In response to a request from a user who routinely analyzes extensive scattering data with a digital computer, a new interface unit is under construction. This will provide digital readout of successive angles and scattering intensities. Output options will include paper tape, magnetic tape, cards, or direct inter connection with a computer. Digital control of scan limits and the scan drive will be provided for operation under computer control.

An atlas of scattering curves generated by Science Spectrum's computer programs will be made available to aid the interpretation of data. Some software packages for rapid data analysis are planned, as well as staff support for the analysis of new applications. Since new users are often completely unfamiliar with light scattering, training seminars will be held covering both the theory

and practice of scattering measurements.

Optical developments include polarizers and analyzers for a variety of polarization studies, as well as disposable plastic sealed sample holders with optical properties superior to the conventional cylindrical glass cuvettes. A refractometer attachment is planned for use in molecular weight determinations. New scattering modules are also planned to provide temperature control for bacterial growth studies, and a continuous flow light scattering monitor for process control applications.

The problem which originally sparked the development of the *Differential I* was the direct optical identification of bacteria. Though rapid drug susceptibility measurements and other applications grew out of this work, the identification problem is not completely solved. The size variations within a culture tend to smooth out the fine detail required for complete characterization of the scattering object. Though cultures of bacteria of radically different shape or size can be distinguished, similar bacteria require precisely controlled growth conditions for effective discrimination.

The approach which appears most promising at this time requires the measurement of the scattering pattern of a single isolated bacterial cell. Experiments with a module that will permit such measurements are in progress (Phillips, 1970)—and so the evolution continues.

References

- Berkman, R. M., and P. J. Wyatt. 1970. Differential light scattering measurements of heat-treated bacteria. *Appl. Microbiol.*, 20: 510.
- Berkman, R. M., P. J. Wyatt, and D. T. Phillips. 1970. Rapid detection of penicillin sensitivity in *S. aureus*. *Nature (Lond.)*, 228: 458.
- Brice, B. A., M. Halwer, and R. Speiser. 1950. *J. Opt. Soc. Amer.*, 40: 768.
- Kerker, M. 1969. *The Scattering of Light and Other Electromagnetic Radiation*. Academic Press, Inc., New York.
- Kratohvil, J. P. 1966. Light scattering. *Anal. Chem. Ann. Rev.*, 38: 517R-526R.
- Phillips, D. T., P. J. Wyatt, and R. M. Berkman. 1970. Measurement of Lorenz-Mie scattering of a single particle: polystyrene latex. *J. Colloid Int. Sci.*, 34: 159.
- Wyatt, P. J. 1968. Differential light scattering: A physical method for identifying living bacterial cells. *Appl. Optics*, 7 (10): 1879.
- . Identification of bacteria by differential light scattering. *Nature (Lond.)*, 221: 1257.
- . Cell wall thickness, size weight content of living bacteria (*S. aureus*). *Nature (Lond.)*, 226: 277.

Professional Accreditation: Objectives and Objections

The physical plant shall have . . .
The program administrator will . . .
The faculty must hold at least a . . .
The students will be able to . . .

Which do you think is an appropriate objective of professional accreditation? My vote is for the last one listed. It is an appropriate concern of a professional accreditation agency to specify what students will be able to do when they complete their training and are adjudged competent to enter a profession. It is not appropriate for an accreditation agency to concern itself with the detail of physical plant, the credentials of administrators and faculty, or the previous experience of students. These factors are the responsibility of the educational institution as is the provision for experiences that assure that the student will be able to do the job when he graduates.

Many, although not all, of the cries of anguish about accreditation seem to come from the two-year colleges which offer a variety of para-medical training programs. Most of these institutions would be quite willing to have professionals in these areas specify what constitutes competency in the field. Their main objection is being told what faculty and facilities they need instead of receiving an objective statement of what graduates should be able to do.

The problem is one of confusion between means and ends. The ends or goals of professional accreditation should be to specify what skills, concepts, and behaviors students must master to be designated as professionally competent and to designate as accredited those programs whose graduates have demonstrated competency. The means is the educational experience which enables the student to acquire such competency. Decisions concerning the kinds of educational experiences and the qualifications of faculty and incoming students are appropriately the business of the educational institution. When the educators define competency

in another profession or those in the profession prescribe the educational experiences, there exists a dangerous confusion of roles.

As a consequence of this role confusion, the educational experiences become permeated with specifications laid down, not by those dedicated to students, but by the profession. Many specifications—square feet of laboratory space, degrees and years of experiences of the faculty, credit hours in this, that, or the other thing accumulated by the students—concern the means and lose sight of the end. The end should be what the student is able to do. None of the above specifications, in and of themselves, guarantee anything at all about what the student will be able to do. When the college is free to determine these specifications according to the most appropriate educational experiences in their particular setting, it is possible for that college to be creative and innovative in the development of programs. When specifications are prescribed to a college by an external agency, many unnecessary problems can be created. When the external agency or the educational institution loses sight of its appropriate goals, it seems to fit Santayana's definition of a fanatic—one who, having lost sight of his goals, redoubles his efforts.

Now, if we in the colleges wish to avoid the consequences of these fanatic efforts, we might try several things. First, we might challenge those who would prescribe *means* instead to prescribe objective *ends*. In effect, tell us what constitutes competency in your profession and we will use our expertise as educators to devise the methods to produce this competency. We might also invite the accrediting agency to devise, and even administer, measurements to determine whether the students have accomplished the objectives and are thus competent in the field. If our means accomplish their objectives, then there should be no problem. As an

alternative or an adjunct to these activities, we might ask several employers to independently make their own determinations of whether our students are competent to perform in their particular profession.

If we are teaching biology to students who wish to become professional biologists, we have the dual role of professional biologist and educator. In this role, we have the responsibility and the opportunity to specify what constitutes competence in our field and to provide the educational experiences that will assure that our students become competent. It is not enough to say, "Well, I covered this in lecture," or "I set up a demonstration of that in lab." We need to define in unambiguous terms what we expect our students to accomplish and why such accomplishments are necessary. Students could then compare their own objectives with the objectives of a professional biologist and determine the degree of fit. Aside from assisting the students, the process of defining our objectives forces us to think about what we are doing and to specify in understandable terms what we are about. The next step is to provide a variety of pedagogical approaches which allow the student to participate in the direction of his own studies, but that is grist for another paper.

If biologists would really like to circumvent problems with accreditation, they could take the lead and specify what constitutes competency in their own profession. This could then be used as a model and it could be suggested that the professional accreditation agencies do likewise. Anyone interested?

JOAN G. CREAGER
Staff Biologist CUEBS
and Associate Professor of Biology
Northern Virginia Community College
Baileys Crossroads, Va.

Features and News

The R/V *Alpha Helix* Antarctic Expedition, 1971

Edvard A. Hemmingsen

During the last austral summer, from 2 January to 23 February 1971, an extensive physiological research program on antarctic animals was carried out on board the R/V *Alpha Helix* at Anvers Island, Antarctic Peninsula. Fifteen scientists from six universities were involved in the program which was sponsored by the National Science Foundation. The Antarctic Expedition was part of a one-year cruise of the vessel, which was started with programs off the coasts of Mexico and Panama and continued with a 6-week program at the Galapagos Islands. The final program of the cruise is now in progress at the Marshall Islands, South Pacific. In previous years, the R/V *Alpha Helix* has been involved in expeditions to, for example, Australia's Great Barrier Reef, the Amazon River, and the Bering Sea.

The R/V *Alpha Helix*, a vessel 40.6 meters long with a displacement 465.5 metric tons, is a national facility operated by Scripps Institution of Oceanography under policies and sponsorship of the National Science Foundation. It has accommodations for 10 scientists and it carries a crew of 12. The vessel was specifically designed and equipped

for the use of experimental biologists. There is one large laboratory (7.3 x 7.9 meters) on the main deck; part of this is a wet laboratory which can be independently temperature regulated. The lower deck has a smaller laboratory, a dark room, a freezer-laboratory combination, and a well-equipped machine shop. The upper deck has a library room large enough for meetings and seminars. Information about the vessel can be obtained from the Scripps Institution of Oceanography; expeditions are selected from proposals submitted by a National Advisory Board.

The Antarctic Peninsula offered several important advantages as the site of the expedition. The area has an abundant and varied fauna which includes one of the few accessible and large populations of the hemoglobin-free icefishes of the family Chaenichthyidae. There are many excellent, weather-protected anchorages to provide the stability needed for laboratory work.

Because of the unusually warm and calm weather and the absence of heavy sea ice during the stay in Antarctica, most of the collecting could be done with the vessel's 4.9 and 6.1 meter utility boats. Thus, since the vessel could be kept in anchorage for long periods of time, interruptions of the laboratory work were kept to a minimum.

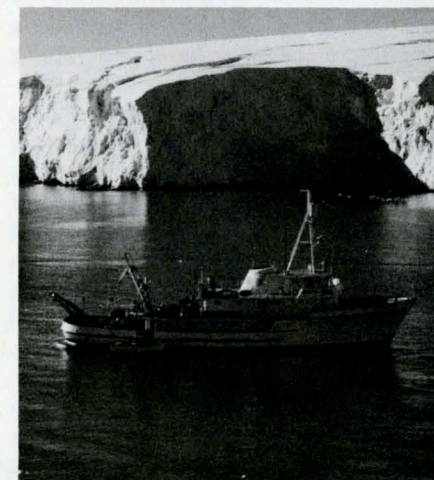
A wide variety of physiological problems, which emphasized thermoregulatory and cardiovascular functions, were studied during the expedition. The studies were often carried out through team efforts and they involved the use of specialized physiological and biomedical instrumentation. Some of the main research activities will be briefly mentioned here.

In a series of investigations by K. Johansen, R. W. Millard, and W. K. Milsom (University of Washington, Seattle), several aspects of the cardiovascular

physiology in antarctic birds were studied. Emphasis was placed on elucidating the role of peripheral blood flow in body temperature regulation and the vasomotor control mechanisms underlying the blood flow changes. Methods employed included direct blood flow measurements by electromagnetic and ultrasonic blood flow meters. Calorimetry and continuous measurements of intravascular blood temperatures as well as tissue temperatures allowed assessment of the blood flow distribution in peripheral tissues. Blood flow to the skin of the Giant Petrel's (*Macronectes giganteus*) webbed feet was found to increase up to several hundredfold in response to abolition of vasoconstrictor tone coupled with vasodilator stimulation. Perhaps the most important finding was the unequivocal demonstration of the presence of cholinergic vasodilator innervation to the skin.

Another phase of the work involved radiotelemetry of cardiovascular data from unrestrained penguins both during swimming and exercise on land. A third project involved measurement of the postembryonic changes in the respiratory properties of blood in the Adélie penguin (*Pygoscelis adeliae*). The young chick was found to have a lower oxygen affinity than the adult bird; this observation is contrary to those obtained in all similar studies on other vertebrates. This unique feature can be considered a specialized adaptation to the habitual diving of the adult penguin.

Studies on the thermoregulatory functions of the feet and flippers of the Adélie penguin were carried out also by F. N. White and K. R. Morgareidge (University of California, Los Angeles) who made use of somewhat different experimental approaches than the preceding workers. The methods used involved measurements of subcutaneous ¹³³Xe clearance rates (for blood flow assessment), animal core temperatures,



The author is with the Scripps Institution of Oceanography, La Jolla, California.

and tissue temperature gradients. The heat flow through the extremities and other body surfaces was quantitatively assessed under a variety of internal and external conditions. The laboratory findings were correlated with those from behavioral field studies which were obtained by the use of temperature radio telemetry from birds and eggs under natural conditions. Some of the results of this study indicate that thermoregulatory responses such as panting and shivering involve peripheral receptors. A physical basis for arterial-venous heat exchange in the legs of the penguins was indicated by the temperature gradient measurements. Anatomical examinations and vascular casts of the legs revealed vessel arrangements which may serve in a fashion somewhat similar to arterial-venous counter-current systems in many other animals.

The heat loss to the environment as a result of respiratory gas exchange is lessened by counter-current heat exchange in the nasal passages of birds. D. E. Murrish (Case Western Reserve University, Cleveland) investigated this heat exchange in three species of penguins and in several other antarctic birds by measuring the exhaled air temperatures and the nasal temperature gradients. Detailed anatomical studies of the nasal passages were also made. A unique active control of the normally passive counter-current heat exchange was found in all the penguins (*Pygoscelis papua*, *P. antarctica*, and *P. adeliae*). The site of this active control appeared to be a highly vascularized section of the nasal passageway.

H. T. Hammel and L. J. Crawshaw (Scripps Institution of Oceanography, La Jolla) studied the thermoregulatory responses in Adélie penguins to selective heating and cooling of the preoptic-anterior hypothalamus through the use of permanently implanted thermodes and temperature-registering thermocouples. The primary objective was to examine the characteristics of the central nervous controlling system for the regulation of internal temperature in these animals. The penguins were trained to walk on a treadmill so that their responses could be studied during exercise. Vasomotor responses in the feet and flippers were produced by changes in the hypothalamic temperature. The central nervous controlling system was responsive to temperatures elsewhere in the core as well as in the periphery. In another project, these

investigators studied the ability of two antarctic fish (*Notothenia coriiceps* and *Chaenocephalus aceratus*) to detect and react to changes in their environmental temperature. The fishes were exposed to water of higher temperatures than that to which they were adapted and were allowed to escape into their normal water. The escape latency was determined for various temperature differences. By using thermodes implanted at the brainstem of *N. coriiceps*, it was found that the behavioral thermoregulatory responses were activated by both peripheral and brain temperatures. *C. aceratus* was found to be more sensitive to temperature differences than *N. coriiceps*.

Individual and collaborative studies by P. F. Scholander, W. Orris, and A. R. Hargens (Scripps Institution of Oceanography, La Jolla) were concerned with several aspects of the colloidal osmotic pressures of the blood and the interstitial fluid pressures in antarctic animals. The studies included measurements of interstitial pressures in the webs of birds; these pressures were often positive. Previously, positive subcutaneous pressures have been found only in spawning salmon. Hargens determined the freezing points of, and the ice propagation rates in, fish blood. The large concentrations of plasma colloids in the cold-adapted fishes were found to have a striking retardant effect on the ice propagation rates and on the ice seeding in supercooled plasma. Thus, the colloids may offer freezing protection in certain situations. Mucus secreted by the intertidal limpet (*Patignera polaris*) also was found to have ice retardant properties, and, therefore, aids in the protection against freezing.

Two other projects involved the use of both the Palmer Station (United States Antarctic Research Program) and the R/V *Alpha Helix* facilities. In one of these projects, G. L. Kooyman and J. P. Schroeder (Scripps Institution of Oceanography, La Jolla) and D. G. Greene (State University of New York, Buffalo) studied many aspects of deep diving in Adélie and Gentoo penguins and in blue-eyed shags (*Phalacrocorax atriceps*); the latter species is known for its deep diving capabilities under natural conditions. Deep dives (up to 70 meters) were simulated through the use of a pressure chamber, while blood gas tensions and other parameters were measured. There was a relatively unhampered gas exchange between air

sacs, lungs, and blood during deep dives, which indicate no, or only partial, collapse of the lungs. The birds had little protection from exposure to high nitrogen tension during dives except for the shortness of the dive itself. None of the species showed a well-developed asphyxial tolerance, in most regards they did less well than mammals.

In other project, which was started at Palmer Station before the arrival of the R/V *Alpha Helix*, E. A. Hemmingsen and J. A. Smith (Scripps Institution of Oceanography, La Jolla) and E. L. Douglas (University of Missouri, Columbia) conducted respiratory studies on the chaenichthyids. These fish lack hemoglobin in their blood, which is colorless and carries oxygen only in physical solution. The studies were particularly concerned with the adaptation of *Chaenocephalus aceratus* to temperatures higher than those of their natural environment. The investigation included determinations of oxygen consumption, temperature tolerance, blood gas tensions, blood lactate concentrations, blood pressures, blood flow, and cardiac output. The basal metabolic rate was found to be somewhat lower than that of other fishes. It was found that the icefishes have a considerable respiratory reserve at rest; the rate of oxygen uptake was little affected until the oxygen tension in the water dropped to one-fourth that of its normal value. This critical oxygen tension did not change markedly even at the highest temperature which the fishes tolerated, namely, 8-10°C. With increasing oxygen demands or hypoxic stresses, increase in water ventilation rather than blood circulation was the dominating response. One of the main compensations for the lack of hemoglobin was found to be a several-fold increase in blood volume and cardiac output.

In addition to these main studies, several less extensive investigations were carried out by various participants. Such varied subjects as the respiration of chaenichthyid larvae, the properties and the function of myoglobin in penguin muscles, and the water vapor permeability of the shells of antarctic bird eggs were examined.

The excellent facilities of the R/V *Alpha Helix*, the impressive fauna, and the wide-ranging interests of the participants created a most stimulating milieu during the expedition. For all concerned the trip was both scientifically and personally rewarding.

FEDERAL R&D EXPENDITURES, 1960-72

Between 1960 and 1972, the chief areas of federal R&D funding have been national defense, space research and technology, and health. Together, these functions are expected to make up 86% of the \$15.7 billion total R&D expenditures estimated for 1972. In 1960, the same three categories represented 95% of the R&D total of \$7.3 billion, and throughout the 1960-72 period these three functions led in such expenditures and in the same order.

The ratio of R&D expenditures to total federal budget outlays rose from 8.5% in 1960 to 12.4% in 1965. Since then the ratio has decreased each year – the ratio of 7.4% estimated for 1972 being the lowest occurring in the 1960-72 period. This relative decline in R&D expenditures reflects more the absolute increase in total federal outlays since 1965 – from \$111 billion to an estimated \$211 billion in 1972, excluding interest – than any substantial absolute decline in R&D expenditures. These expenditures rose from \$13.8 billion in 1965 to \$16.3 billion in 1968, but have dropped back into the \$15-16 billion range since then. Relative to other types of federal expenditures taken as a whole, research and development have experienced a significant reduction in emphasis since the mid-1960s.

This information was taken from a new NSF report, *An Analysis of Federal R&D Funding by Budget Function, 1960-72*, to be issued in a few months as a contribution to the growing need for data relating research and development to national priorities. It will be the first report of this nature to be published by the Foundation although an annual series has been published on federal R&D funding by agencies.

PREDATOR CONTROL TASK FORCE

A task force to study predator control programs throughout the country has been formed, according to an announcement from Secretary of the Interior Rogers C. B. Morton. Members of the task force are: Stanley Cain, University of Michigan; Fred Wagner, Utah State University; John Kadlec, University of Michigan; Richard Cooley, University of California, Santa Cruz; Maurice Hornocker, University of Idaho; Durward L. Allen, Purdue University; and A. Starker Leopold, University of California, Berkeley. The group, sponsored by Interior and the Council on Environmental Quality, has been charged with examining all aspects of predator control, including poisoning carried on by state and local governments and the private sector. They will also look into the economics of a national insurance program as a possible alternative to predator control and recommend changes which may be needed in Interior's present administration of its program.

NASA LIFE SCIENTIST RESEARCH PROGRAM

NASA is initiating a Life Scientist Program in which university faculty and their graduate students from the nation's universities and medical schools will receive appointments to do relevant research at NASA's Centers. The program, recommended by the National Academy of Sciences, is designed to increase participation between university life scientists and their counterparts within NASA in contributing to the advancements of life sciences disciplines related to the NASA mission. It is also designed to encourage ground research facilities at the Manned Spacecraft Center, Houston; Ames Research Center, Mountain View, Calif.; and Langley Research Center, Hampton, Va. Initially, the program will support five scientists who will spend approximately one-third of their time with their graduate students at one of the three Centers.

Seaborg Resigns from AEC

Glenn T. Seaborg, chairman of the Atomic Energy Commission since 1961, has resigned to return to research and teaching at the University of California, Berkeley. President Nixon has nominated James R. Schlesinger, assistant director of the Office of Management and Budget (OMB) to succeed Dr. Seaborg. Before his return to California where he will continue research on the transuranium elements for which he was awarded the Nobel prize in chemistry in 1951, Seaborg will lead a U.S. delegation to the USSR in August and attend meetings in Geneva and Vienna in September.

Schlesinger originally joined this Administration as assistant director of the Bureau of the Budget (now OMB) in 1969. He has taught economics at the University of Virginia and headed a study at the Rand Corporation, Santa Monica, Calif., on nuclear proliferation. His nomination which is not expected to cause any controversy is subject to Senate approval.

The President has also picked William O. Doub, chairman of the Maryland Public Service Commission, to succeed Theos J. Thompson, the AEC commissioner who was killed in a plane crash last year.

BIOLOGY BRIEFS

SERUM HEPATITIS VIRUS

A test developed during the German measles epidemic of 1964 by a University of Connecticut microbiologist has been used successfully by a former colleague to detect the virus of serum hepatitis. Philip I. Marcus, head of the U of C microbiology section, described the new development as a "major breakthrough," since the serum hepatitis virus detection "has been eluding virologist for many years."

Dr. Marcus originally developed the German measles virus test as a researcher at Albert Einstein Medical College in New York. His colleague, who extended the test to serum hepatitis, is David Carver, now of Johns Hopkins University Medical School. According to Dr. Marcus, there is also a possibility the test can be useful in detecting infectious hepatitis, a virus generally transmitted to humans by polluted sea life.

To suggest the importance of the assay system he discovered, Dr. Marcus explained that it is necessary for researchers to first measure a virus before a vaccine can be developed to counter it. "Our test permits the scientist to follow the growth of a virus in tissue cells under conditions where the virus does not overtly damage the cells. This was impossible before. Now we can study the effect that various agents might have on the virus. Once we reach that point we can experiment with the agents which might prevent its growth," he added. "There are presently vaccines undergoing experimental testing but until now it's been impossible to determine whether the infectious virus was still present in the inactivated vaccine. Our detection test will permit better quality control on the vaccine as it is developed." Dr. Marcus said.

OLDEST ANCESTRAL APE BONE FOUND

The oldest limb bone of an ape related to humans has been discovered among Yale University fossils collected several years ago in Egypt. The bone appears to be from a small ape, *Aegyptopithecus zeuxis*, that lived nearly 30 million years ago, according to Elwyn L. Simons, professor of paleontology and curator of vertebrate paleontology in Yale's Peabody Museum of Natural History. Professor Simons was leader of the 1967 expedition that recovered the fossil in Egypt's Fayum Desert, southwest of Cairo. A nearly complete *Aegyptopithecus* skull, oldest known for a close relative of man, was also found during that expedition.

"The identification of the arm bone," says Simons, "clarifies the question of the manner of movement of man's early ancestors, because it shows how the arms were used." Previously, the kinds of locomotion employed by earliest apes, such as their ways of climbing or walking, were totally unknown. Many scientists had assumed that the earliest ape-like ancestors of man were similar in their limb

structure to present-day Old World monkeys, such as baboons or macaques.

Study of the newly identified *Aegyptopithecus* fossil "surprisingly" indicated that the early apes were very much like certain of the present-day South American monkeys in their tree-climbing movements, particularly the Howler Monkeys. This would suggest that ancestral apes never went through a stage resembling Old World monkeys, a previous common hypothesis.

NEW METHOD OF DETECTING CORN LEAF BLIGHT

Cornell University researchers have developed a rapid means of screening corn plants on a large scale to determine whether they are resistant or susceptible to the destructive Southern corn leaf blight, *Helminthosporium maydis*.

The method involves the use of disease-causing chemicals derived from the infectious fungus which greatly speeds up the otherwise time-consuming screening process for plant breeders. The chemical, a toxic substance, is injected into the plant thus producing early disease symptoms. Unlike conventional methods, the technique does not require live disease organisms to produce infection in the corn field, thus eliminating the danger of contamination.

Within 3 days of injecting the toxin into the stem of a growing plant (2-3 weeks old), it will show streaks of dead tissues in one or two leaves if susceptible to corn blight. Plants showing no such symptoms are considered resistant.

FRENCH DEVELOP INSECTICIDE

Robert Aries, technical director of Dynachim, a Paris-based chemical company, has reported the development of APC 747, a new self-evaporating insecticide which is considerably less toxic than DDVP (dichlorvos) which is used in household strips for flies and mosquitoes and in pet collars. Dr. Aries made his announcement at the 90th annual Convention of the French Association for the Advancement of Science. He described APC 747, whose formula is isopropyl thiocarbonate of S-acetonitrile, as having about the same evaporation and fly-killing characteristics as DDVP, but only a third of its toxicity.

APC 747 was developed jointly by the French chemical manufacturer, Azote et Produits Chimiques and the Institut National de Recherche Chimique Appliquée. The Dynachim Co. has compounded the product with stabilizers and resins so that it can be used in long-term, continuous emission insecticide strips. Being a sulphur derivative rather than an organophosphorus compound, APC 747 may eliminate the problem of insect resistance and the health objections to DDVP.

"MOST VERSATILE BIOLOGICAL CATALYST KNOWN" ISOLATED BY UM BIOCHEMISTS

University of Michigan Medical Center biochemists recently isolated an elusive red protein substance from liver known as Cytochrome P-450. This accomplishment has enabled these scientists to better understand not only how the body metabolizes useful chemicals but also how it is able to detoxify such harmful substances as petroleum products, certain carcinogens, nicotine, alcohol, and marijuana.

The UM scientists, led by Minor J. Coon, did not discover P-450; the Japanese scientists Omura and Sato did. However, the UM investigators are the first to succeed in separating the protein from liver membranes. Considering the insults to our physiology due to pollution, the liver as a detoxifier may become even more important. Dr. Coon suggests that the secret to increasing liver efficiency lies in the possibility of finding a method of preparing a low molecular weight synthetic substitute for natural P-450 so that it can be absorbed by the liver. At present, natural P-450 is too large a molecule to get into liver cells by external means.

Without P-450, people would not even tolerate such simple medications as aspirin, yet with P-450 people can tolerate such violent compounds as barbituates. It is a scientific anomaly as it is both an activator and antidote. Someday it may be possible, through liver biopsy, to establish precise limitations to powerful medications in a given patient.

PORPOISE PROTECTION FROM SHARKS

The feasibility of using a porpoise as a watchdog to protect divers from attacking sharks has been demonstrated for the Navy by a team of scientists from the Mote Marine Laboratory, near Sarasota, Fla. Perry W. Gilbert, laboratory director and professor of neurobiology and behavior at Cornell University, said that he has completed a program for the Office of Naval Research (ONR) in which a porpoise was trained to repel sharks repeatedly on command. Dr. Gilbert said, "Although no diver was involved in the program, I'm sure that with more work a porpoise can be used to guard divers while they are working underwater."

Dr. Gilbert and Blair Irvine, a research associate, aided by Randall Wells and Ric Martini, scientific assistants at the Laboratory, conducted their experiments for 18 months in two salt-water tanks connected by a narrow, gated flume and hoisting rig. Four species of sharks — the lemon, nurse, brown, and bull — averaging 2.5 meters in length and about 136 kg in weight were used in the experiments.

In the first step, a dead shark was floated from the channel through the narrow flume into the tank containing a 200 kg, 2.2-meter male porpoise. The porpoise was trained to strike the shark when a sound signal with a specific frequency was projected into the water. Next, small live sharks were led into the tank and the porpoise successfully repelled them. Finally, fully grown live sharks were directed into the porpoise's tank and were repelled on command.

LANGUAGE CENTER IDENTIFIED

Two University of Rochester scientists have shown for the first time where language is produced in the normal human brain. Dale W. McAdam, associate professor of psychology and of neurology, and Harry A. Whitaker, assistant professor of linguistics and of psychology, announced their findings in the 30 April 1971 issue of *Science* and at the meeting of the American Academy of Neurology.

The section of the brain they studied is called Broca's area, located in the frontal lobe of the brain, either on the right or left side. McAdam said, "Right-handed people usually operate from the left side of the brain, but left-handed people occasionally have a different brain organization." The subjects in the experiment were all right-handed women with normal speech. McAdam said, "There is no reason to believe there is a sex difference in this brain function" and their findings probably apply equally to men.

The two scientists stressed that previous investigators obtained data under abnormal conditions from brain damaged patients or via surgical means or through the use of drugs or electrical stimulation during brain surgery. In the UR experiment, each of the subjects was seated in a high-backed, padded chair in a sound-deadened chamber. Seven recording electrodes were attached to the head and then each subject was told to produce a number of sounds. As each of the responses was made, the electrical signals in the brain were recorded by the electrodes. The resultant data verified that Broca's area had the greatest amount of electrical activity during speech and "provides the first direct physiological evidence for localization of language production functions in the intact normal human brain."

MICROBES DESTROY DDT

Cornell University scientists have reported the first known step-by-step complete breakdown of DDT by microorganisms. The Cornell studies pinpoint a specific biochemical pathway used by bacteria to totally destroy the pesticide. The decomposition mode, formulated by Frederick K. Pfaender and Martin Alexander, has been documented in the laboratory and is now being tested in samples from natural environments.

Pfaender, a graduate student, stated that a particular kind of bacterium, *Hydrogenomonas*, was shown to break the DDT molecule into a compound (para-chlorophenylacetic acid). This chemical, in turn, was completely broken down by another set of microorganisms. Pfaender said, "To determine whether these laboratory experiments had any relevance to things actually occurring in nature, we added DDT to two different systems containing natural microbial communities. In both a fresh water plus sediment system and with sewage organisms, DDT was degraded." The researchers presented their findings at the annual meeting of the American Society for Microbiology.

PEOPLE AND PLACES

Charles F. Ehret, a senior scientist in the biology and medical research division of Argonne National Laboratory, has been named a co-recipient of the Argonne Universities Association (AUA) Distinguished Appointment Award for 1971. **Paul A. Flinn**, professor of physics and metallurgical engineering, Carnegie-Mellon University, also received an award. Now in its second year, the program enables an Argonne staff member to spend one year at an AUA university of his choice and brings a university faculty member to Argonne for a similar period of time. Each appointee receives, in addition to his normal support, a \$5000 merit award. The purpose of the program is to recognize and reward outstanding accomplishments by scientists and engineers on the Argonne staff and on university faculties and to foster interaction between AUA universities and Argonne through a year-long exchange of individuals who have displayed exceptional talent and have gained reputations of distinction. As a result of research carried out in Argonne's biological and medical research division, Dr. Ehret has formulated a theory on circadian rhythms, stating that the biological time sense is a special and inevitable feature of the gene action systems of higher plants and animals. The AUA award will enable Dr. Ehret to further test his theory during a one-year stay at the University of Wisconsin, working in collaboration with Van R. Potter.

Jacob G. Rempel, who retired last year as Rawson Professor of Biology at the University of Saskatchewan, has been awarded the Entomological Society of Canada's Gold Medal "in recognition of an outstanding achievement in entomology in Canada." Professor Rempel, who was born in the Ukraine and came to Canada as a young man, taught biology at Saskatchewan for more than 30 years. One of his particular areas of interest has been on the Prairie mosquitoes and their role in the transmission of western equine encephalitis.

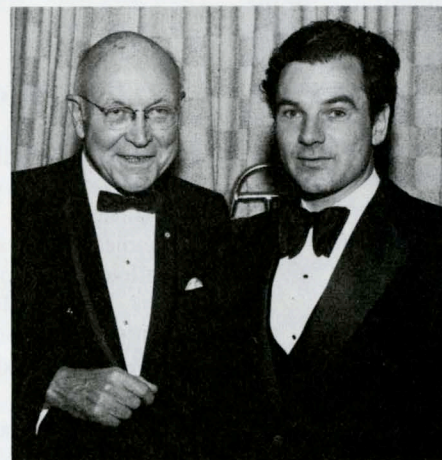
Jack Bennett, associate professor of biology at Northern Illinois University, was elected president and **N. R. Brewer** of the University of Chicago was named executive secretary at the 64th annual meeting of the Illinois State Academy of Science. Dr. Brewer will establish a permanent central office for the Academy at the University of Chicago.

• **Michael J. Pelczar, Jr.**, vice-president for graduate studies and research at the University of Maryland, was selected by the Maryland Branch of the American Society for Microbiology for the 16th annual Barnett Cohen Award. The memorial award, named for an outstanding Johns Hopkins University microbiologist, honors Dr. Pelczar as "one who has distinguished himself in the field of micro-

biology and is highly respected by his students and peers. . . ." • **William N. Sullivan**, entomologist of the Agricultural Research Service, USDA, Beltsville, Md., and **Lyle D. Goodhue**, former ARS chemist, were the joint recipients of the Eric Rotheim Medal and Scroll, presented by the Federation of European Aerosol Associations. The two scientists are co-inventors of the insecticidal aerosol principle for control of insects. • **L. Leon Campbell**, head of the department of microbiology at the University of Illinois at Urbana-Champaign, received the 24th Pasteur Award of the Illinois Society for Microbiology. Campbell was recognized for his work with students, research in bacteriology, and professional contributions including those as editor of the *Journal of Bacteriology*.

Jack Press, department of biochemistry, University of California at Davis, received the \$2000 prize of the American Chemical Society's Award in Enzyme Chemistry, sponsored by Pfizer, Inc. The award is in recognition of "his distinguished achievement in discovering the role of an enzyme called adenosine diphosphoglucose (ADPG) synthase which regulates the synthesis by bacteria and algae of glycogen, an essential carbohydrate." Dr. Preiss' work revealed that bacteria, as well as plants, depend upon ADPG for glycogen production.

Heinz Fraenkel-Conrat (left), winner of the California Museum of Science and Industry's first California Scientist of the Year Award in 1958, congratulates the 1971 winner, **Peter Duesberg** of the University of California,



Berkeley. Duesberg, nominated by the 1958 winner, also from Berkeley, was selected for his pioneering work to elucidate the complexities involved in the transformation of normal cells into cancer cells by the RNA tumor viruses as a major contribution to the solution of cancer problems. The award is made yearly by the Los Angeles-based state museum.

The **Rev. James A. Mulligan, S. J.**, associate professor of biology, St. Louis University, has been named a fellow of the Woodrow Wilson International Center for Scholars in Washington, D.C., effective 1 September. As a fellow at the Center, Father Mulligan will be working closely with approximately 20 other fellows from all parts of the world drawn from academic life and other pursuits who have been selected to further the aims of the Center. The scholars will be searching for solutions to environmental problems through international cooperation. Father Mulligan will work at the Smithsonian Institution.

New officers for the Biological Council of Canada for 1971-72 are: President, **John B. Armstrong**, executive director (medical) of the Canadian Heart Foundation; and Vice-President, **Michael Shaw**, dean of agricultural sciences, University of British Columbia. **Roy L. Taylor**, director of the Botanical Garden, University of British Columbia continues as secretary and **A. Clark Blackwood**, department of microbiology, Macdonald College, continues as treasurer. **J. L. Auclair**, chairman, department des sciences biologiques, Université de Montreal and **J. W. Pearce**, department of physiology, University of Toronto, were elected executive members.

David Baltimore, associate professor of microbiology in the department of biology, Massachusetts Institute of Technology, was the recipient of the 1971 Eli Lilly & Co. Award in Microbiology and Immunology presented at the annual meeting of the American Society for Microbiology. Dr. Baltimore received the award in recognition of his contribution to the development of a new field of research — the molecular biology of animal viruses. Also at the Society's annual meeting, **Ralph S. Wolfe**, professor of microbiology at the University of Illinois, Urbana, received the Carski Foundation Distinguished Teaching Award.

Vincent J. Hearing, a recent Ph.D. recipient in the biology department of The Catholic University of America, has accepted an invitation for a 3-year term as a junior fellow in the Society for Fellows at the University of Michigan. The recently founded Society is patterned after the Society of Fellows at Harvard. The Society seeks scholars who "are vastly original and creative within their own field, not simply the best graduate who ever matriculated." Junior fellows are free to devote their entire time to productive scholarship. Dr. Hearing's dissertation was on the synthesis of proteins in chloroplasts.

Some recent appointments: **Joseph Daniel**, associate professor at the University of Colorado, Boulder, to head of the department of zoology and entomology, University of Tennessee, Knoxville . . . **James E. Darnell, Jr.**, professor of biological sciences, Columbia

University, to chairman, biological sciences department at Columbia . . . **Robert W. Howell**, chief, oilseed and industrial crops research branch, USDA, to chairman, agronomy department, University of Illinois . . . **Douglas G. Chapman**, professor of forestry, fisheries, and mathematics at the University of Washington, to dean of the college of fisheries . . . **James E. Legates**, professor of animal science, North Carolina State University, Raleigh, to dean, School of Agriculture and Life Sciences at the University . . . **Jack J. Stockton**, professor of veterinary microbiology at Purdue University, to dean of the school of veterinary science and medicine . . . **Walter S. Vincent**, associate professor of anatomy and cell biology, University of Pittsburgh, to chairman, biological sciences department, University of Delaware . . . **Edward C. Melby, Jr.**, director of animal medicine at Johns Hopkins University, to professor of veterinary clinical sciences at Ohio State University . . . **Robert F. Goheen**, president of Princeton University, has announced his resignation, effective no later than June 1972.

George W. Keitt, Jr. has been appointed chairman of the Brooklyn Botanic Garden's research department which has headquarters at the Garden's Kitchawan Field Station. Since 1967, Dr. Keitt has been a professor and chairman of the department of biology at Mackinac College, Mackinac Island, Mich. From 1959 to 1967 he was an assistant professor in the department of biological science at Florida State University. Also at the Garden, **H. Brian Feil**, a horticulturist who specializes in landscaping, has been named the superintendent at the Fanny Dwight Clark Memorial Garden in Albertson, Long Island.

Carleton M. Herman, AIBS Governing Board Representative, has received the Distinguished Service Award, the highest honor of the Department of the Interior. Dr. Herman, an internationally known leader in the field of



wildlife disease, has published over 100 scientific articles on such subjects as avian malaria, trichomoniasis, and canine distemper in raccoons. He was instrumental in the founding of

the Wildlife Disease Association and the creator and editor of *Wildlife Diseases*, the first biological journal published on microcard. According to Interior's citation, "In all his activities, both as a scientific investigator and as a leader in biocommunication, he has brought acclaim and recognition to the Department of Interior."

Dr. Herman was also awarded the honorary diploma by the American Veterinary Epidemiological Society "For his distinguished service and contributions to the progress of public health."

A Japanese bonsai tree, believed to be from 800 to 1000 years old, has arrived at the Brooklyn Botanic Garden. The tree, which is well known in Japan, was seen by George S. Avery (see his article, Vol. 21, No. 14, p. 766), former director of the Garden and an authority on bonsai, during a tour for Garden members. Kyuzo Murata sold the tree to the Garden, whose bonsai collection is recognized as one of the leading ones in the United States and the world. Unlike the other bonsai in the Garden's collection, the new tree was stunted by nature, not by man.

Harvard University has established a **Center for Human Genetics** with Henry I. Kohn as its first director. Dr. Kohn is the David Wesley Gaiser professor of Radiation Biology whose primary interests are in mutagenic rates and in a variety of agents, such as ionizing radiation and environmental chemicals, which cause mutations in man and animals.

The **Commission on College Physics** has published the *Proceedings of the Conference on Computers in Undergraduate Science Education* which was held in Chicago in August 1970. Although the *Proceedings* are mainly concerned with the physical sciences, they do contain one ecological example in which growth rates are discussed. The *Proceedings* are available on request to qualified individuals. When ordering a copy, specify discipline, institutional affiliation, and the nature of your interest in the educational use of computers. Requests should be addressed to American Institute of Physics, State University of New York, Stony Brook, N.Y. 11790.

MEETING REPORTS

Phytotoxins

An advanced study institute on *Phytotoxins in Plant Diseases* was held 7-21 June, at Pugnochiuso, near Foggia, Italy. The Institute was sponsored by the Scientific Division of the North Atlantic Treaty Organization (NATO), probably one of the more worthwhile expenditures made by this organization. The objectives of the Institute were to present and discuss current knowledge on the chemistry, metabolism, and mode of action of toxins

produced by plant pathogens. The organizers were Professor A. Graniti, Department of Plant Pathology, University of Bari; Professor A. Ballio, Department of Chemistry, University of Naples; and the scientific director was Professor R. K. S. Wood, Department of Botany, Imperial College, London, who will also edit the published proceedings of the Institute.

The format for the Institute was unique, consisting of two major lectures each day, accompanied by two or three seminars, generally on the theme of the lectures. Nineteen lectures were presented to approximately 60 auditors, who were invited to attend on the basis of their current and continuing interest in phytotoxins. The subject matter covered was equally divided between mode of action and the chemistry of the toxic compounds. In addition, two lectures and one seminar treated ultrastructural modifications caused by phytotoxins.

The opening lecture, on the Evolution of the Toxin Concept by A. Graniti, set the stage for the Institute with a concise classification of phytotoxins and related biologically active substances produced by plant pathogens. Graniti also introduced a new term, "phyto-agressin," for pathogen-produced toxin enzymes, thus distinguishing them from phytotoxins, which are by definition nonenzymatic.

The literature which abounds with classification schemes and definitions for phytotoxins has at times tended to diminish interest in toxin research by raising the specter of artifact in connection with these toxic substances being true determinants of plant disease. However, the tenor of the lectures and seminars dispelled any doubt that phytotoxins are real and important to pathogenesis.

The lecture of R. Durbin of Wisconsin, on Bacterial Phytotoxins, was largely concerned with toxic substances produced by plant pathogenic bacteria of the genus *Pseudomonas* and conveyed the concept that these toxins were in fact determinants of pathogenicity. They induce a host reaction which can be classified as chlorosis, necrosis, wilting, or growth abnormality. The exact metabolic sequence involved in producing any one of these reactions varies with the specific toxin. Bacterial phytotoxins are composed of simple carbohydrates and/or amino acid residues. They range in molecular weight from 400 to approximately 20 million. As yet, however, there is no complete analysis of the structure of any bacterial phytotoxin. The chemical structure for the chlorosis-inducing toxin produced by *Pseudomonas tabaci* has been tentatively identified as α lacto amino β hydroxy amino pimelic acid. Initially, its mode of action was believed to be that of an antagonist of methionine. However, Durbin and his group have recently demonstrated conclusively that the toxin inhibits glutamine synthetase.

Toxins produced by fungi of the genus *Fusarium* and related genera were discussed

by H. Kern, Zurich. Recounting some of the earlier research of the Swiss group reminded members of the Institute of the pioneering efforts in this field by the late Professor Ernst Gaumann. The more recent efforts of the group at Zurich are concerned with the toxins marticin and isomarticin. The precise role of these substances in pathogenesis has not been clearly established. However, marticin is produced in greater concentrations by the more virulent strains of *Fusarium pisi*. Its mode of action appears to be the decarboxylation of α keto acids. Bioassays for the detection of even the most subtle effects of phytotoxins were described by S. Naef-Roth, Zurich.

R. Scheffer, Michigan, indicated that at least eight plant-infecting fungi are known to produce host-specific toxins in culture. Studies have been conducted by the Michigan group on toxins produced by *Helminthosporium victoriae* on oats, *H. carbonum* on maize, and *Periconia circinata* on grain sorghum. The toxins produced by these fungi selectively affect hosts of the producing fungus. Nonhosts, including resistant cultivars of susceptible species, will tolerate 100 to 1 million times higher levels of these toxins than do susceptibles. Resistance to the toxins in each suspect species is controlled by a single gene pair and host resistance implies resistance to the toxin. The three toxins caused the same biochemical changes that are evident in infected plants, e.g., the HV toxin produced by *H. victoriae* caused increases in respiration and an almost immediate loss of electrolyte from cells following exposure to the toxin. Changes which occur in toxin-treated susceptible tissue are indicative of damage to the plasma membrane and are compatible with the hypothesis of toxin receptor or sensitive sights on membranes of the susceptible cell. The chemistry of these host-specific toxins, which are all relatively small polypeptide compounds, was discussed by R. Pringle, Ottawa. The HV toxin is a nitrogen-containing sesquiterpene with a peptide of five amino acids, aspartate, glutamate, glycine, valine, and leucine. The periconia toxin is a low molecular weight polypeptide of less than 2000. Its amino acid complement includes aspartate, glutamate, alanine, serine, and valine, which account for 80% of the molecular weight. The *H. carbonum* toxin has an empirical formula of $C_{32}H_{50}N_6O_{10}$, and the molecular weight of approximately 657. None of these polypeptide toxins have been fully characterized as yet due to their extreme instability. An interesting facet of some recent research with the HV toxin was disclosed by O. Yoder, of the Michigan State group, wherein non-pathogenic mutants of *H. victoriae* (unable to produce the toxin) become pathogenic in susceptible host tissue when small amounts of toxin are added to the inoculum. This seems to substantiate the contention that the infection process is a priori-dependent upon toxin production.

The biochemical diversity of phytotoxins was made apparent in a series of lectures on the chemistry and biosynthesis of amino acid, terpenoid, and polysaccharide-glycopeptide phytotoxins presented, respectively, by M. Barbier (Paris), C. Casinovi (Rome), and C. Salemink (Utrecht).

An outstanding example of interdisciplinary research was provided by Italian scientists attending the Institute. Discovery by the Bari plant pathologists of the toxin fusiococcin, produced by the almond pathogen *Fusicoccum amygdali*, stimulated intense interest on the part of chemists and plant physiologists in the chemical configuration and general biological activity of this compound. Large research groups headed by A. Ballio, C. Casanovi, and L. Canonica, at the Universities of Naples, Rome, and Milan, respectively, rapidly and efficiently revealed the complete and absolute stereochemistry of fusiococcin via traditional organic chemistry, NMR, infrared and mass spectroscopy, and X-ray analysis of a heavy atom derivative. Fusiococcin was shown to be a diterpenoid, with an empirical formula of $C_{36}H_{56}O_{12}$. E. Marre, Milan, substituted fusiococcin into more than two decades of auxin (IAA) experimentation and found the toxin to be, in many respects, a more potent plant growth regulator than the legendary IAA. In a comparative analysis between IAA and fusiococcin, the former stimulated growth 250% and the latter 400%. Auxin stimulated pyruvate utilization via the Krebs cycle 80%, whereas the toxin stimulated its use 300%. ATP yield was increased 20% by auxin and 35% by the toxin. A number of other metabolic pathways were also shown to be activated more strongly by the toxin than by IAA.

The plant wilt syndrome (signalling a water deficit), with its associated decreases in respiration and photosynthesis, characterizes the activity of a number of phytotoxins. A. Dimond, Connecticut, discussed the relative importance of mycelia, tyloses, gels, melanoid pigments, and polysaccharides in reducing water flow in xylem vessels. According to him, the possibility that toxin-induced wilt reflected permeability changes in membranes of infected host cells has not been fully substantiated.

R. Wood, London, advanced the theory that, in some instances, death of plant cell protoplasts is caused directly by cell wall macerating enzymes (phytoaggressins). The inference was that the host cell protoplast, as consequence of toxin action, becomes morphologically and biologically imperfect. In fact, artificially prepared protoplasts survive without walls only in isotonic solutions.

The theoretical aspects of the effects of phytotoxins on the permeability of cell membranes was discussed by O. Page, Canada. The mechanisms by which microbial toxins damaged host cells are not clearly understood. However, toxins must eventually influence adversely the membrane system of the cell; hence, the diverse membrane-bounded subcel-

lular organelles were discussed as targets of toxin action.

D. Gottlieb, Illinois, drew parallels, in a theoretical discussion on modes of action, between certain antibiotics and phytotoxins. Their effects could be similar mechanistically and hence, like some antibiotics, they could interfere with respiration by suppressing terminal oxidation systems, or directly alter RNA and/or protein synthesis. It was suggested that, in the final analysis, the influence of toxins would probably be upon membrane integrity through their effect upon protein and/or lipid synthesis.

R. Goodman, Missouri, described ultrastructural modifications induced by three different toxins. The HV toxin induced formation of lomasome-like structures, suggesting that Golgi vesicles are not being incorporated normally into cell walls, revealing wall metabolism dysfunction. The chlorosis caused in tobacco leaves by the *P. tabaci* toxin appeared similar to chlorosis associated with either natural or actinomycin-D-induced senescence. In all instances, the ultrastructural modifications were identical. Production of the necrotoxin ammonia by a number of phytopathogenic bacteria was clearly related causally to degeneration of the plasmalemma, tonoplast, and membranes of chloroplasts, mitochondria, and microbodies in apple and tobacco leaf cells.

In the final lecture, J. Meyer, Belgium, described the ecological significance of toxin production by plant pathogens providing a *raison d'être* for these biologically active compounds.

A particularly valuable contribution to the Institute was the discussion by A. Ballio, Rome, who described some methods available to the modern chemist for the rapid elucidation of structure of biologically active products. He reminded the participants that the role of the chemist is by no means diminished by the progress made possible by modern instrumentation. Biologically active natural products are often available in minute quantities and their extractions and purification require considerable skill. He noted too that it was becoming more and more apparent to chemists that structure elucidation is only an episode of a much larger and more intriguing story in which biologists and chemists form an integrated team. Such a joint venture is required in the elucidation of the mechanism of action of natural products such as toxins.

In summary, it would appear that phytotoxin research is experiencing a renaissance which has at least three stimuli: the discovery of several new host-specific toxins, the use of modern instruments to elucidate chemical structure, and perhaps most important of all, the interdisciplinary approach to problem-solving.

ROBERT N. GOODMAN
Department of Plant Pathology
University of Missouri
Columbia, Missouri

ENVIRONMENTAL ENHANCEMENT

Natural Resource Conservation, An Ecological Approach, by O. S. Owen, The Macmillan Co., New York, 1971, 593 p., illus., \$9.95 (74-119125).

In these days of belated environmental concern, each new publication contributing to our understanding of the problems is welcomed with interest. The present book, organized on an ecological framework, is aimed particularly at the nonspecialist, where the need is perhaps the greatest. One notes, while writing this review, that Congress currently has scheduled at least a score of public hearings on pending legislation related to natural resource issues. This volume, in an informal yet authoritative manner, provides useful background information for any serious consideration of reforms and new policies.

This book makes a splendid companion volume to Ehrenfeld's *Biological Conservation*, reviewed in the March 1 issue of *BioScience*. The latter is concerned chiefly with the biota, with communities of plants and animals. Owen's book puts more stress on the inorganic factors—soils, water, atmosphere—although it is impossible to completely divorce the various components of the total environmental complex. All are intricately inter-related and must be considered together.

At long last we have come to realize how we have degraded our natural environment, and what some of the consequences are. Our dilemma stems from "four major factors: rapid population increase, pollution, excessive consumption of resources, and the gradual deterioration of a land ethic. . . . The population increase clouds the entire environmental picture, and in a sense, is the underlying cause of our present crisis." Under the artificial stimulus of efficient and insipid advertising, and with undue regard for the gross national product, we have heedlessly exploited our resources. The world's most affluent nation, America, "has also become the most effluent." We have failed to note the words, quoted from Aldo Leopold (1949), that "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

RICHARD H. MANVILLE
Fish and Wildlife Service
Washington, D.C.

FLIES AS VECTORS

Flies and Disease, Vol. 1, Ecology, Classification, and Biotic Associations, by B. Greenberg, Princeton University Press, Princeton, N.J., 1971, 856 p., illus., \$30.00 (68-56310).

This set of two volumes will undoubtedly become the basic reference on the role of flies in disease and will serve both the specialist and nonspecialist in this capacity for many years to come. The present review is concerned with Volume I; Volume II is in preparation.

Approximately one-quarter of Volume I is divided equally into a discussion of the ecology of flies of the Palaearctic, with a series of keys to adult synanthropic flies of this region, and to the genera *Musca* and *Drosophila*. Also included is a key to the larvae of Palaearctic and cosmopolitan species. The important taxonomic characters used in the keys are well illustrated in an extensive series of drawings which will make the keys useful even to the novice. In addition, a series of 15 color plates depicting an assortment of adult female flies has been included.

A discussion of fly ecology in the context of changes taking place in the environment is especially well done. Many original data on flies are presented and synthesized in a way which crystallizes the concepts underlying the effects of man's impact on the environment. This section is particularly appropriate at this time when man's influence upon the world in which he lives has become a household concern. Flies probably provide the best documented case of spontaneous synanthropy thus far. The literature in this field is published in Eastern European journals and is relatively inaccessible to Westerners. For this reason, the excellent synthesis to be found in this volume represents a valuable contribution to the biological literature.

The last section of the book which takes up over three-quarters of Volume I is a systematic compilation of fly-organism associations. These compilations are arranged first by species of fly and again by organism. Each association is well documented and an exhaustive list of citations will serve as an outstanding key to a difficult literature.

RICHARD L. BEAUDOIN
Naval Medical Research Institute
Bethesda, Maryland

INTRODUCTION TO ECOLOGICAL PHYSIOLOGY

Animal Physiology, 3rd ed., by K. Schmidt-Neilsen, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1970, 145 p., illus., \$6.95 (cloth), \$2.95 (paper) (71-110093).

The 6 years which have passed since the publication of the second edition of this interesting and useful little volume have seen a tremendous upsurge and broadening of interest in things ecological and environmental. It is therefore both welcome and strategic that a new, expanded, and up-dated version has now appeared. I am aware of no other book on ecological and comparative physiology which is written so that intelligent high school graduates both in and outside the life sciences can understand it. Its clarity, brevity, and style are such that it should appeal to a wide range of readers, all of whom will leave it with a greatly heightened understanding and appreciation of the diversity and elegance of the physiological adaptations of many kinds of animals (both invertebrate and vertebrate) to many kinds of environmental conditions.

The book's organization is essentially that used in the second edition. There are many sections which have been revised and expanded to include new knowledge and understanding (e.g., discussions of metabolic scope, energetic efficiency of locomotion, aspects of neurophysiology, orientation in electric fishes). Most old figures have been redrawn and generally improved, and there are many new figures. One of the redrawn figures is the only major source of puzzlement I found. Chapter 7, on Integration, in both editions includes a figure diagramming the location of the most important hormone-producing organs in vertebrates. In the second edition, the organism represented in this figure is a man. In the third edition, the organism is a gorilla. Is there some oblique social commentary in this change?

I recommend this new edition highly.

MALCOLM GORDON
University of California
Los Angeles

SOCIOBIOLOGY

Social Implications of Biological Education, edited by A. B. Grobman, The Darwin Press, Inc., Princeton, N.J., 1971, 134 p., illus., \$5.95 (77-131404).

In a world where students and teachers are crying for relevancy in the curriculum, this little book, a compilation of many ideas on the social implications of biology, emphasizes the political and social needs toward an understanding of the biological sciences.

Recommended for teachers of biology and science, this book attempts to introduce the

teacher to some of the significant implications of science and society. Five broad areas are defined—medicine, behavior, genetics, population, and evolution. It gives needed insight into the research and direction science is taking in meeting the needs of a changing society.

The format of this book is unique in that, as you read through the various chapters, you feel as if you are attending the NABT Convention in which these presentations were given in 1969. First the main papers for each of the areas are presented, followed by discussions from leading scientists in the area. These discussions support or criticize the main paper, and you readily can compare the various points of view that prevail within the scientific circle. This discussion section is then followed by a question-and-answer section in which various questions from the floor are posed, and those scientists involved answer them. This, of course, gives you an opportunity to see further direction and insight of the speakers.

The main criticism of the book is that of the selection of areas. There is no mention given to the entire area of environmental science, which is probably the most socially aware area in the sciences today.

Each of the five areas has its own unique quality which gives some social implications. For example, health and advances in medicine are discussed at length with implications of political, social, and moral obligations in organ transplants and the shortage of doctors both home and abroad. In behavior, an interesting discussion of the "behavioral revolution," that of how man views himself, is developed, both politically and socially. The most interesting area discussed in the book is that of population: Garrett Hardin discussed his "Graduated Checklist of Heresies," which is an excellent way for teachers to stimulate thought and discussion with high school students. The development of zero population growth, space, and calorie considerations are just a few mentioned. An interesting distinction is made between population control and birth control which many educators should be aware of. In the genetics area, Dr. Wallace develops a fine plan of attack in discussing the biology of race. Using Mendelian heredity, he develops a pattern of analysis and uses the only figure in the book to develop his point. This can be useful to the classroom teacher in developing this important aspect of heredity. Lastly, the section on evolution attempts to compare religious acceptance of evolutionary theory as compared to the scientific viewpoint. This also has merit, especially in the teaching of evolution with the many controversies that it poses. Future implications of evolutionary theory are also explored. This section, however, falls short because it does not have any discussion section where one may compare various viewpoints of other scientists, nor does it have a question-and-answer section. Perhaps this section "evolved" at the last minute and lack of preparation

forced the change in a most interesting format.

HAROLD J. MCKENNA
The City College of the
City University of New York

HISTORY OF CELL THEORY

Cell and Molecular Biology, An Appreciation, by E. Rosenberg, Holt, Rinehart & Winston, Inc., New York, 1971, 234 p., illus. (paper) (70-136775).

This paperback is intended as a text or supplement to a text in introductory biology. It was designed primarily for the student who is majoring in the arts, humanities, or social science. However, it could be useful as a supplement to many texts used for general biology or, together with two or three books of a similar nature on other facets of biology, could serve as a textbook. The central theme is the cell theory and an historical development of the modern concepts in molecular biology and genetics. The book begins with an historical treatment of the concepts of the origin of life from the Greeks of Aristotle's time, through the periods of Redi's testing of the theory of spontaneous generation and Pasteur's sterilization procedures, to Koch's procedures for pure cultures and the theory that life is continuous from some origin on a primitive earth, usually credited to Oparin.

After covering briefly the nature of living systems, the book surveys the form of living cells and their components with the light and electron microscope. The next section begins with basic physical concepts of thermodynamics and the energy transformations necessary for living systems. There follows a brief coverage of intermediate metabolism treated in a nontechnical way for those who have had high school chemistry or its equivalent. The treatment of genetics begins with Mendel's experiments on peas, but rapidly moves to bacteria and viruses for examples of genetic systems. The role of DNA is illustrated by Avery's transformation experiments. This is followed by a brief treatment of the chemistry of the nucleic acids and proteins, with only enough coverage to understand protein synthesis and the genetic code.

For growth and regulation, the book draws heavily on the microorganisms and the experiments of Manod and Jacob, ending with concepts of the operon model, repression, feedback systems, allosteric interactions, and regulatory mechanisms.

A final light touch which makes the book different is a fictitious dialogue between a poet and a scientist who are the lone survivors of earth's destruction, save one robot. At the end, the robot is transformed into a beautiful female who guides their escaping spaceship to the planet Vita for a new start. Beyond this commonplace plot, there is an interesting and

unusual dialogue, with a slight apology to Socrates for plagiarism. Altogether it makes an interesting and useful volume.

J. HERBERT TAYLOR
The Florida State University
Tallahassee

PALEONTOLOGY

The Elements of Palaeontology, by R. M. Black, Cambridge University Press, New York, 1971, 339 p., illus., \$13.50 (cloth), \$4.95 (paper).

Introductory texts in paleontology are a welcome sight, especially at a time when the field is progressing rapidly in new and interesting directions. Thus it is disappointing to report that this book reflects none of the current excitement. Rhona Black's approach is a curious admixture of detail and superficiality. Purported to cover a broad field of knowledge, it dwells interminably on minute morphological details of certain invertebrate classes and genera, while slighting or wholly ignoring others (e.g., 70 pages are devoted to bivalves, gastropods, and cephalopods, yet the monoplacophorans, chitons, and scaphopods are not mentioned). The vertebrates and plants are covered in just a few more pages than are devoted to the mollusks. The text is well illustrated and most illustrations are new. However, annotations on photographs and lines or letters singling out features are either too small or so placed as to be obscured. The color photographs are unnecessary, as the subjects gain no value from color rendition. A minor but annoying practice is the cropping of vertebrate illustrations to such a degree that parts of the head or tail (or both) of the animal are missing.

Evolution is treated in a most perfunctory manner and seems to be equated with geologic history. The advertised emphasis on biological aspects of paleontology falls far short of current approaches. There are glimmerings of what could have been, as in the section relating shell form to mode of life in bivalves, but in general the "biological approach" translates as "soft part nomenclature."

This is a British book concerning British fossils. Its provincialism is evidenced by the all too frequent use of local formational and age names without reference to widely recognized standard time scales. This may also account for the lack of emphasis on certain important groups of fossils that are not commonly found in the British Isles. As a teaching aid, it would show to best advantage as a laboratory manual in invertebrate paleontology, but in this regard, *Principles of Invertebrate Paleontology* by Shrock and Twenhofel (1953) remains without peer.

VICTOR A. ZULLO
University of North Carolina
Wilmington

GENETICS OF EVOLUTION

Genetics of the Evolutionary Process, by T. Dobzhansky, Columbia University Press, New York & London, 1971, 505 p., illus., \$10.95 (72-127363).

Since Darwin proposed what has rightly been called the greatest unifying theory in biology, studies of evolutionary mechanisms have been concerned principally with putting the theory of evolution into a sound genetic framework. The modern "synthetic theory," however, does much more than fill in details. It presents a more dynamic and multifactorial view of evolution than did the simple classical theory of mutation and directional selection. The genetic concepts of balanced polymorphisms, disruptive and normalizing selection, and the ecological and genetic phenomena involved in speciation represent considerable intellectual advances from the basic principle of evolution by natural selection. These advances are the subject of Dobzhansky's *Genetics of the Evolutionary Process* which has evolved from his previous classic work *Genetics and the Origin of Species*.

When considered in the context of modern genetics, the theory of evolution, though unifying, is by no means unified. The origin of the widespread heterozygosity in natural populations, for instance, is by no means well understood and sometimes is explained by adaptive neutrality of the variants, and sometimes by balancing selection. The relative importance for speciation, of geographical isolation versus other types of isolation, is unclear both in individual cases and in general. Group selection is heralded by some as a major factor in the evolution of behavior, but dismissed by others as genetically unsound. These controversies and others are given a clear, critical, and balanced treatment in this volume.

The book begins with a synopsis of basic genetics, together with a brief discussion of the relevant aspects of molecular genetics. These sections are perhaps overcondensed, but are adequately dealt with in texts devoted to such subjects. Dobzhansky is at his most stimulating when on his home ground; balanced polymorphisms and their relevance to genetic load are particularly well covered, as is the genetics of speciation. The different kinds of selection are treated thoroughly, though on a nonmathematical level. Genetic drift, racial variation, and isolating mechanisms are given well-balanced and reasoned discussion. A few topics, such as sympatric speciation, the importance of chromosome number, polyploidy, the exclusion principle, etc., could have been more extensively discussed, as could some of the newer evolutionary ideas coming from molecular genetics. In my opinion, the book would also have benefited from the inclusion of a glossary (since new words are sometimes introduced without definitions) and more illustrations would have

made for more enjoyable reading. Chapter summaries or conclusions would also have been useful. But these are minor criticisms; the book is an excellent and authoritative review of the field. It can be highly recommended as a text for advanced courses in nonmathematical population genetics and evolutionary mechanisms.

PETER J. BRYANT
University of California, Irvine

FOR THE BIOLOGY MAJOR

Basic Ideas in Biology, by E. A. Phillips, The Macmillan Co., New York, 1971, 715 p., illus., \$10.95 (77-80308).

This extensive compendium is refreshing because it organizes biological knowledge into organismal, cellular, genetic, developmental, human, behavioral, environmental, evolutionary, and systematic categories. The treatment of biological ideas is intensive. Experiments from recent periodicals are included and interpreted in a problem-solving context. The relevancy of biological knowledge to social, economic, and political problems is obvious in the section on environmental biology, but not so elsewhere.

Each chapter includes a reference to literature cited and each section lists journals and books for additional readings. There is an extensive glossary and an index.

The prospective biology major will find the text an excellent resource. The book is probably too sophisticated for most nonmajors. It should be in the library of every instructor of introductory biology courses.

TED F. ANDREWS
Governors State University
Park Forest South, Illinois

Please Note

All correspondence concerning books and book reviews should be addressed to John A. Behnke, *Editor BioScience*, c/o Department of Biology, New York University, Bronx, New York 10453.

Erratum

In New Titles, *BioScience*, Vol. 21, No. 10, p. 499, the text, *Topics in the Study of Life*, edited by D. Bucklin, Harper & Row Publishers, should have been listed as *Topics in the Study of Life: The Bio Source Book*, contributors: Hans Ris, James W. Lash, Alfred S. Sussman, William H. Telfer, Herschel L. Roman, Vincent G. Dethier, Monte Lloyd, and Richard C. Lewontin.

Professional Opportunities

Santa Catalina Marine Biological Laboratory

The Santa Catalina Marine Biological Laboratory is pleased to announce its Fall Program for 1971: Comparative Physiology of Marine Animals (Drs. Lewis Bishop and Hector Fernandez) will be offered 30 September–3 November, Oceanology (Drs. Richard McGinnis and Richard Pieper) 8 November–15 December 1971 and Marine Ecology (Drs. Jack Lewis of the Wellcome Marine Laboratory, England, and Robert Given) 6 January–9 February 1972. Each of these graduate level classes carries 5-semester units credit; registration is through the University of Southern California.

For additional information, write to Dr. Russel L. Zimmer, Santa Catalina Marine Biological Laboratory, Box 398, Avalon, Calif. 90704 or telephone AC 213, Avalon 811 (operator's assistance is required).

INDUSTRY, GOVERNMENT, ACADEME ARE YOU SEEKING BIOLOGISTS?

Your job description can be listed, without charge in the *AIBS Employment Newsletter* which is distributed by the **AIBS Placement Service** to over 700 job-seekers.

The *Newsletter* is issued six times annually (February, April, June, August, October & December) to qualified persons trained in all disciplines of the life sciences.

To take advantage of this opportunity to recruit your personnel from the widest possible selection, send job descriptions to the AIBS Placement Service, 3900 Wisconsin Avenue, NW, Washington, D.C. 20016, or telephone 202/224-5581 ext. 48.

• **POSITIONS SOUGHT** Charges \$0.25 per word with a \$4.00 minimum required. Box numbers may be used but will be counted as 5 additional words. Payment must accompany copy.

INDEX TO ADVERTISERS

AIBS	864
Earth Satellite Corp.	857
E-Z Sort Systems, Ltd.	844
Harvard University Press	842
E. Leitz, Inc.	C4
Mogul-ED, Div. of the Mogul Corp.	844
University Software Systems	C3
R. U. Utrecht	C3

• **COPY DEADLINE** All copy must reach the AIBS by the 1st or 15th of the month preceding the issue in which it is to appear. All copy should be addressed to Employment Information, AIBS, 3900 Wisconsin Ave., N.W., Washington, D.C.

Information for Contributors

Correspondence: All correspondence should be directed to the Editors, *BioScience*, American Institute of Biological Sciences, 3900 Wisconsin Ave., N.W., Washington, D.C. 20016 U.S.A.

Editorial Policy: The Editors will welcome manuscripts on all biological or biologically oriented subjects, but they urge the authors in specialized areas to use language understandable to as broad an audience as possible. All manuscripts will be reviewed by at least two scientists competent in the field.

The usual length of feature articles is 6000 words, about six *BioScience* pages; however, longer manuscripts will be accepted with the approval of the Editors. Manuscripts must conform to the *C. B. E. Style Manual for Biological Journals*. Research reports should be concise statements of no more than 2500 words summarizing the original work. Illustrations are acceptable and are recommended for inclusion with all papers. Since the word counts above do not allow for illustrations, text length should be adjusted to accommodate them. The editors reserve the right to edit the manuscripts; alterations will not be made without the permission of the authors.

Papers are accepted for publication on the condition that they are submitted solely to *BioScience* and that they will not be reprinted or translated without the consent of the Editors. The publication date of accepted papers will usually be in the order received. The date the manuscript was accepted for publication will be indicated on the published paper. Normally, there is a minimum lapse of 6 months between receipt of manuscript and publication.

Preparation of Manuscript: In the preparation of copy, manuscripts should be neatly typewritten, double-spaced throughout including references, tabular material, footnotes, etc., on one side only of 8-1/2 x 11 inch white bond paper. Please submit the original plus one additional copy. The author should retain a copy. A separate title page should be provided, and footnotes, figure captions, and tables should be typed on sheets separate from the text. At least one of the copies submitted must be complete with figures, tables, and references. Please convert all weights and measures to the metric system.

Illustrations: Illustrations such as photographs, maps, line drawings, graphs, etc., should be submitted, unmounted, with the manuscript. Number figures consecutively and identify on the reverse side. Glossy photographs are required and must be at least 4 x 5 inches, but not larger than 8-1/2 x 11 inches. Originals of drawings are requested. Generally, drawings larger than 8-1/2 x 11 inches are not acceptable. Lettering on all illustrations must be sufficiently large to allow reduction to a double or single column. Figure captions for each illustration should be typed on a separate page and accompany the illustration.

Abstract: An abstract of 50 words or less must accompany the manuscript; therefore a summary is not required.

Footnotes: Unpublished documents and personal communications should be cited in the text by footnotes. Footnotes should be indicated by consecutive, superscript numerals rather than by asterisks or other symbols.

Literature Cited: In the text, references to literature citations should be designated by the author's name and year of publication in parentheses. If there are more than two authors, only the senior author's name should be listed in the text with the abbreviation et al., for example (Smith et al., 1965). Only published references should be given in the Literature Cited, and each should conform in style to the name-and-year system of the *C. B. E. Style Manual for Biological Journals*.

Reprints: Orders for reprints may be placed either before or after the issue is printed, but must be prepaid or accompanied by an institutional purchase order. Allow 4 weeks for delivery after publication.



UNIVERSITY OF UTRECHT, NETHERLANDS

CHAIR OF SYSTEMATIC BOTANY

Applications or suggestions are invited for the post of **Ordinary professor of systematic botany** at the Institute of Systematic Botany of the University of Utrecht. The duties include the teaching of plant systematics at both undergraduate and postgraduate level as well as the general guidance of scientific research in this field. Another chair covers palaeobotany and palynology whereas a new lecturer will be appointed for ecology. Present scope of research includes classical systematics, biosystematics, plant geography, plant anatomy, nomenclature and documentation.

The applicant should have an open mind with respect to the new and modern developments in plant systematics and should have an overall interest in general systematics and plant geography.

Annual salary D.fl. 69.159. = \$19,710

Applicants and those who have suggestions to make with respect to possible candidates are requested to write within one month to the Committee "vacature ordinariaat bijzondere plantkunde," Bureau van de Subfaculteit der Biologie, Transitorium II, Heidelberglaan 2, Universiteitscentrum "De Uithof," Post Utrecht, Holland.

A curriculum vitae and a list of publications are solicited.

UNIVERSITY SOFTWARE SYSTEMS presents

USS/MACRAN[®]

a proven system for Time Series Analysis. Over 20 installations throughout the U.S. and Canada.

UNISTAT[®]

a new system for complete statistical analysis of data.

DIGIFIL

a program for digital filter design.

These proprietary software systems are programmed in Fortran IV and are available for most medium to large scale computers. Systems are available on one time payment leases or monthly payment plan.

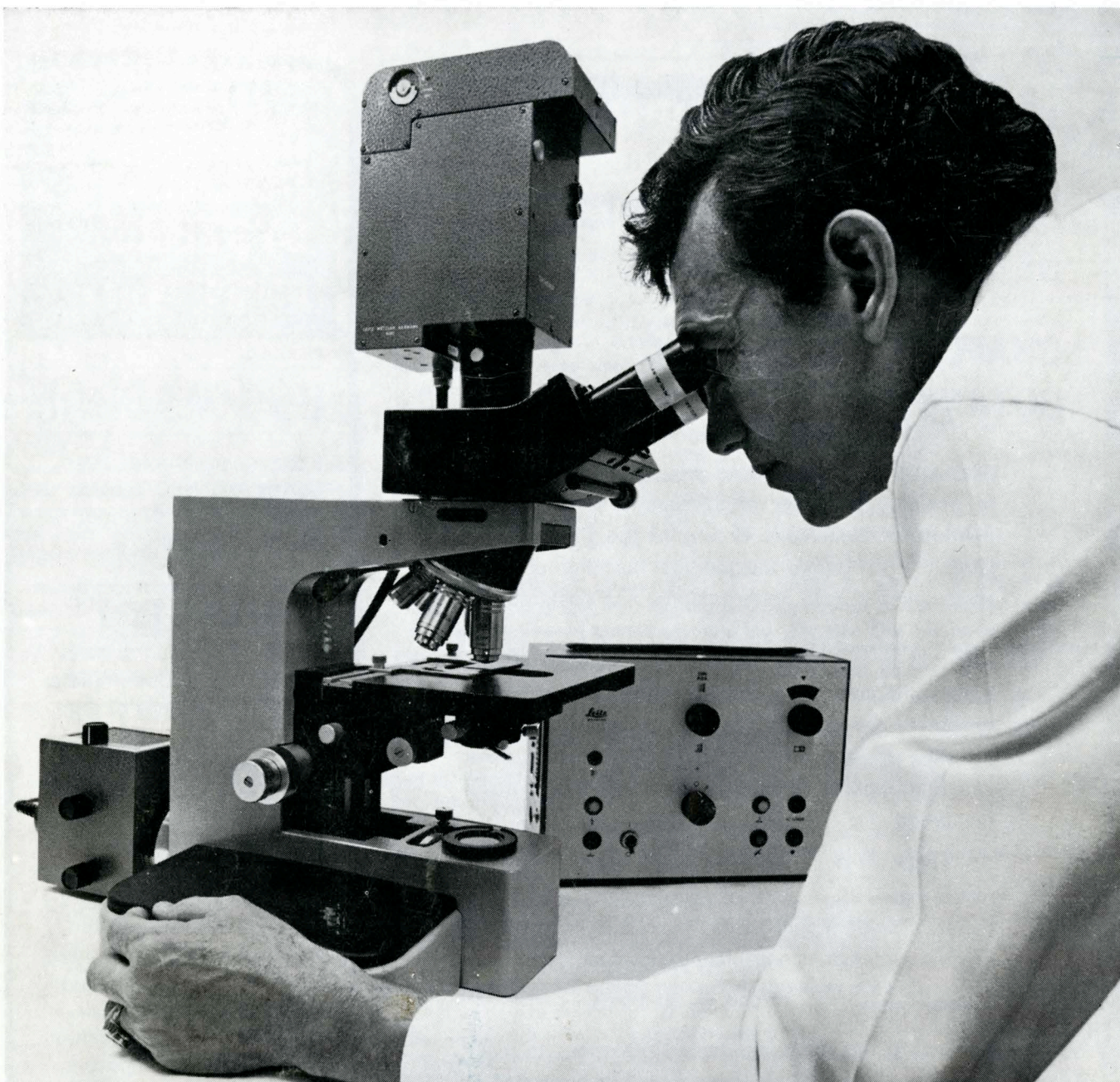
For further information contact: Loren Enochson



UNIVERSITY
SOFTWARE
SYSTEMS

P.O. Box 24117
Los Angeles, Calif. 90024
Phone (213) 478-0565

In England, contact:
Computer Cooperatives Ltd.
Institute Building
Guildford, Surrey, England



We've improved the Orthomat Microscope-Camera (Making the best even better is our business)

It's not easy to improve on anything so good. The only improvements we could come up with were to transistorize the control box... making it smaller. And increase the range of shutter speeds... from 1/100 sec.—30 min.: to from 1/200 sec.—30 min.

When you have an automatic 35mm microscope-camera that gives you a precisely exposed photomicrograph every time; a camera that doesn't let you waste an exposure; that trips the shutter, calculates exposure, and advances the film automatically; that automatically compensates for

light intensity changes during exposures; that has a shutter especially dampened against vibration; that lets you switch film even in the middle of a roll; that gives the right exposure time not only in bright-field, but in dark-field, fluorescence and polarized light; and that's built with fantastic Leitz precision... there really isn't much need for improvements.

However, the few we found have been included in the Leitz ORTHOMAT II Microscope-Camera. 78070

Leitz® E. Leitz, Inc., Rockleigh, N. J. 07647